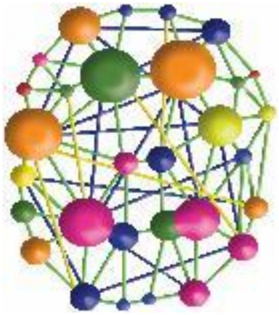
Interpretation of Raw and Complex Quantitative EEG Analyses

Robert Coben, PhD
Integrated Neuroscience Services



- Thanks to Rusty Turner, MD
- Jack Johnstone, PhD and Marvin Sams
- Intro to Workshop
- Where are you?
- What are your goals?

“Whatever you need to see in a QEEG you can see in the raw waveform”. – Jay Gunkelman

This is true to a degree. Maybe not about complex relationships in the data.

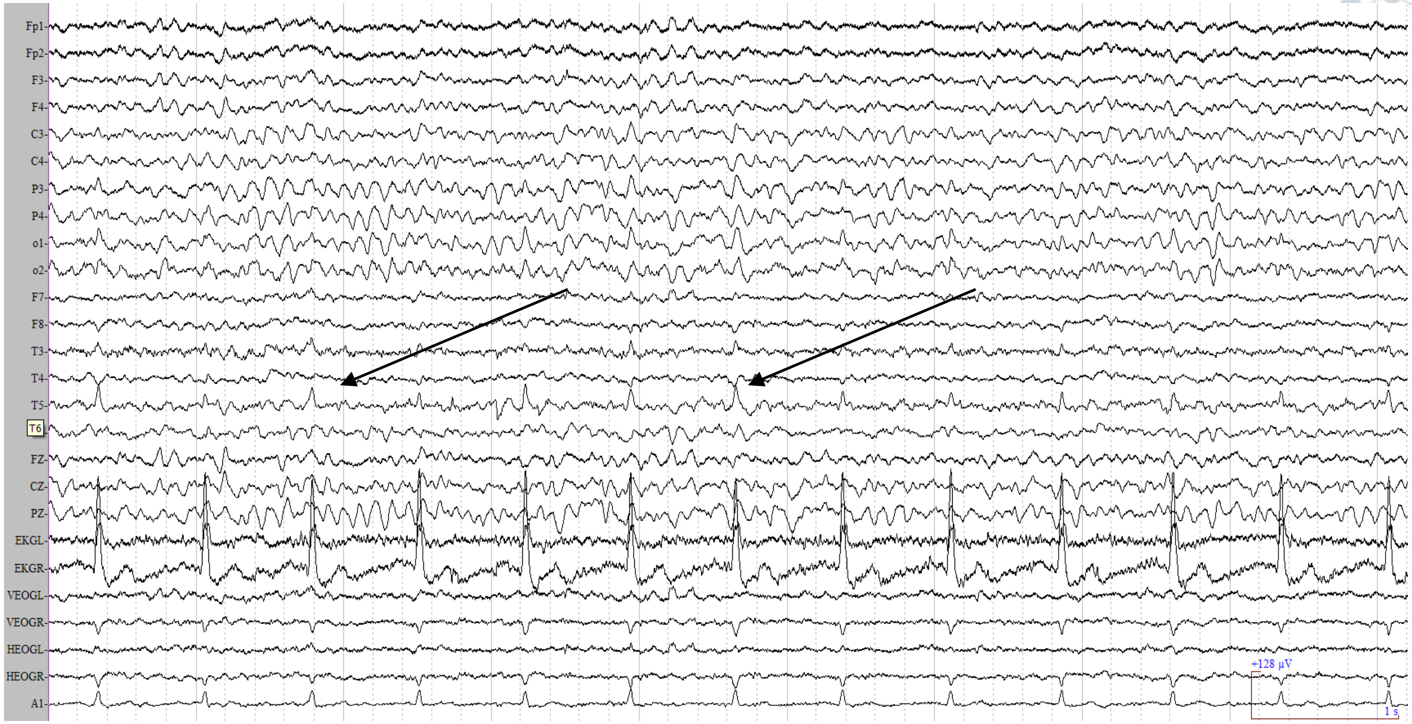
Artifacting

Avoiding the "garbage in – garbage out"

Artifact – types and methods deletion

- Artifacts come in two types:
  - Physiological
    - Muscle Artifact
    - Eye Movement
    - Perspiration
    - EKG (ECG)
    - Respiration
    - Tongue Movement
  - Non physiological
    - 60 Hz (50 Hz) Interference
    - EEG electrode popping
    - Other environmental sources

EKG



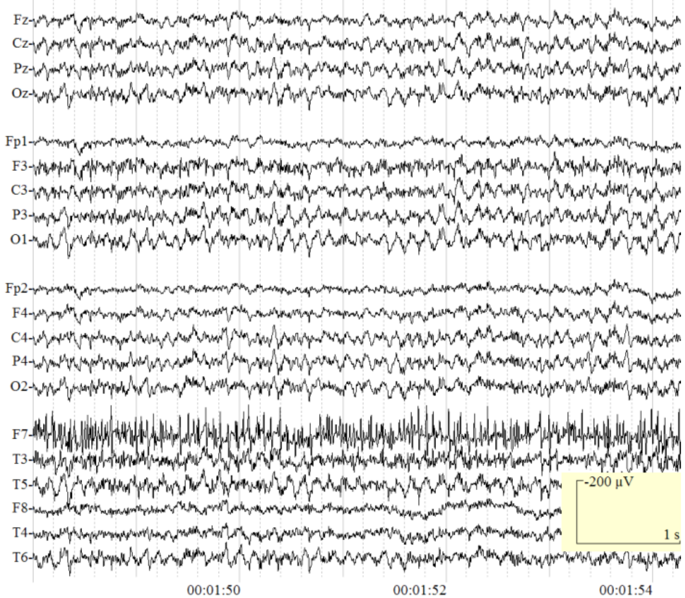
Fp1
Fp2
F3
F4
C3
C4
P3
P4
o1
o2
F7
F8
T3
T4
T5
T6
FZ
CZ
PZ
EKGL
EKGR
VEOGL
VEOGR
HEOGL
HEOGR
A1
+128 µV
1 s

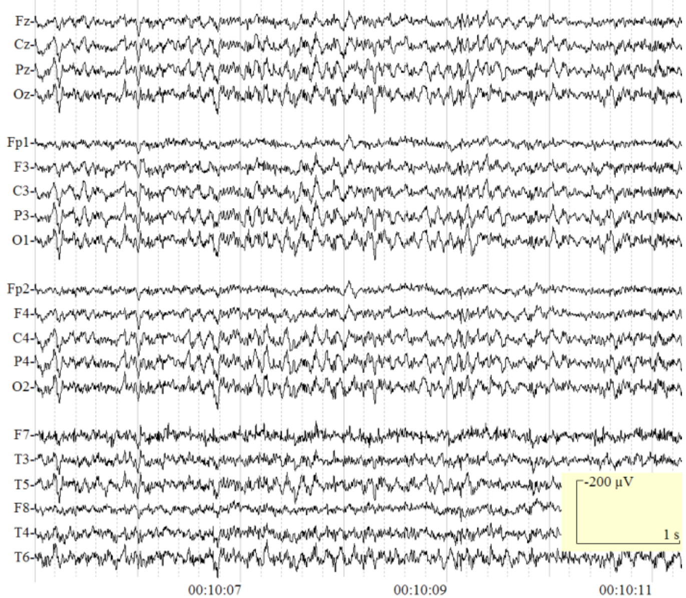
Blink

Alpha suppression

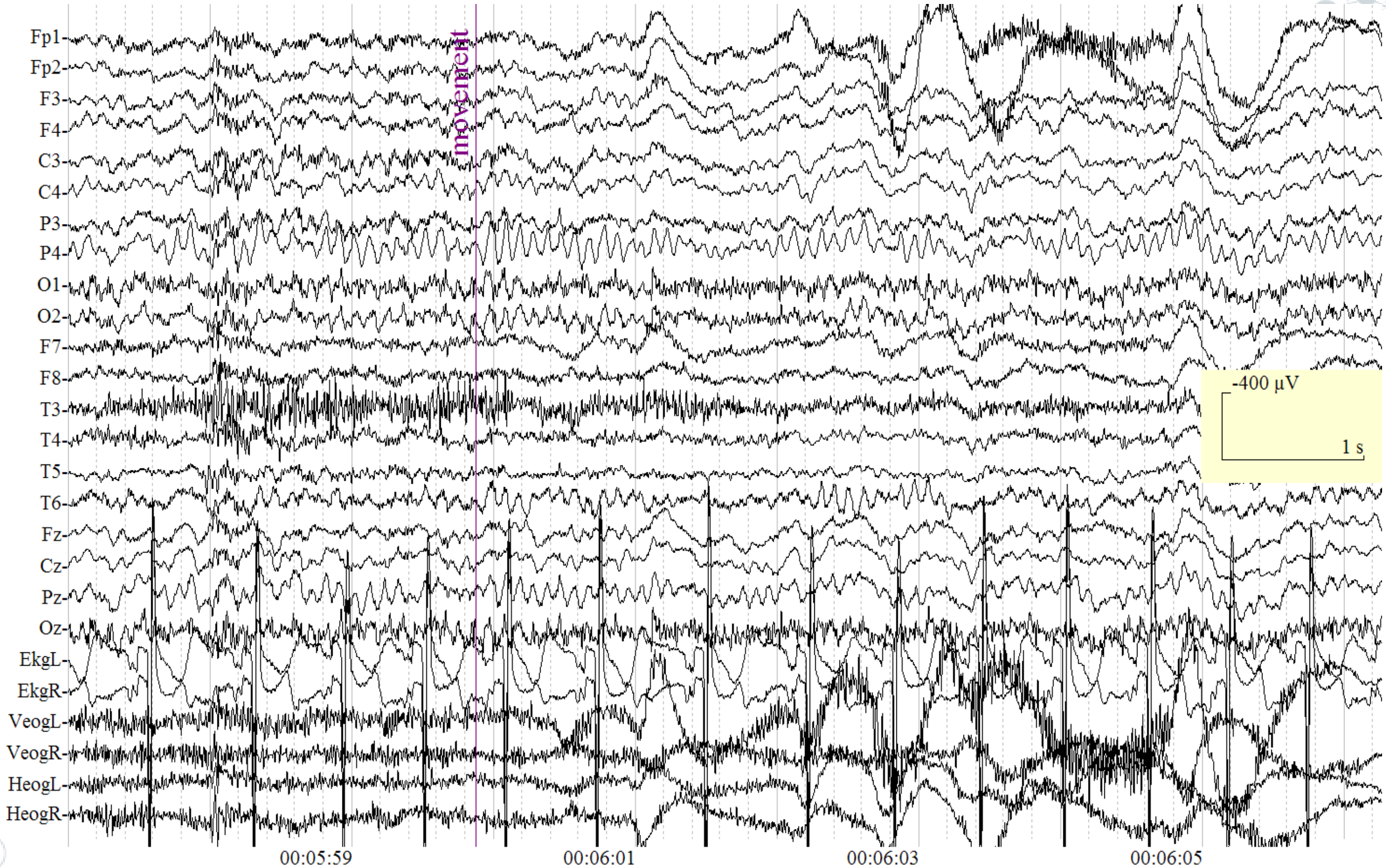
Muscle

Change in Beta activity over the course of study: manipulating the patient





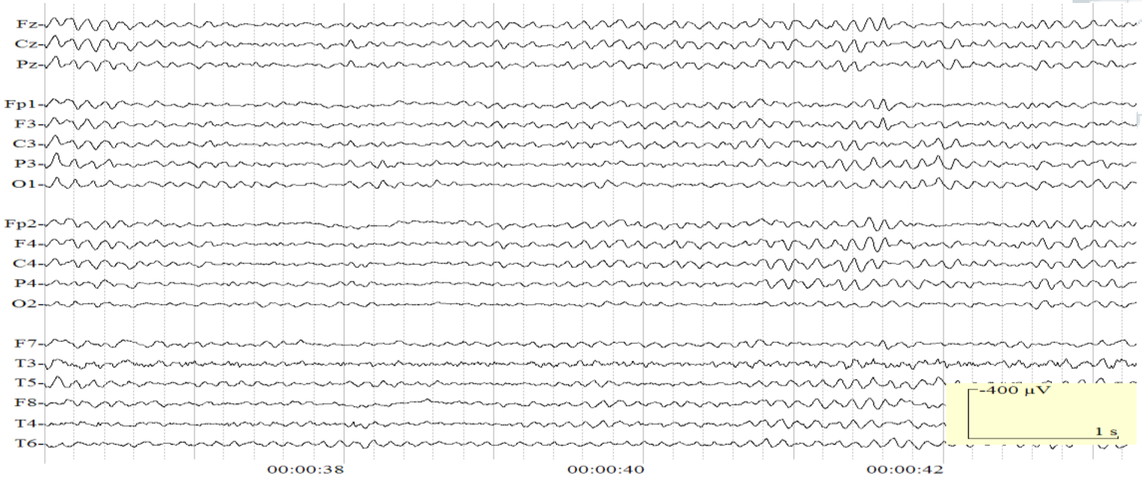
Movement



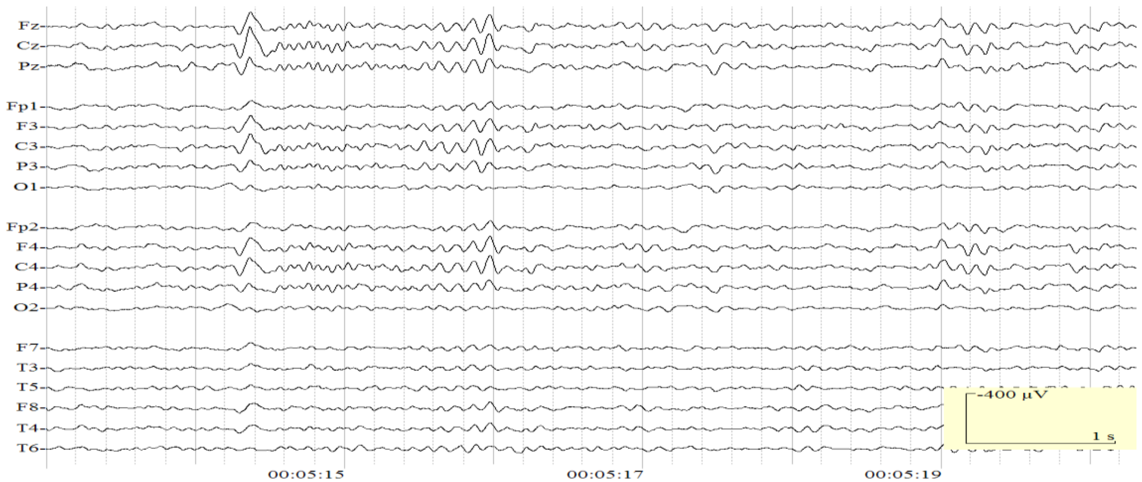
Fp1
Fp2
F3
F4
C3
C4
P3
P4
O1
O2
F7
F8
T3
T4
T5
T6
Fz
Cz
Pz
Oz
EkgL
EkgR
VeogL
VeogR
HeogL
HeogR
movement
-400 µV
1 s
00:05:59
00:06:01
00:06:03
00:06:05

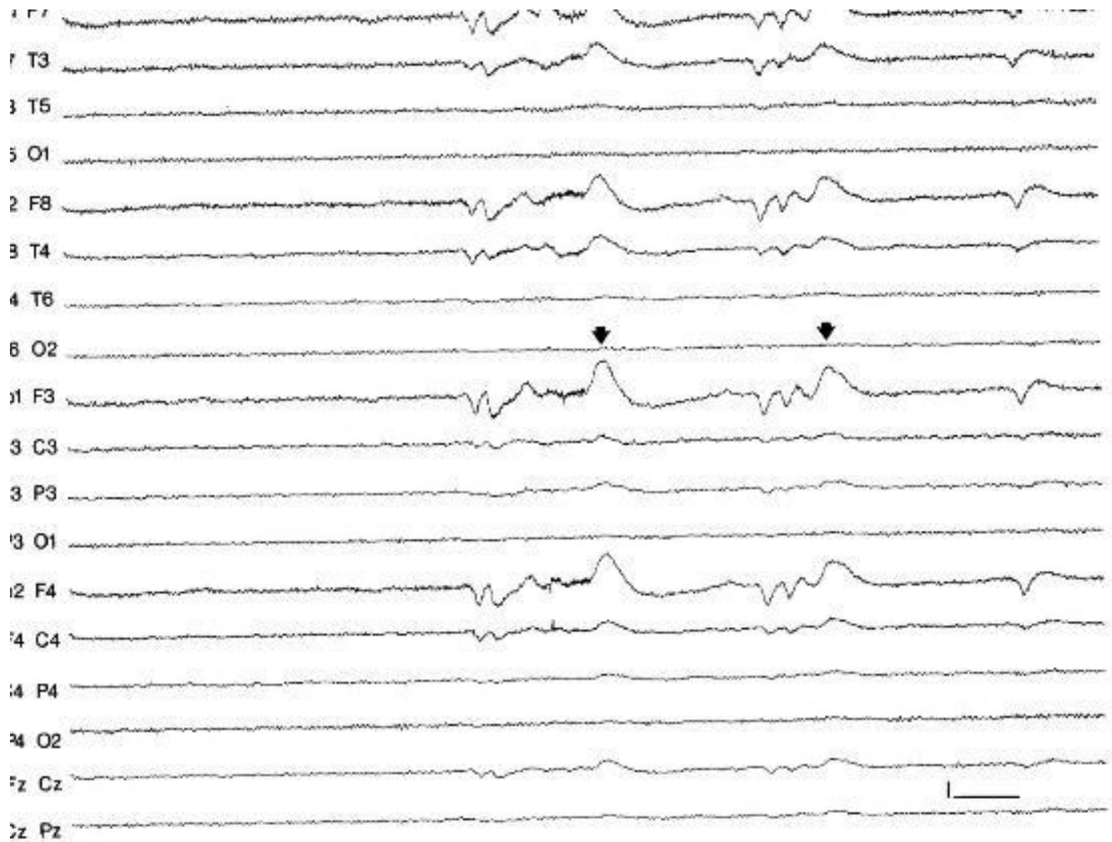
Drowsy states

Resting



Stage 2 sleep





gure A6.2. Eye-movement artifact. These artifacts may have nplitudes greater than 100 µV, as is the case with those marked / the arrows. They are readily identified by their anterior-osterior distribution; amplitude is highest in the derivations ontaining the frontal pole electrodes and diminishes as the elec-odes move backward. At times, the artifacts can be quite rhyth-iic and may be mistaken for FIRDA. Any doubts are resolved by attaching an electrode to the cheek below the eye and recording between this and the ipsilateral ear lobe. This derivation will show waves that are out of phase with the deflections in question if they are indeed eye-movement artifacts. Filters: low frequency = 1 Hz, high frequency = 70 Hz. Calibrations: horizontal = 1 second, vertical = 50 µV.

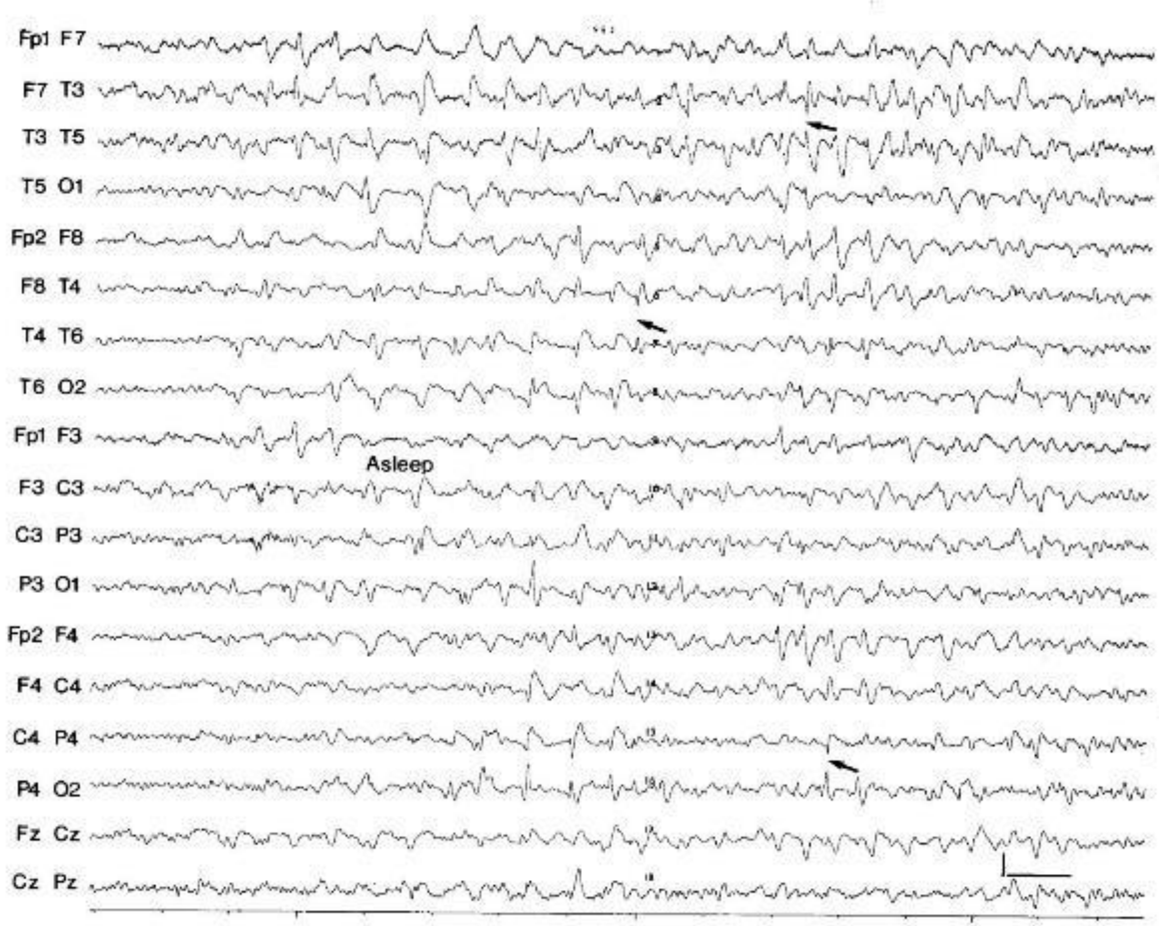
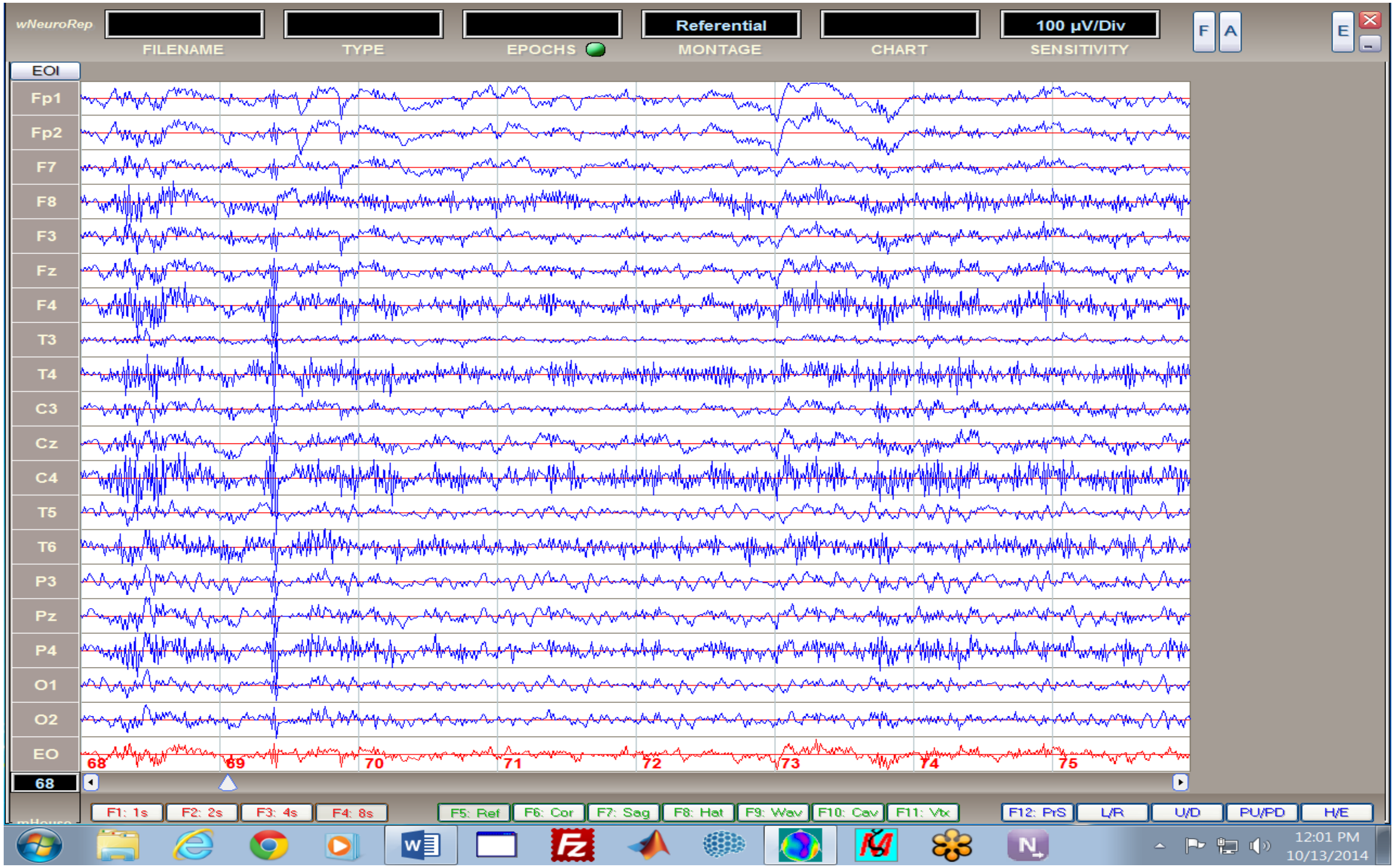
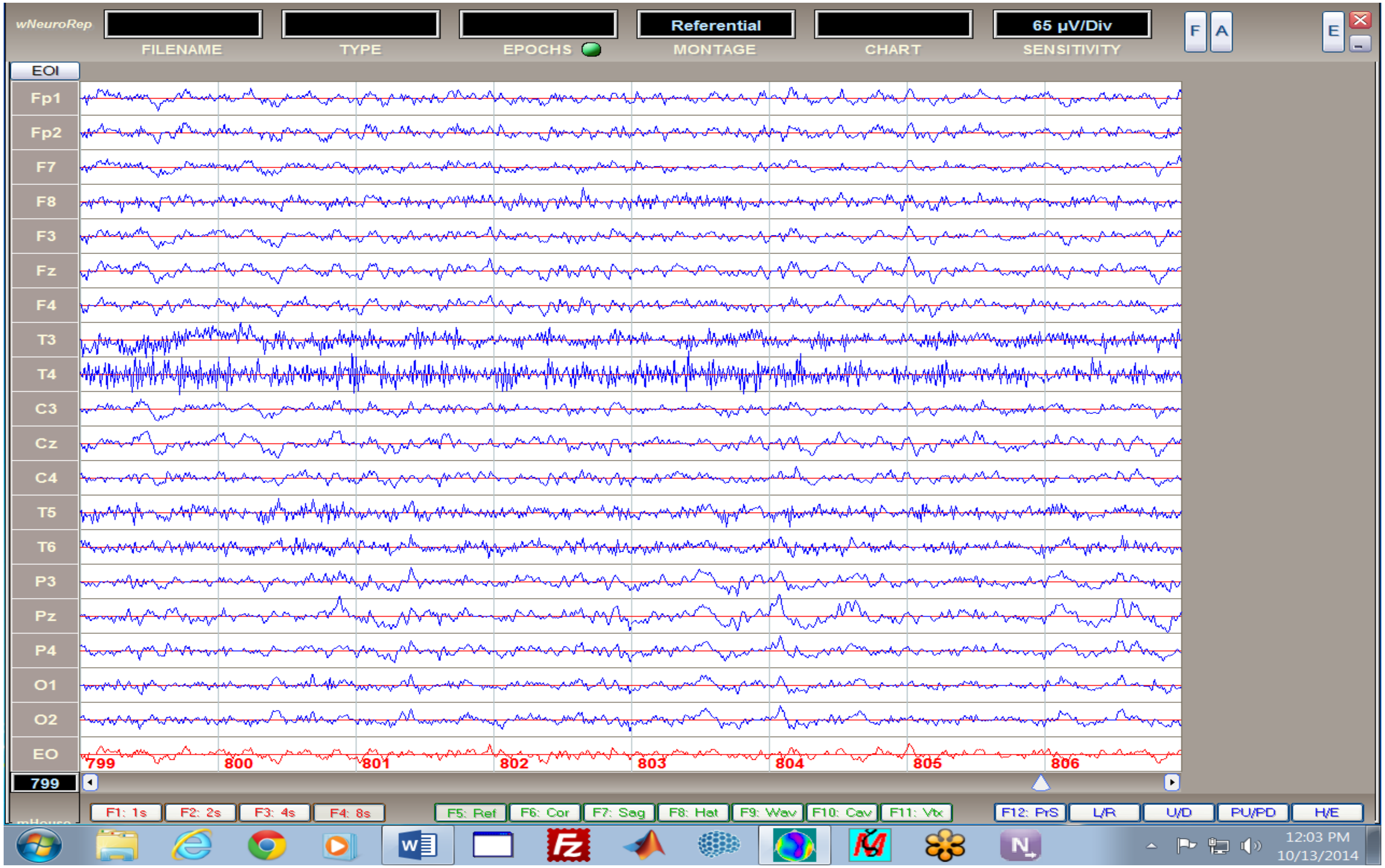


Figure 15.27. Multifocal spike discharges in an 8-year-old, mentally subnormal girl with a history of tonic-clonic as well as myoclonic seizures that were poorly controlled with anticonvul multifocally from either side. Filters: low frequency = 1 Hz, high frequency = 70 Hz. Calibrations: horizontal = 1 second, vertical = 100 μV

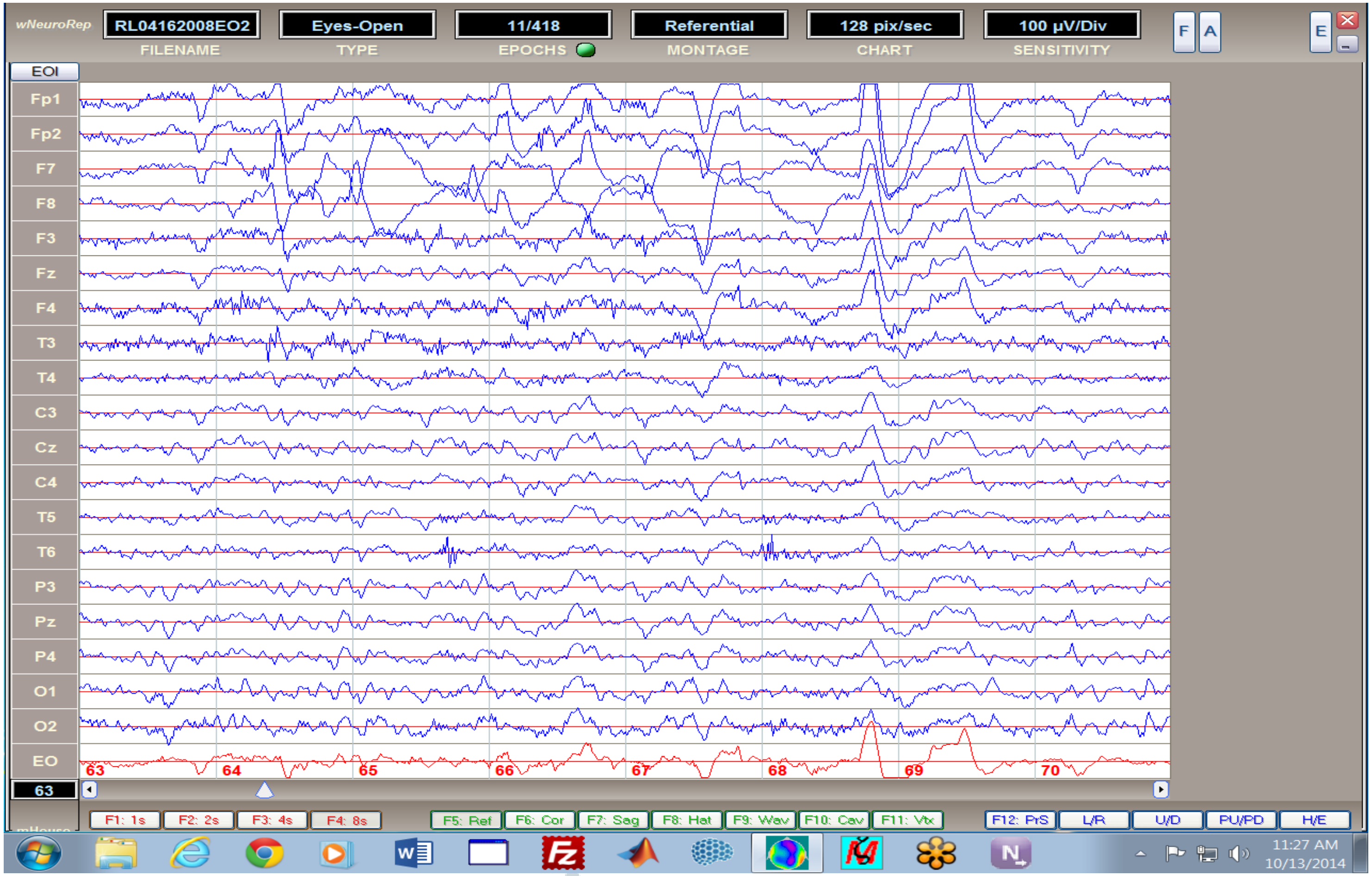
EMG artifact



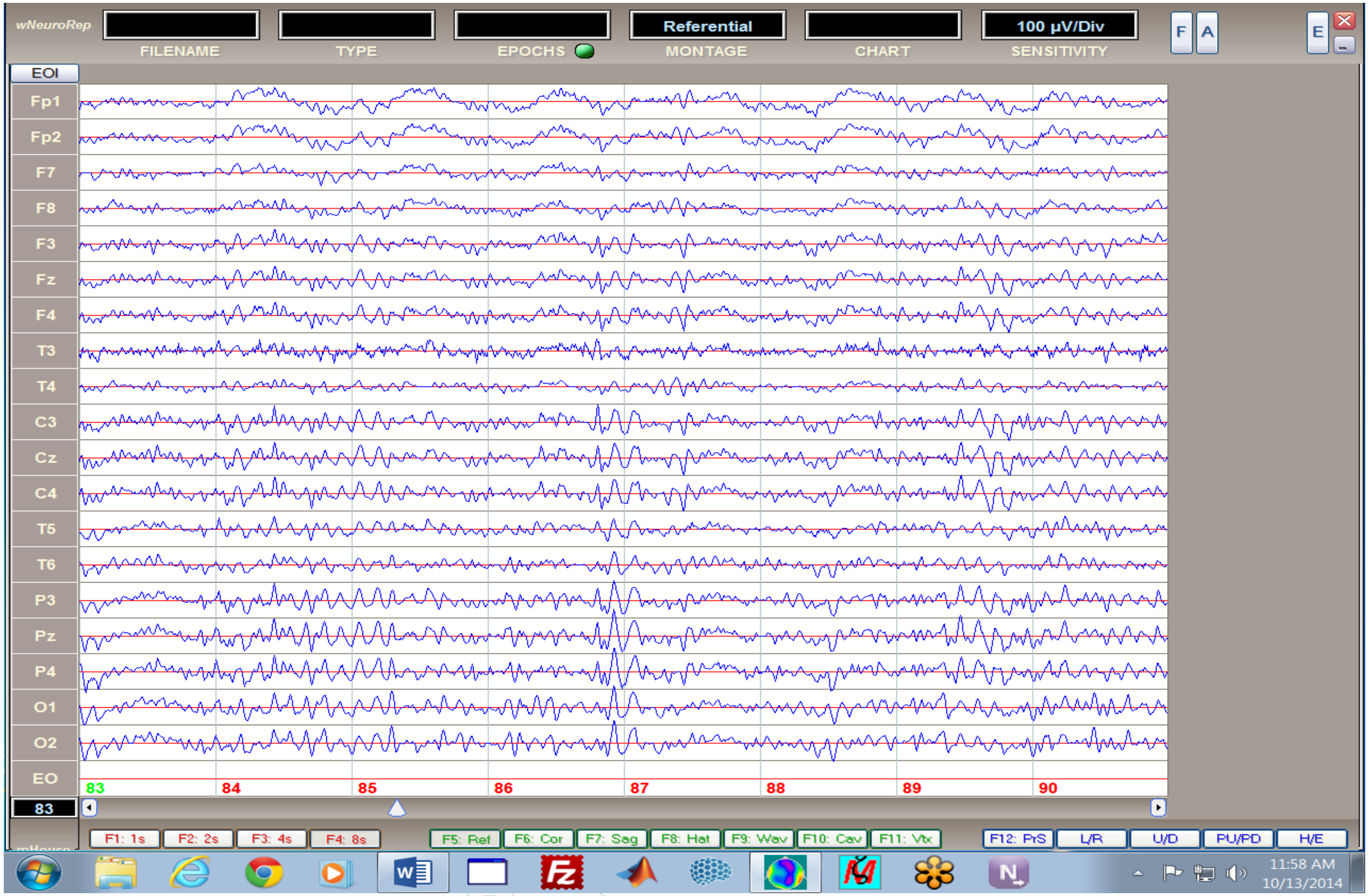
Temporal EMG



Ocular Artifact



Eye Rolling



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Referential
100 µV/Div
FILENAME
TYPE
EPOCHS
MONTAGE
CHART
SENSITIVITY
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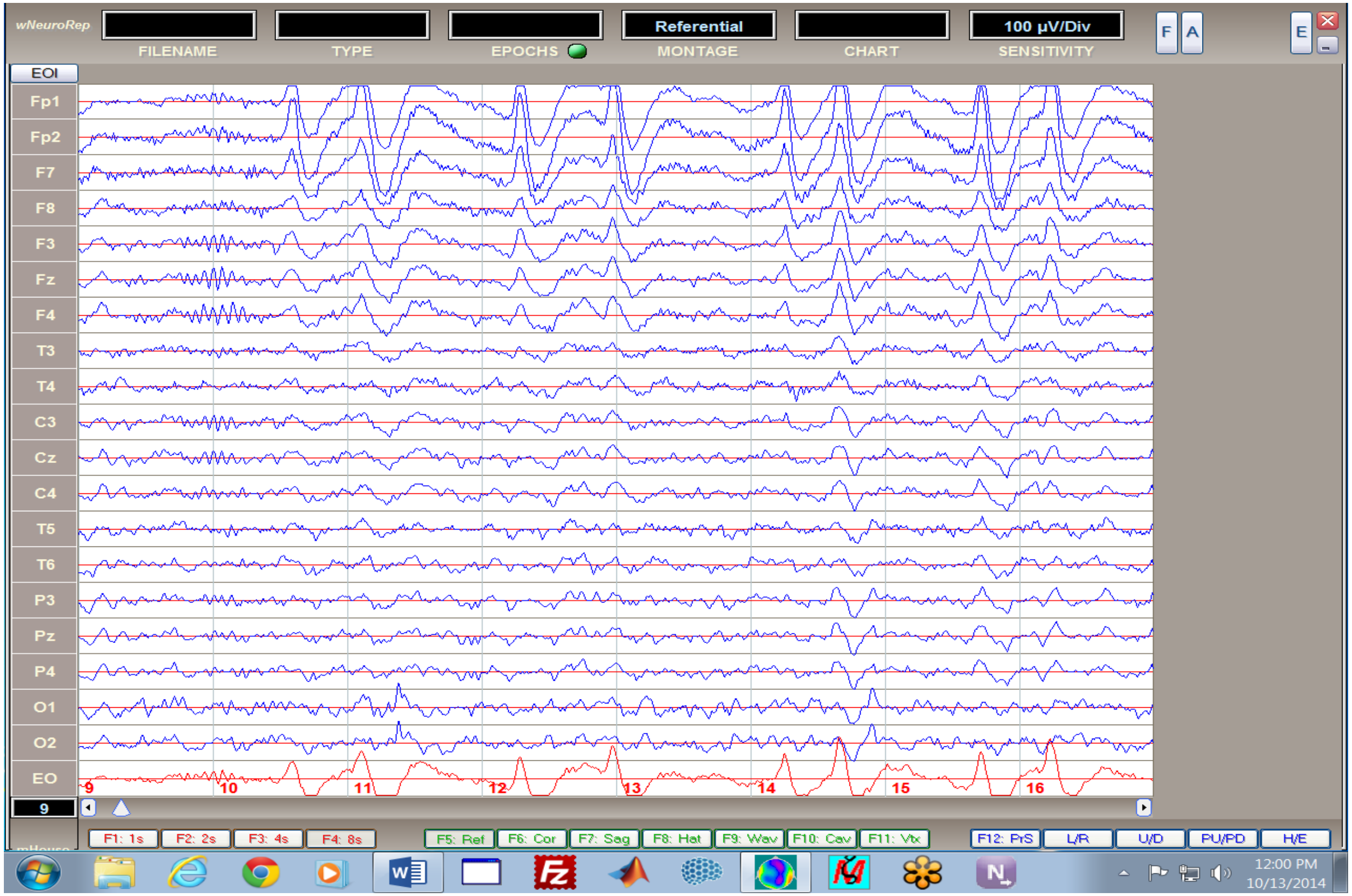
A
E
EOI
Fp1
Fp2
F7
F8
F3
Fz
F4
T3
T4
C3
Cz
C4
T5
T6
P3
Pz
P4
O1
O2
EO
83
84
85
86
87
88
89
90
F1: 1s
F2: 2s
F3: 4s
F4: 8s
F5: Ref
F6: Cor
F7: Sag
F8: Hat
F9: Wav
F10: Cav
F11: Vtx
F12: PrS
L/R
U/D
PU/PD
H/E
11:58 AM
10/13/2014

Eye Blinks



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MONTAGE
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C3
Cz
C4
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T6
P3
Pz
P4
O1
O2
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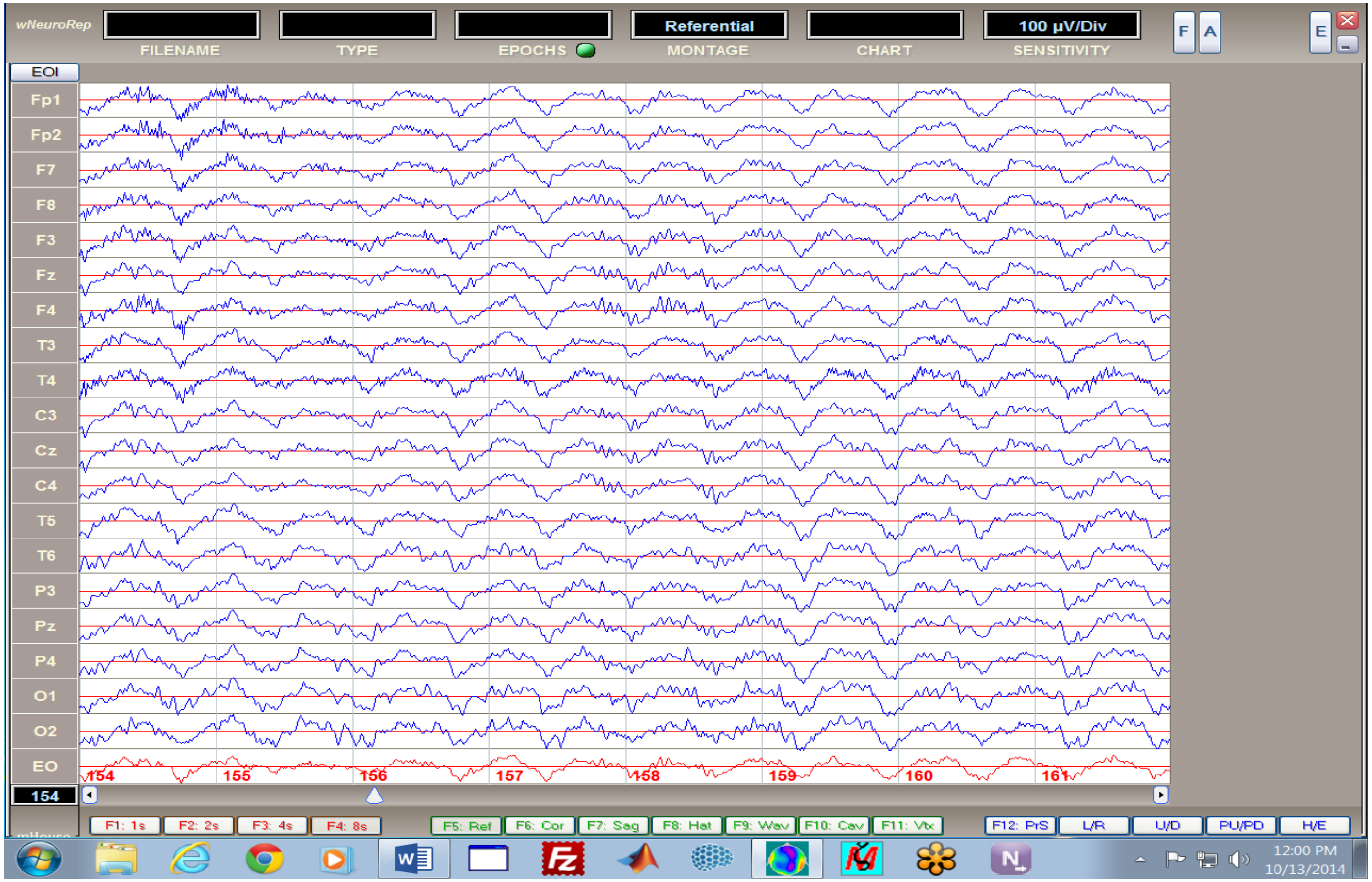
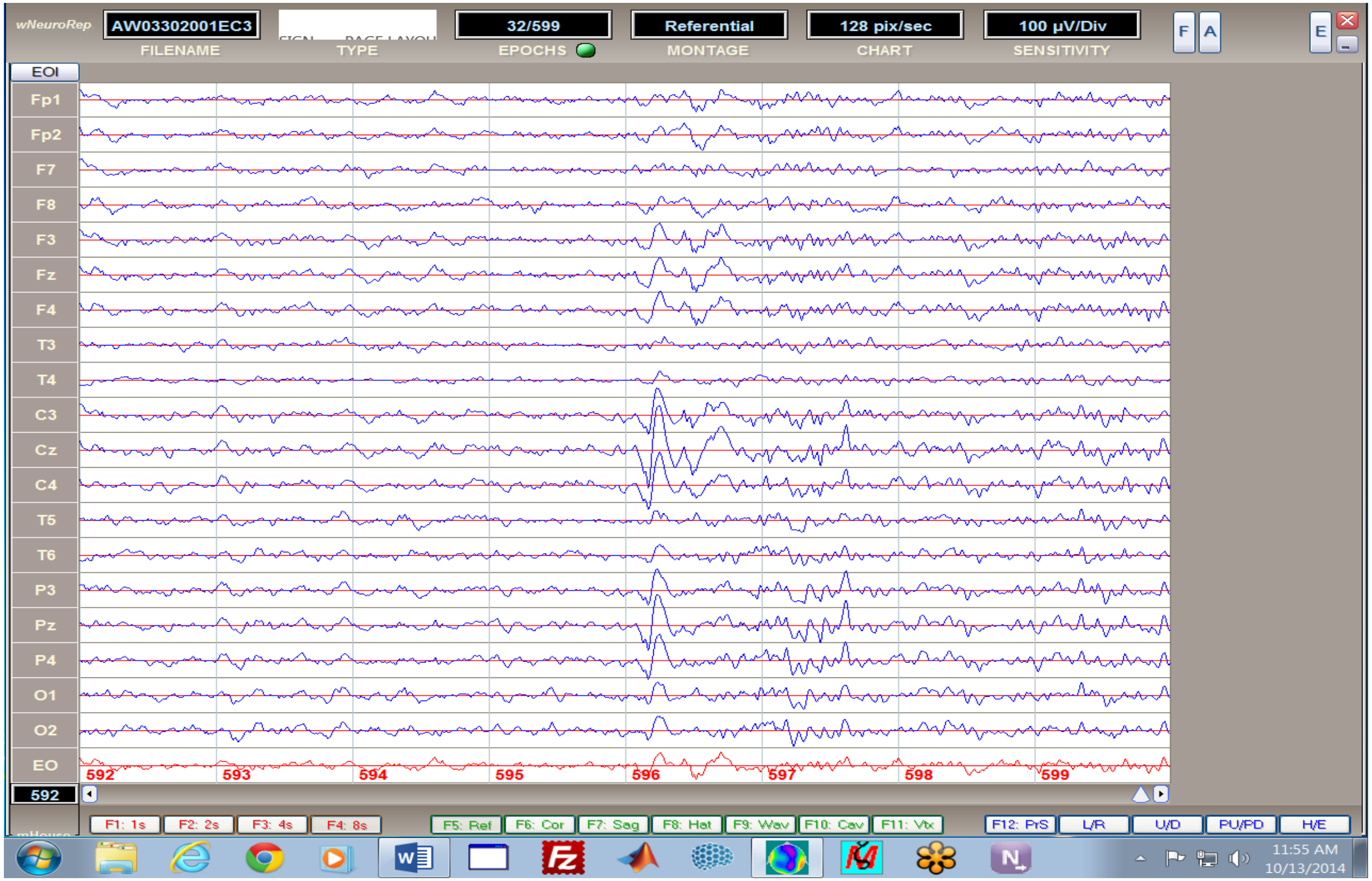
13
14
15
16
F1: 1s
F2: 2s
F3: 4s
F4: 8s
F5: Ref
F6: Cor
F7: Sag
F8: Hat
F9: Wav
F10: Cav
F11: Vtx
F12: PrS
L/R
U/D
PU/PD
H/E
12:00 PM
10/13/2014

Eye Movement +



Sleep



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Fp2
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F8
F3
Fz
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T3
T4
C3
Cz
C4
T5
T6
P3
Pz
P4
O1
O2
EO
592
593
594
595
596
597
598
599
F1: 1s
F2: 2s
F3: 4s
F4: 8s
F5: Ref
F6: Cor
F7: Sag
F8: Hat
F9: Wav
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F12: PrS
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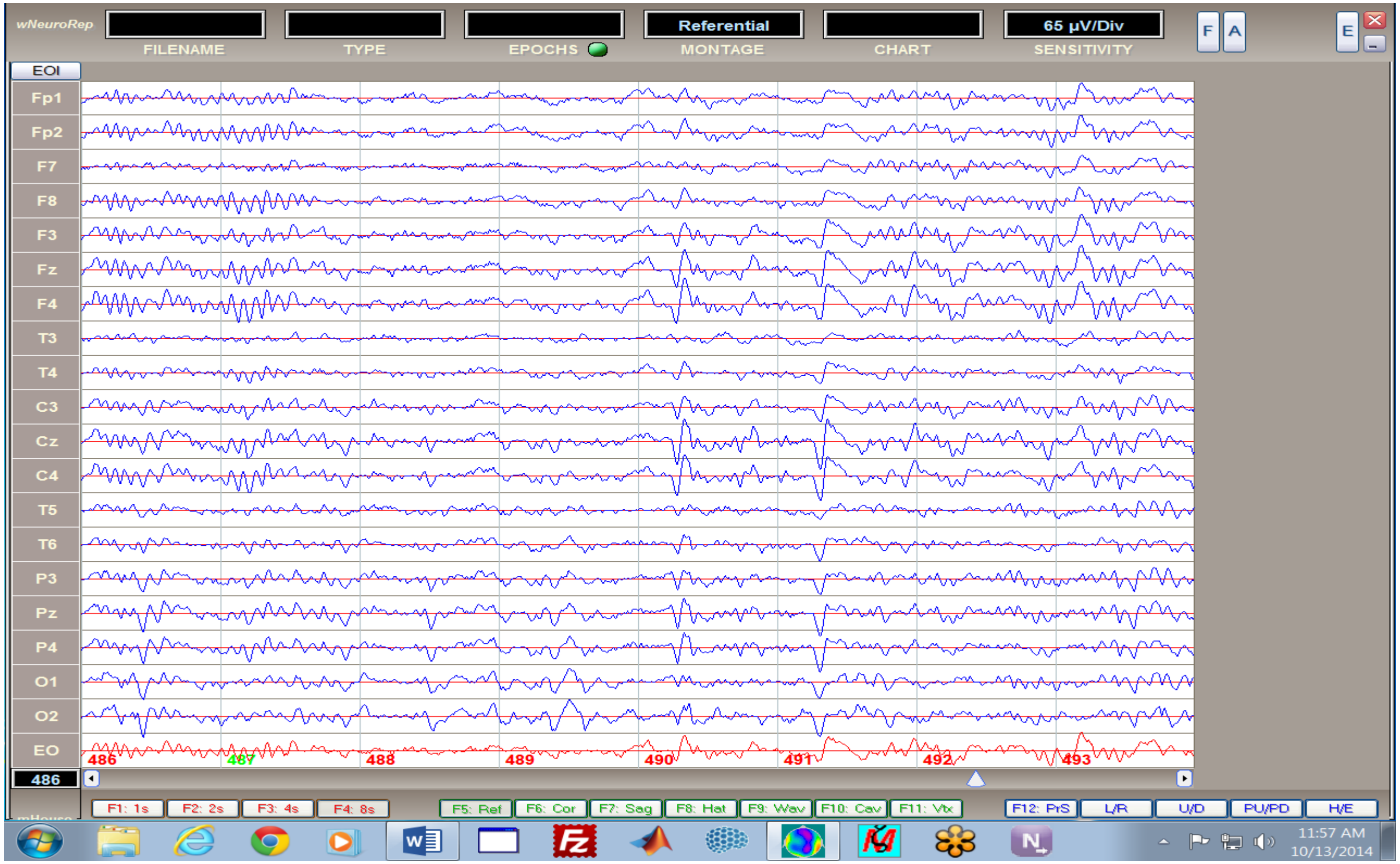
10/13/2014

Sleep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P4
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EO
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487
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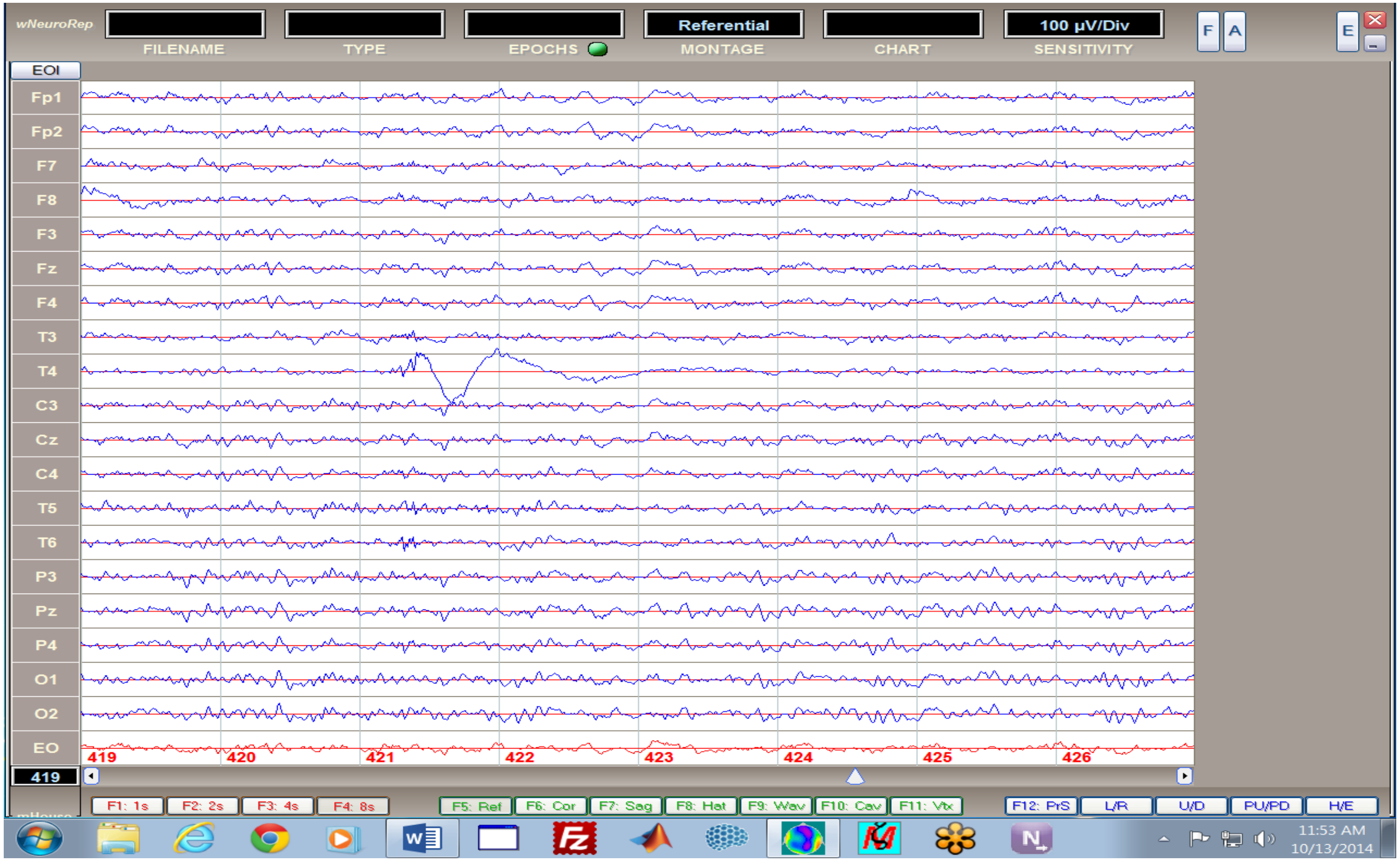
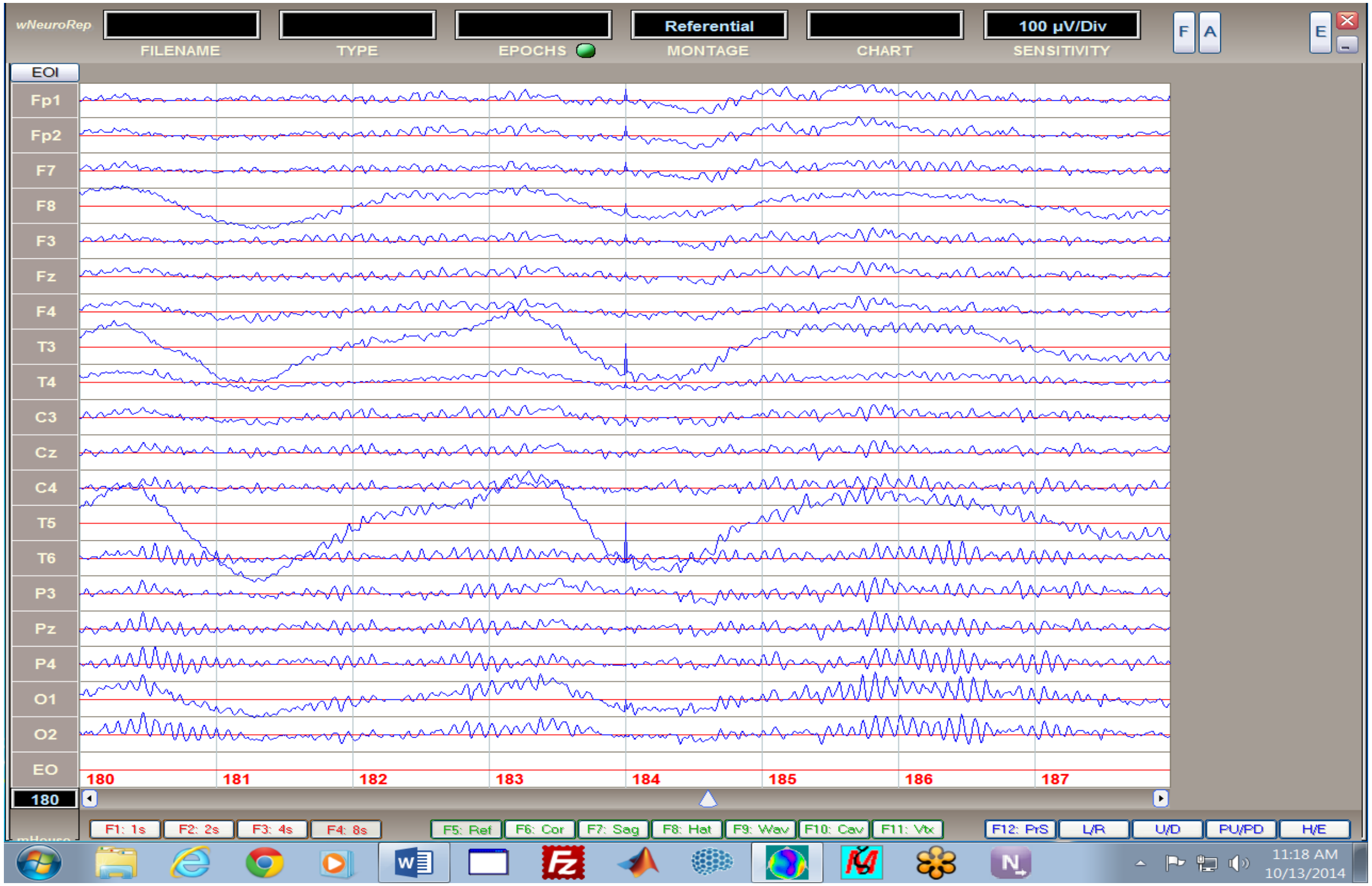
486
F1: 1s
F2: 2s
F3: 4s
F4: 8s
F5: Ref
F6: Cor
F7: Sag
F8: Hat
F9: Wav
F10: Cav
F11: Vtx
F12: PrS
L/R
U/D
PU/PD
H/E
11:57 AM
10/13/2014

Electrode Artifact



Delta Drift



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TYPE
EPOCHS
Referential
MONTAGE
CHART
100 µV/Div
SENSITIVITY
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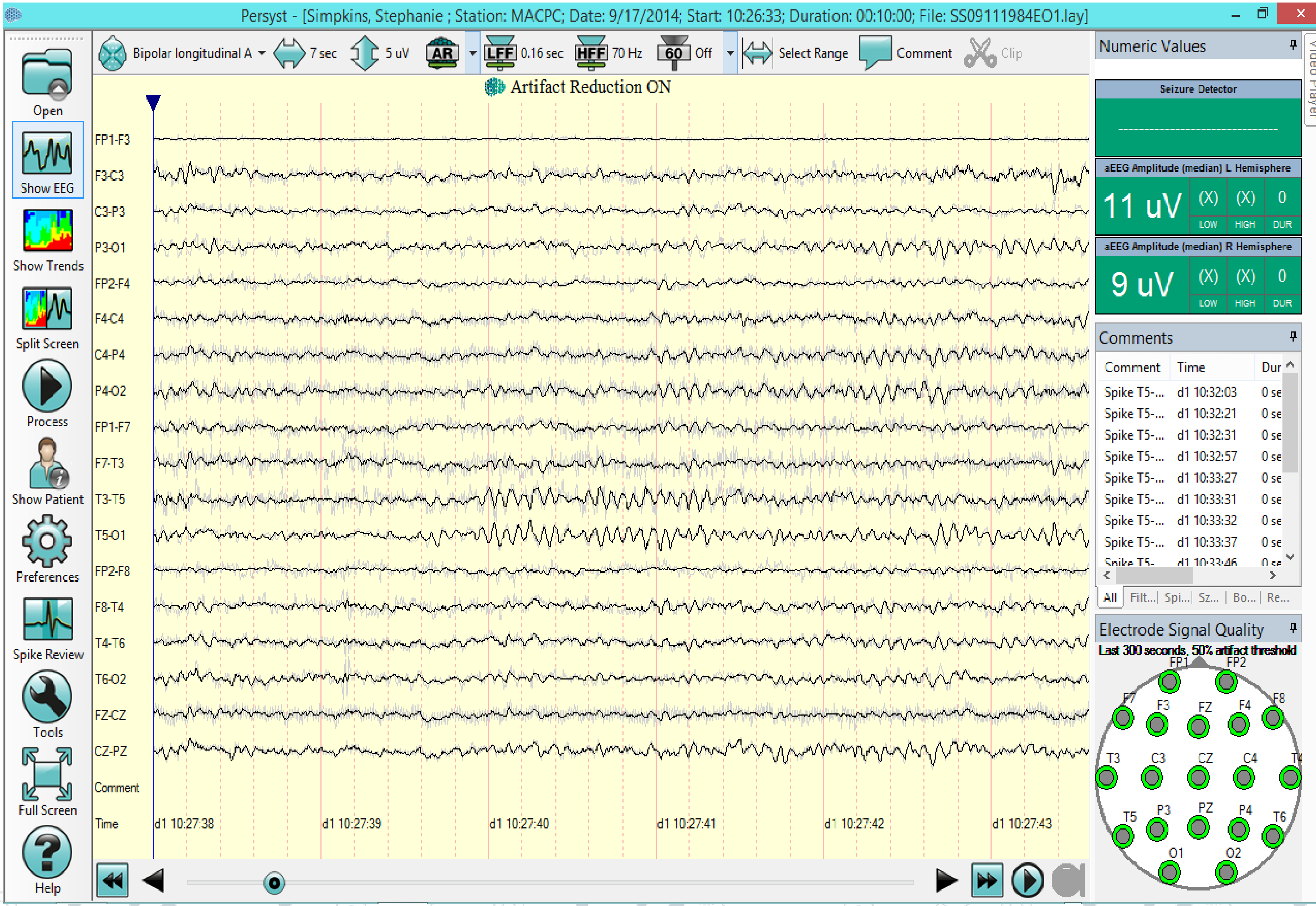
Fp2
F7
F8
F3
Fz
F4
T3
T4
C3
Cz
C4
T5
T6
P3
Pz
P4
O1
O2
EO
180
181
182
183
184
185
186
187
F1: 1s
F2: 2s
F3: 4s
F4: 8s
F5: Ref
F6: Cor
F7: Sag
F8: Hat
F9: Wav
F10: Cav
F11: Vtx
F12: PrS
L/R
U/D
PU/PD
H/E
11:18 AM
10/13/2014

Cardiac Artifact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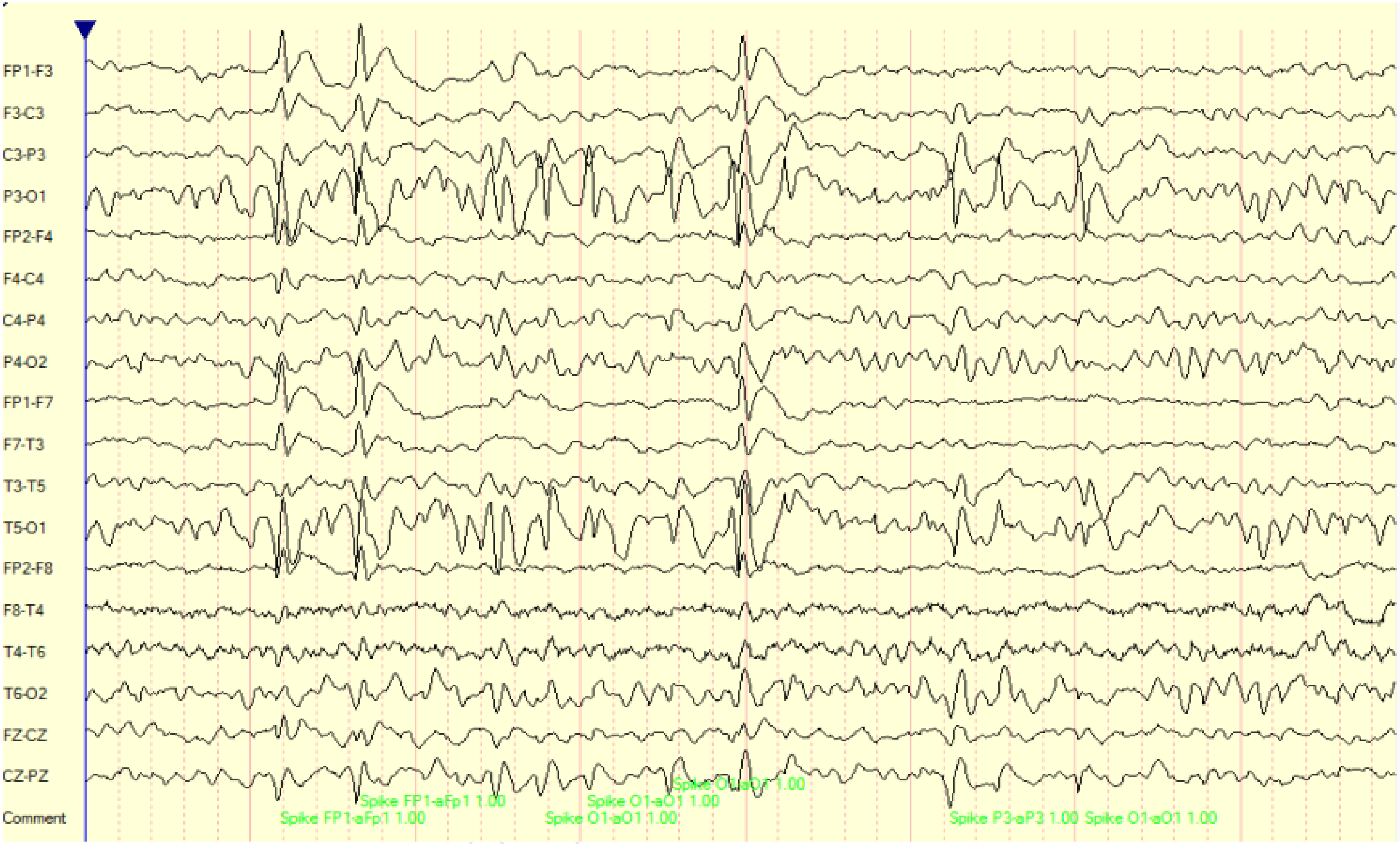
Show EEG
Show Trends
Split Screen
Process
Show Patient
Preferences
Spike Review
Tools
Full Screen
Help
Bipolar longitudinal A
7 sec
5 uV
AR
LFF 0.16 sec
HFF 70 Hz
60 Off
Select Range
Comment
Clip
Artifact Reduction ON
FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
FZ-CZ
CZ-PZ
Comment
Time
d1 10:27:38
d1 10:27:39
d1 10:27:40
d1 10:27:41
d1 10:27:42
d1 10:27:43
Numeric Values
Video Player
Seizure Detector
aEEG Amplitude (median) L Hemisphere
11 uV (X) (X) 0
LOW HIGH DUR
aEEG Amplitude (median) R Hemisphere
9 uV (X) (X) 0
LOW HIGH DUR
Comments
Comment Time Dur
Spike T5-... d1 10:32:03 0 se
Spike T5-... d1 10:32:21 0 se
Spike T5-... d1 10:32:31 0 se
Spike T5-... d1 10:32:57 0 se
Spike T5-... d1 10:33:27 0 se
Spike T5-... d1 10:33:31 0 se
Spike T5-... d1 10:33:32 0 se
Spike T5-... d1 10:33:37 0 se
All Filt... Spi... Sz... Bo... Re...
Electrode Signal Quality
Last 300 seconds, 50% artifact threshold
FP1 FP2
F7 F3 FZ F4 F8
T3 C3 CZ C4
T5 P3 PZ P4 T6
O1 O2

The Importance of Understanding the Raw EEG

- It all boils down to the squiggly lines.
- If it's not in the EEG then the maps can't be right.
- Must be able to tell the difference between artifacts and real EEG.
- QEEG is an average metric of what is in the EEG. Averaging can miss important details contained in the extremes.
- Seizure/subclinical spike and wave discharges.
- Other EEG oscillations.

EEG Oscillations


FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
FZ-CZ
CZ-PZ
Comment
Spike FP1-aFp1 1.00
Spike FP1-aFp1 1.00
Spike O1-aO1 1.00
Spike O1-aO1 1.00
Spike O1-aO1 1.00
Spike P3-aP3 1.00
Spike O1-aO1 1.00

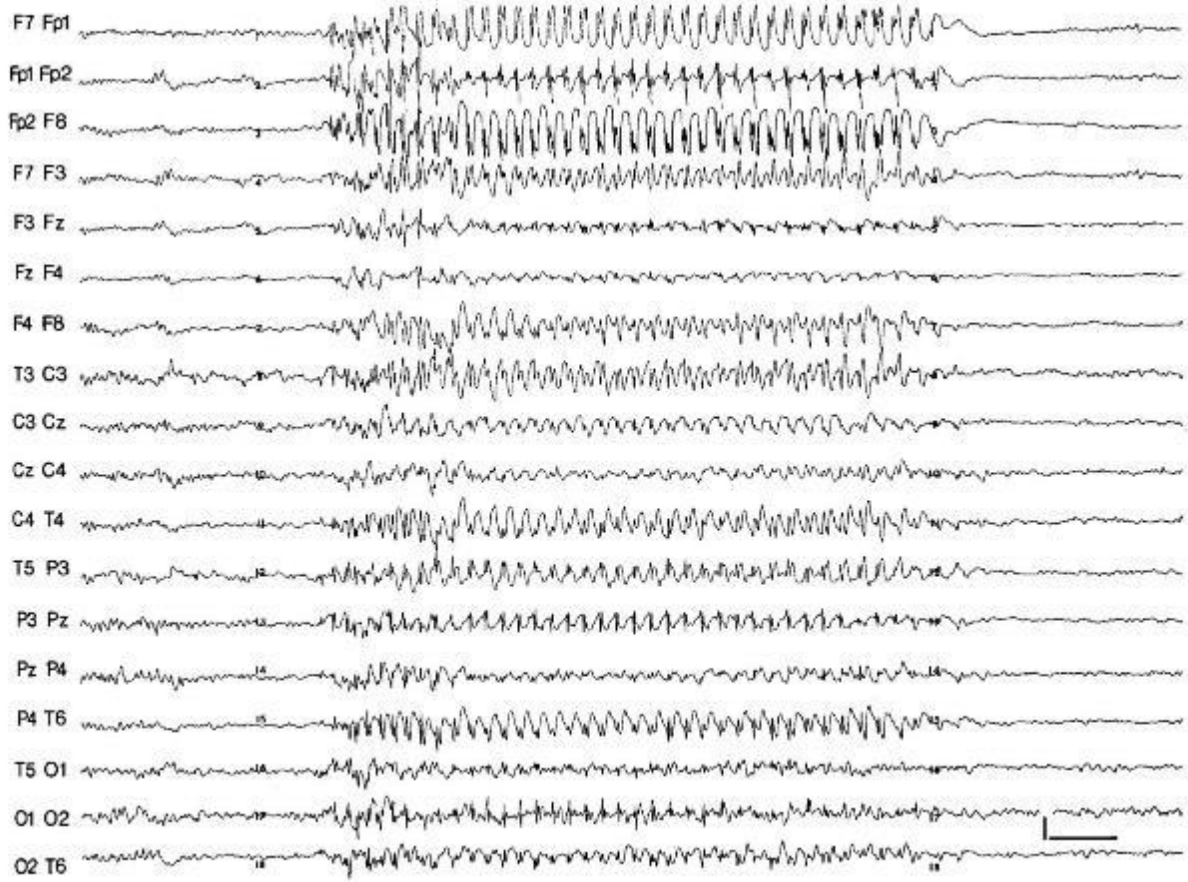
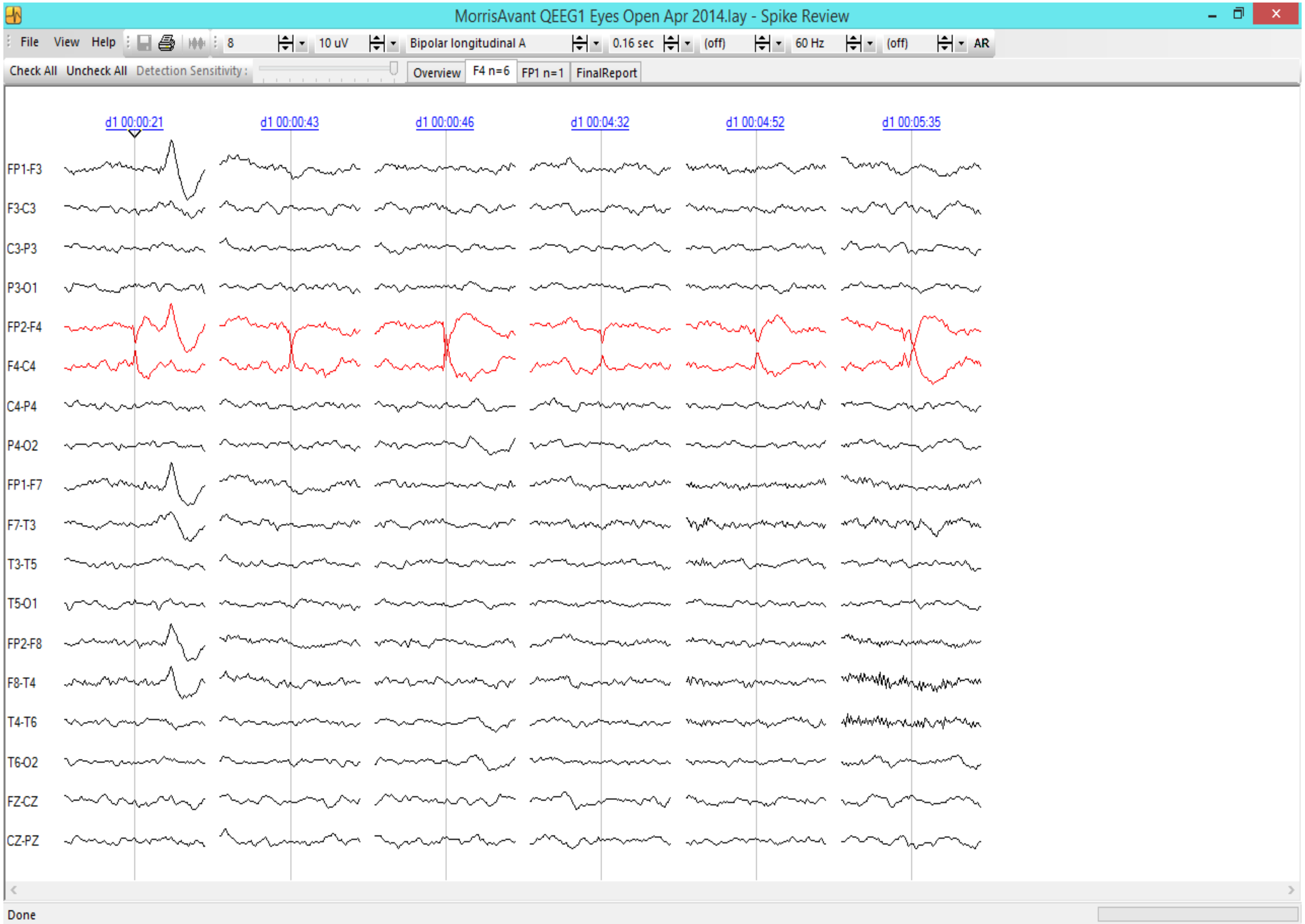


Figure 15.28. Three per second spike and wave discharges typical of absence in a 10-year-old boy with staring spells. The generalized bisynchronous, frontally dominant spike and slow-wave complexes occur at a frequency of about 3.5 to 4 Hz. The patient was unresponsive during this period. Filters: low frequency = 1 Hz, high frequency = 70 Hz. Calibrations: horizontal = 1 second, vertical = 150 µV.


MorrisAvant QEEG1 Eyes Open Apr 2014.lay - Spike Review
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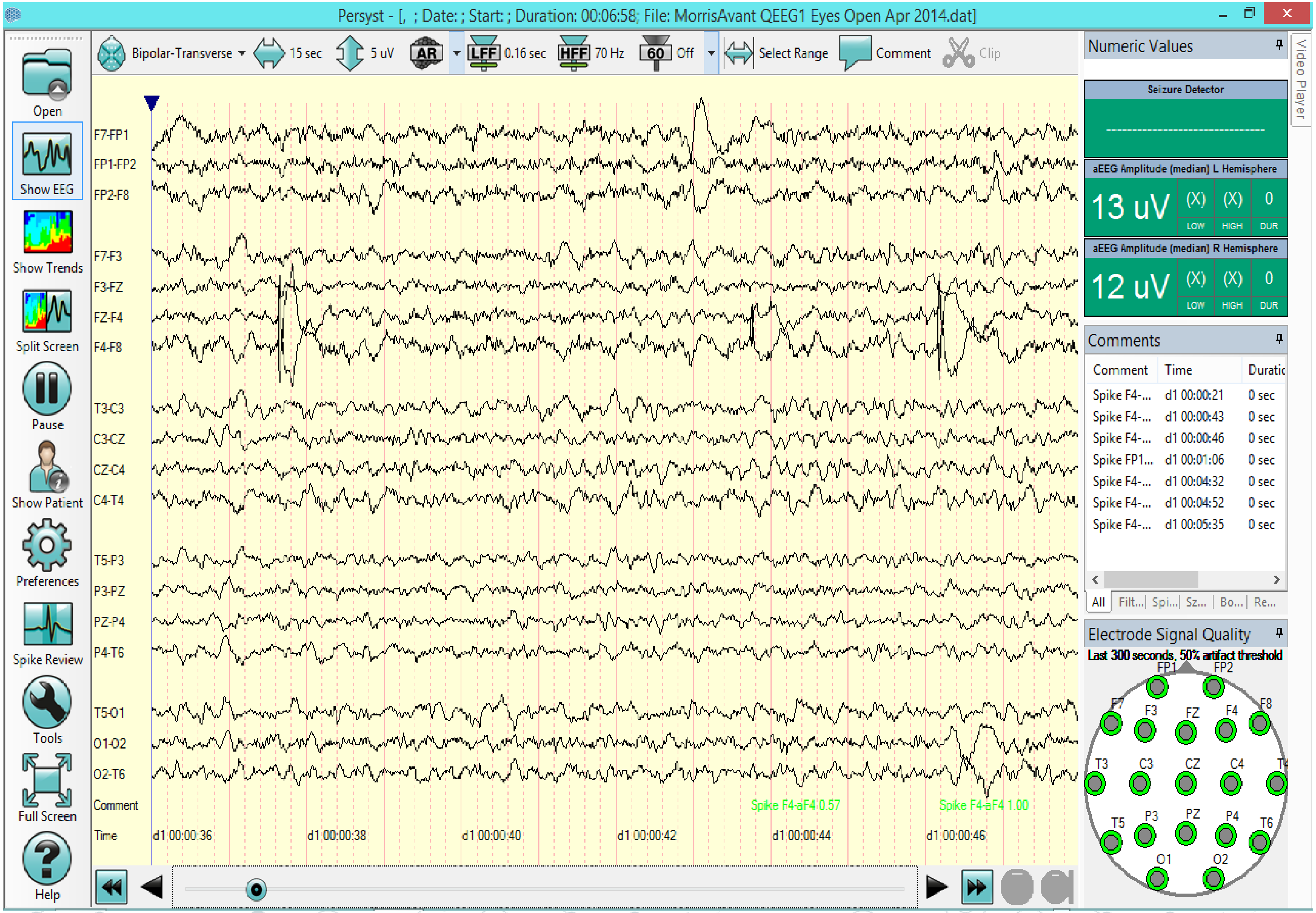
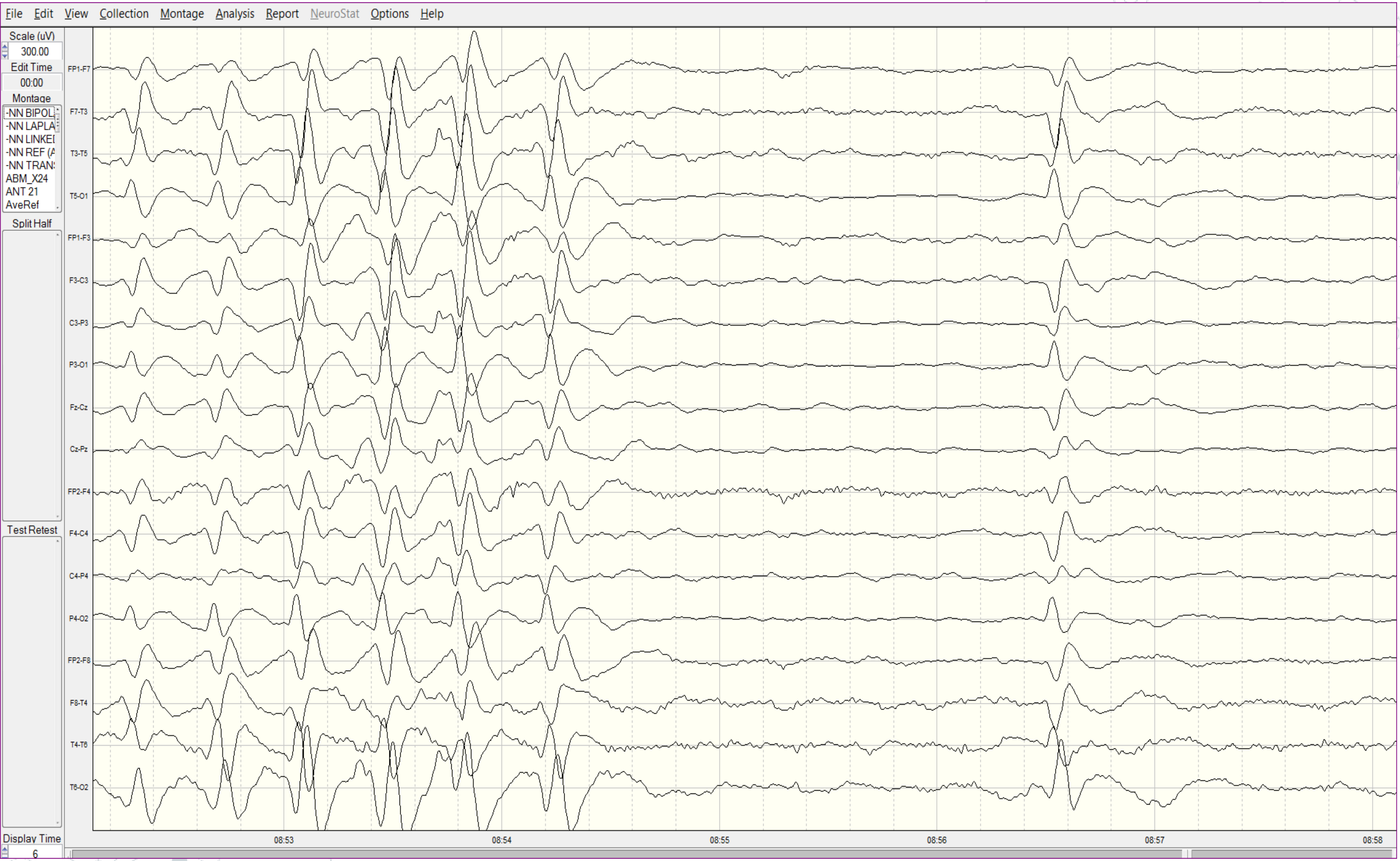
8
10 uV
Bipolar longitudinal A
0.16 sec
(off)
60 Hz
(off)
AR
Check All Uncheck All Detection Sensitivity :
Overview
F4 n=6
FP1 n=1
FinalReport
d1 00:00:21
d1 00:00:43
d1 00:00:46
d1 00:04:32
d1 00:04:52
d1 00:05:35
FP1-F3
F3-C3
C3-P3
P3-O1
FP2-F4
F4-C4
C4-P4
P4-O2
FP1-F7
F7-T3
T3-T5
T5-O1
FP2-F8
F8-T4
T4-T6
T6-O2
FZ-CZ
CZ-PZ
Done


Persyst - [, ; Date: ; Start: ; Duration: 00:06:58; File: MorrisAvant QEEG1 Eyes Open Apr 2014.dat]
Open
Show EEG
Show Trends
Split Screen
Pause
Show Patient
Preferences
Spike Review
Tools
Full Screen
Help
Bipolar-Transverse
15 sec
5 uV
AR
LFF 0.16 sec
HFF 70 Hz
60 Off
Select Range
Comment
Clip
F7-FP1
FP1-FP2
FP2-F8
F7-F3
F3-FZ
FZ-F4
F4-F8
T3-C3
C3-CZ
CZ-C4
C4-T4
T5-P3
P3-PZ
PZ-P4
P4-T6
T5-O1
O1-O2
O2-T6
Comment
Time
Spike F4-aF4 0.57
Spike F4-aF4 1.00
d1 00:00:36
d1 00:00:38
d1 00:00:40
d1 00:00:42
d1 00:00:44
d1 00:00:46
Numeric Values
Video Player
Seizure Detector
aEEG Amplitude (median) L Hemisphere
13 uV
(X) (X) 0
LOW HIGH DUR
aEEG Amplitude (median) R Hemisphere
12 uV
(X) (X) 0
LOW HIGH DUR
Comments
Comment Time Duratic
Spike F4-... d1 00:00:21 0 sec
Spike F4-... d1 00:00:43 0 sec
Spike F4-... d1 00:00:46 0 sec
Spike FP1... d1 00:01:06 0 sec
Spike F4-... d1 00:04:32 0 sec
Spike F4-... d1 00:04:52 0 sec
Spike F4-... d1 00:05:35 0 sec
All Filt... Spi... Sz... Bo... Re...
Electrode Signal Quality
Last 300 seconds, 50% artifact threshold
FP1 FP2
F7 F3 FZ F4 F8
T3 C3 CZ C4
T5 P3 PZ P4 T6
O1 O2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View
Collection
Montage
Analysis
Report
NeuroStat
Options
Help
Scale (uV)
300.00
Edit Time
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-NN BIPOL
-NN LAPLA
-NN LINKEI
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AveRef
Split Half
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Display Time
6
FP1-F7
F7-T3
T3-T5
T5-O1
FP1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
FP2-F4
F4-C4
C4-P4
P4-O2
FP2-F8
F8-T4
T4-T6
T6-O2
08:53
08:54
08:55
08:56
08:57
08:58

File
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NeuroStat
Options
Help
Scale (uV)
300.00
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-NN BIPOL
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-NN REF (A
-NN TRAN
ABM_X24
ANT 21
AveRef
Split Half
Test Retest
Display Time
6
FP1-F7
F7-T3
T3-T5
T5-O1
FP1-F3
F3-C3
C3-P3
P3-O1
Fz-Cz
Cz-Pz
FP2-F4
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C4-P4
P4-O2
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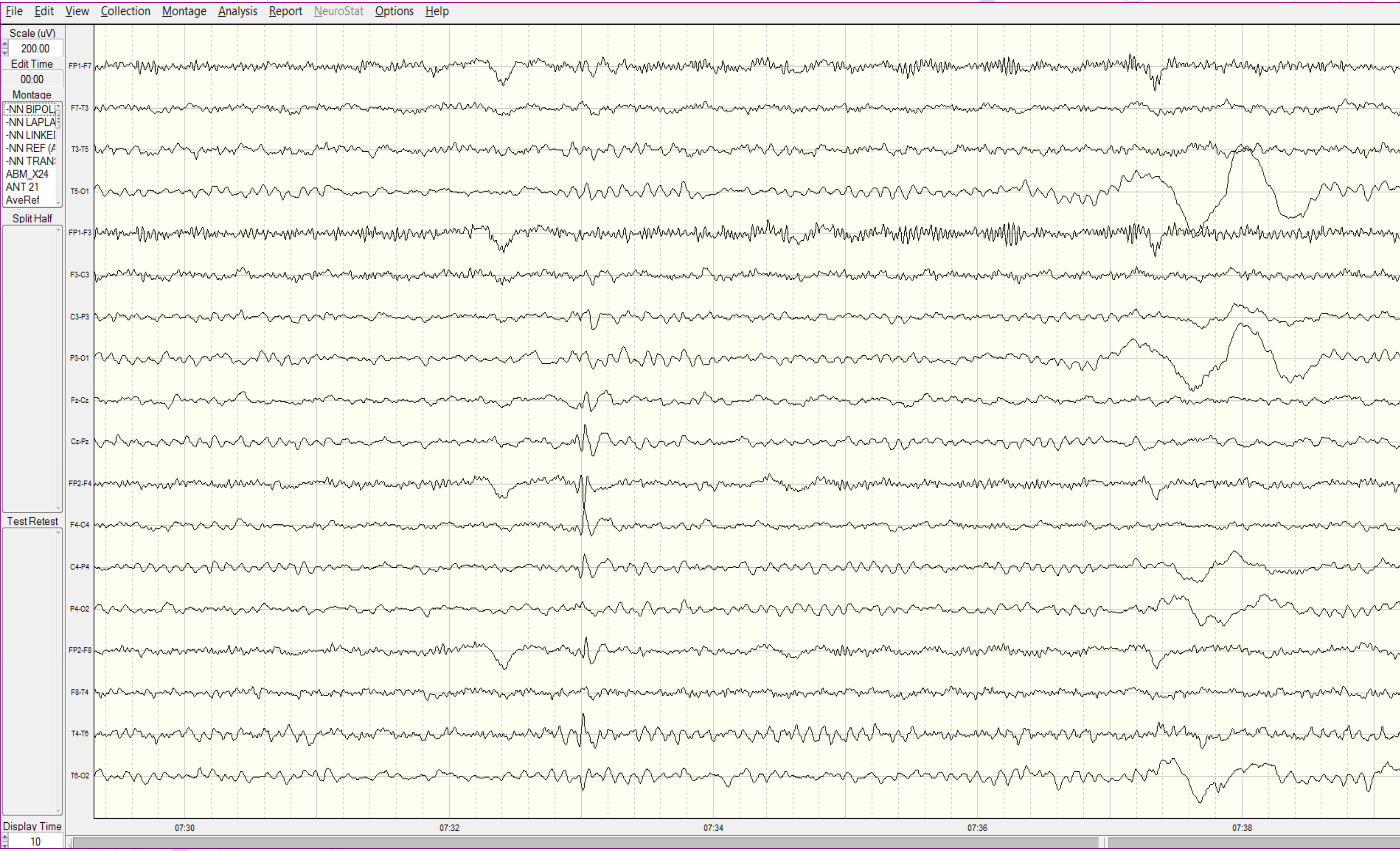
08:36
08:37
08:38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Split Half
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FP1-F7
F7-T3
T3-T5
T5-O1
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F3-C3
C3-P3
P3-O1
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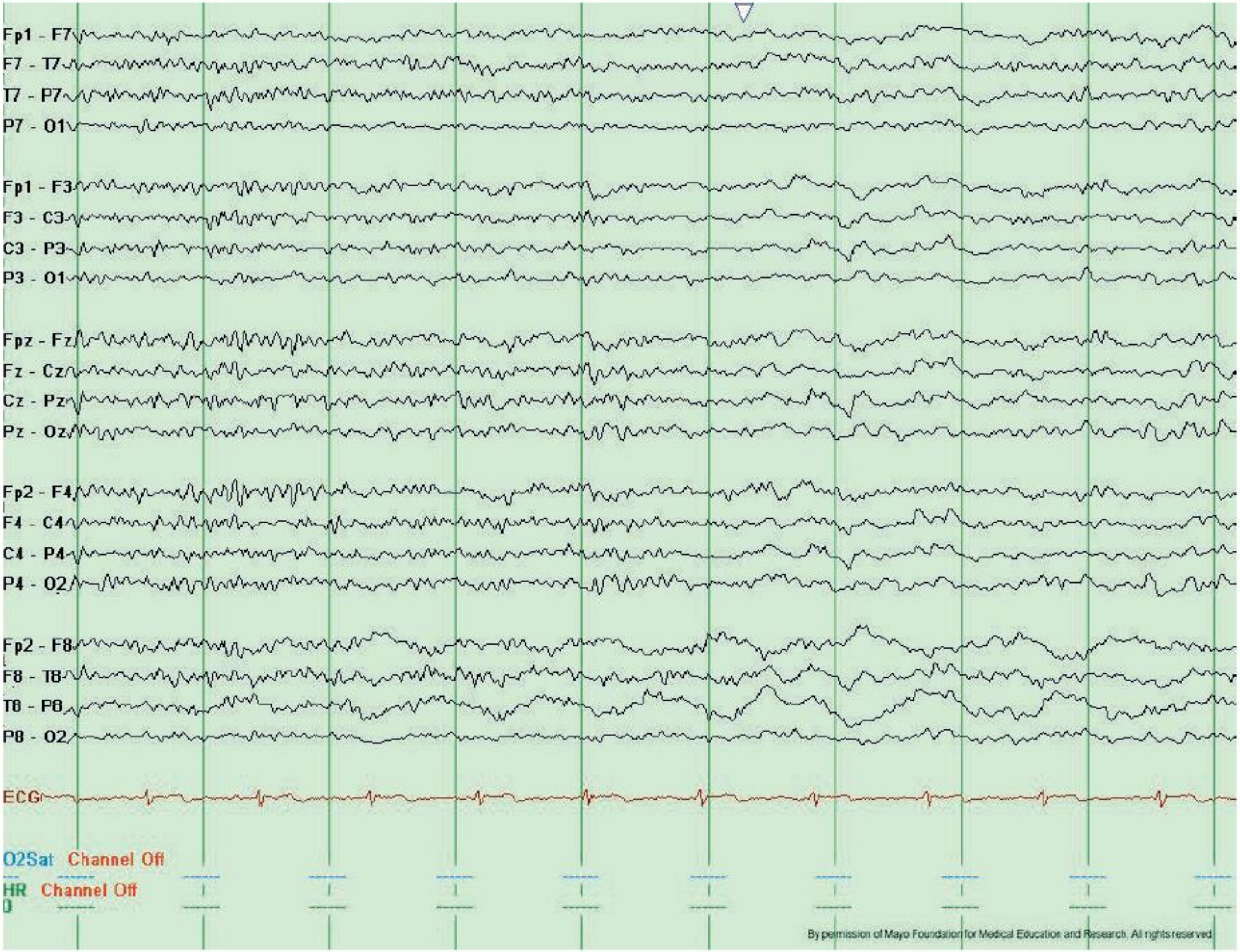


Figure 54. Focal slowing over the right temporal region as the result of a right temporal brain tumor in a 35-year-old man. Note the focal delta frequency slowing in the right temporal region as compared with the homologous normal right temporal region. Longitudinal bipolar montage. Copyright 2013. Mayo Foundation for Medical Education and Research. All rights reserved. Figure courtesy of Jeffrey W. Britton, MD.

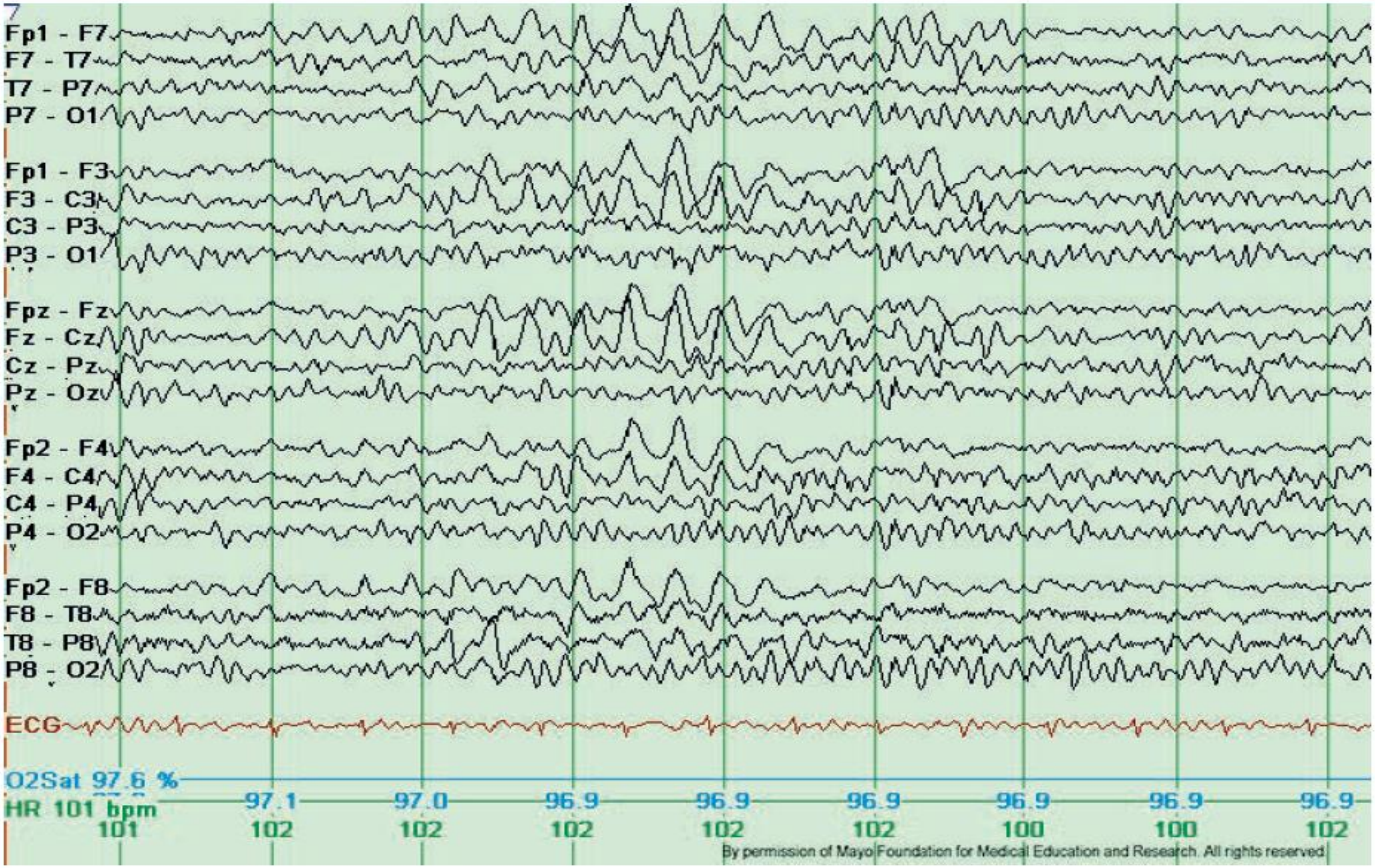
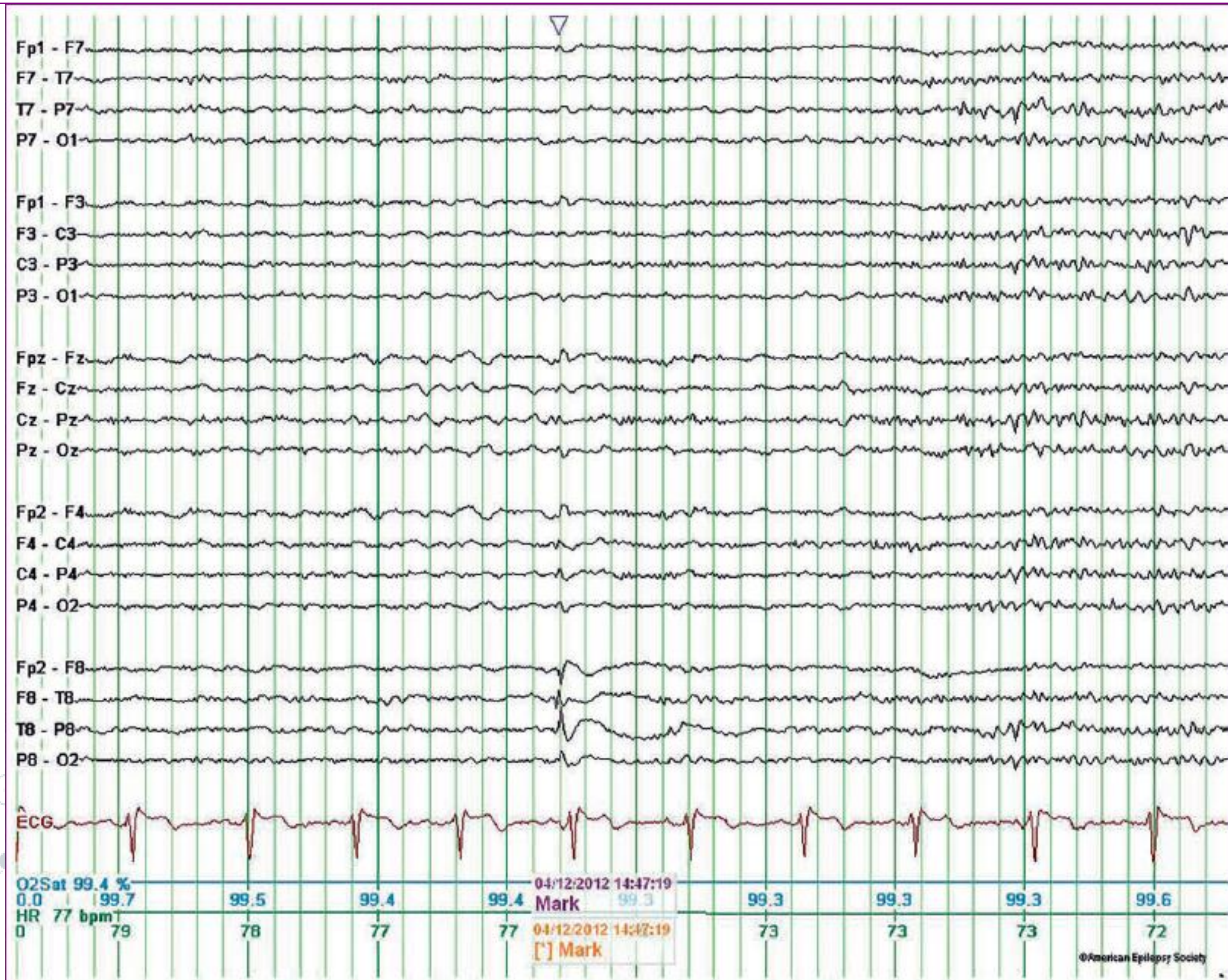


Figure 55. FIRDA pattern with a slightly slower theta EEG background in an elderly man with a metabolic encephalopathy. Periods of well-formed posteriorly dominant alpha activity are still also seen. Longitudinal bipolar montage. Copyright 2013. Mayo Foundation for Medical Education and Research. All rights reserved. Figure courtesy of Jeffrey W. Britton, MD.

Frontal Intermittent Rhythmic Delta Activity (FIRDA)

Figure 62. Right temporal IED in a 32-year-old man with right mesial temporal lobe epilepsy. (a) Channels 17 (FP2-F8) and 18 (F8-T8) show a "phase-reversal" of negativity, allowing localization of the spike discharge as maximally negative at the F8 electrode site (i.e., given maximal negativity at F8 and the conventions of EEG polarity, which state that when the Grid 1 electrode site, FP2 in channel 17, is more positive than the Grid 2 site, F8, the result is a surface positive downward deflection; whereas in channel 18, F8 is more negative than the T8 Grid 2 electrode site, resulting in an upward deflection). Thus, the phase-reversal demonstrates that the F8 electrode site holds maximal negativity and allows localization of the spike focus to that site. (b) Focal/regional slowing appears over the right temporal region, which has a rhythmic character consistent with the pattern known as temporal intermittent rhythmic delta activity (TIRDA), a frequent finding of epileptiform significance in those with temporal lobe epilepsy. Copyright 2013. Mayo Foundation for Medical Education and Research. All rights reserved. Figure courtesy of Erik K. St. Louis, MD.



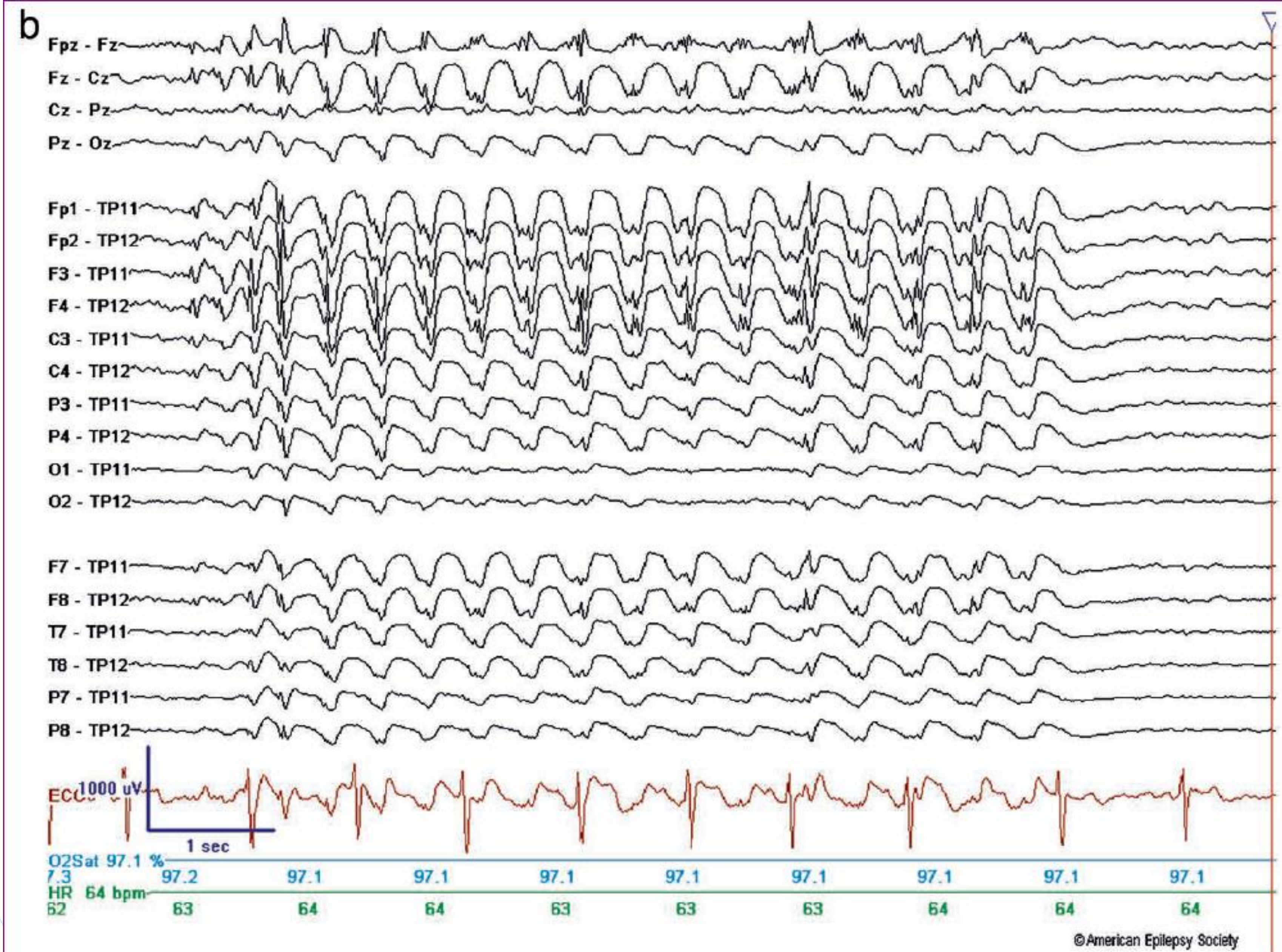


Figure 63. The 3-Hz (typical) generalized spike-wave IED. This IED is most commonly seen in children with CAE. (a) Longitudinal bipolar montage. (b) Ipsilateral ear reference montage. Copyright 2013. Mayo Foundation for Medical Education and Research. All rights reserved. Figure courtesy of Jeffrey W. Britton, MD.

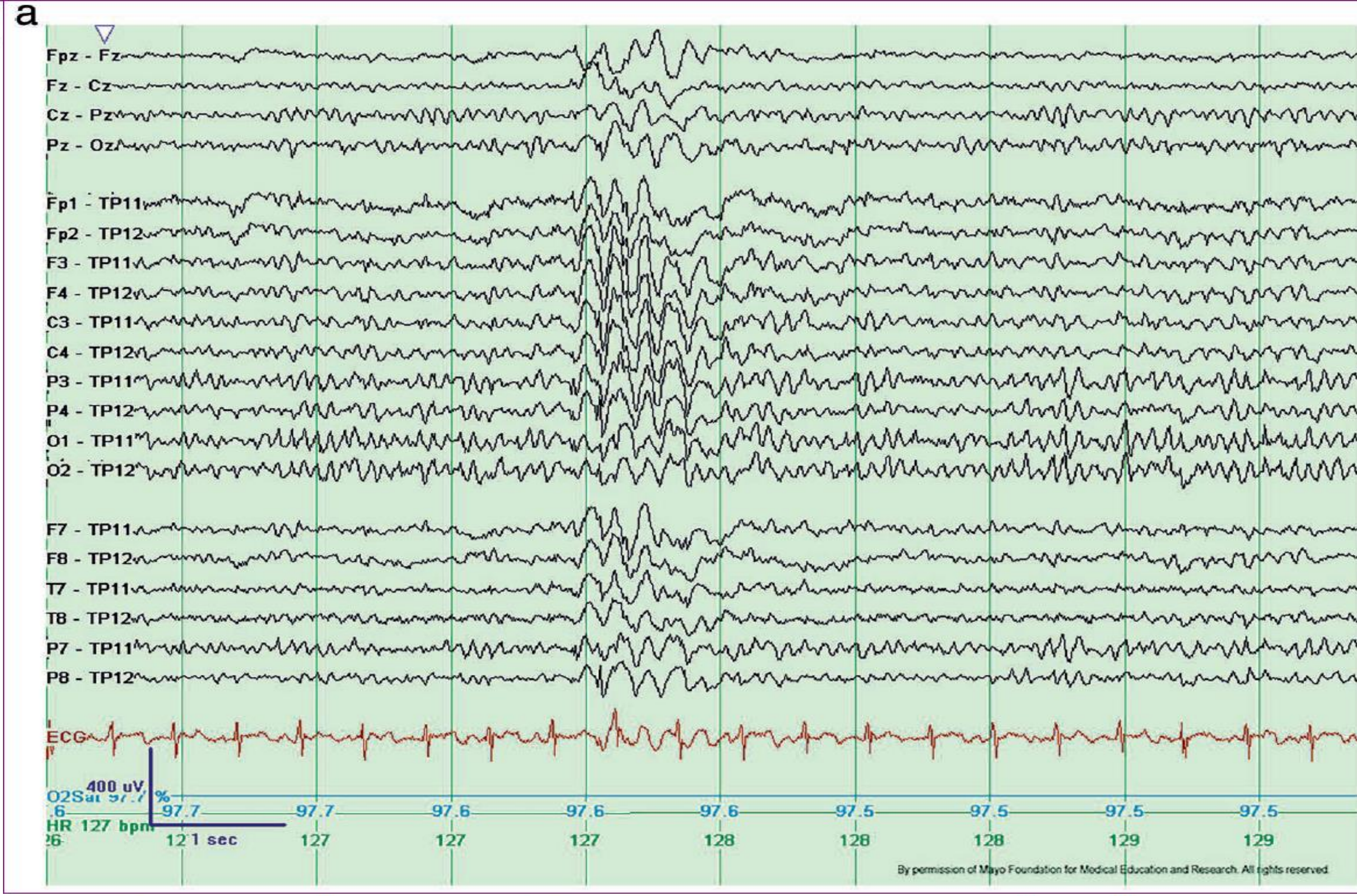


Figure 64. Atypical generalized spike-wave IED. This IED is most commonly seen in children with juvenile absence or myoclonic epilepsy syndromes. Example (a) shows the discharges are spontaneous. In (b), the discharges are induced by the activating procedure of photic stimulation, representative of a so-called photoparoxysmal response, which often occurs in those with primary idiopathic generalized epilepsy syndromes. Figure courtesy of Jeffrey W. Britton, MD.

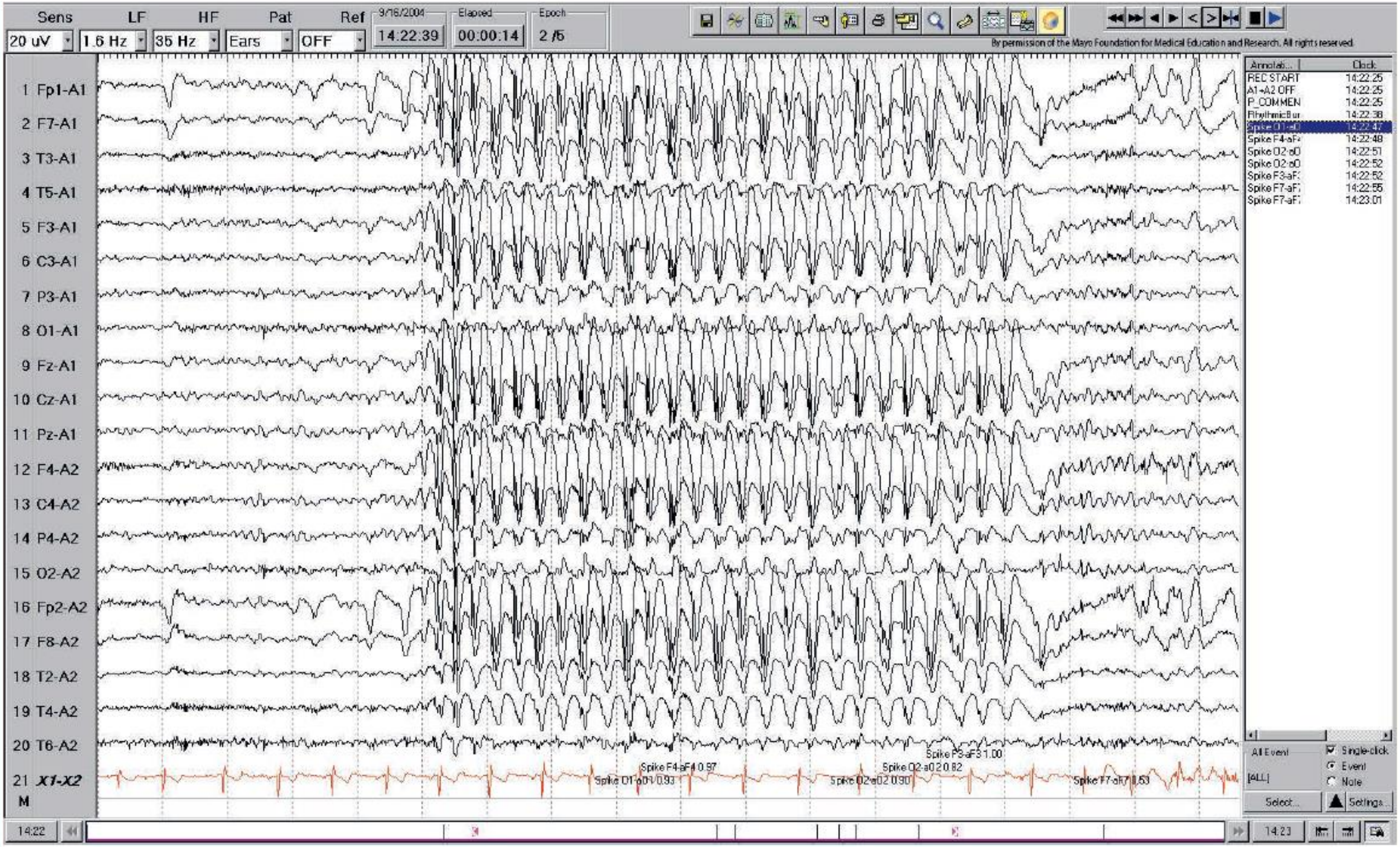
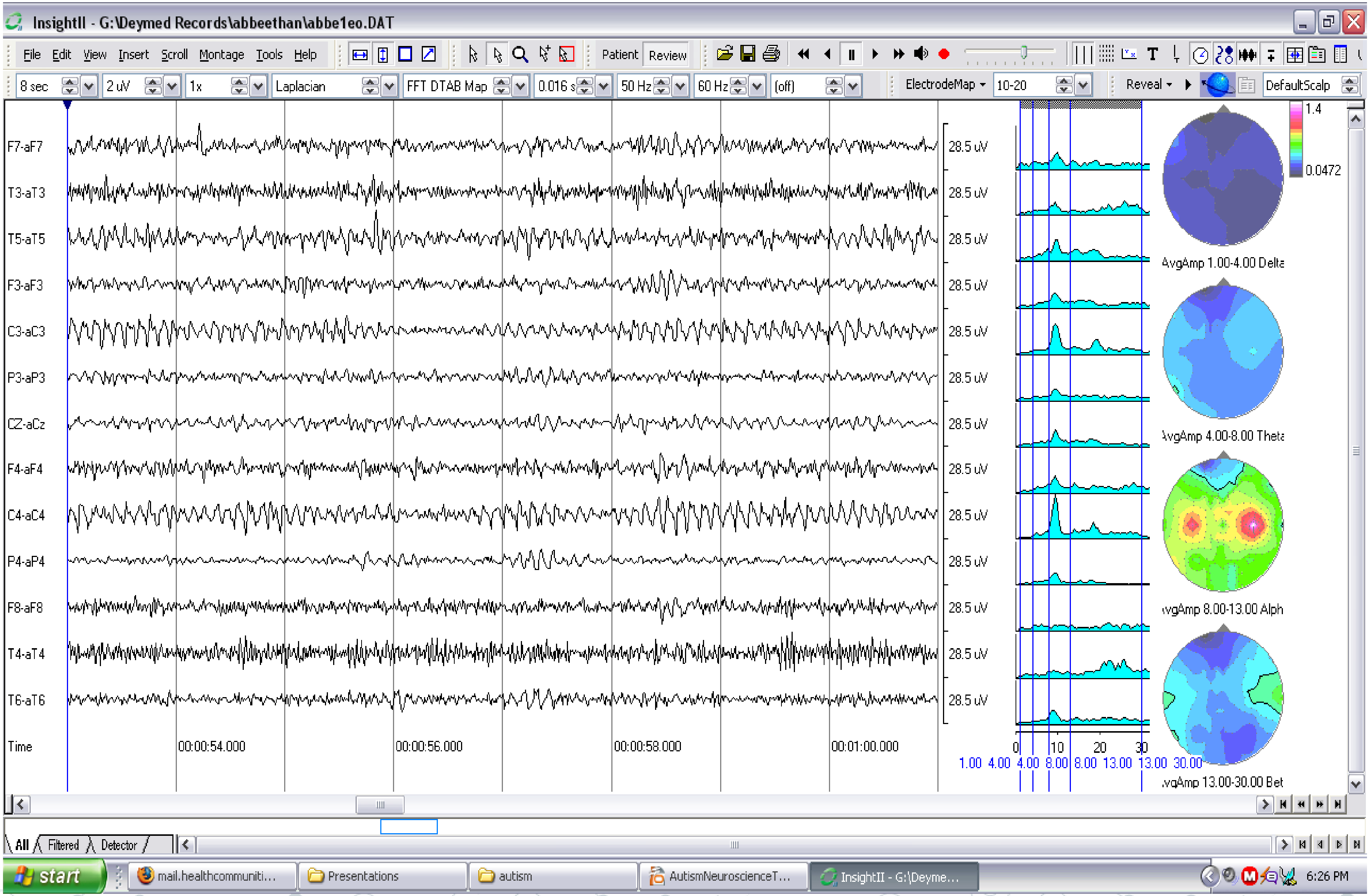


Figure 69. Absence seizure. During an absence seizure, the typical ictal EEG pattern is an extension of the interictal pattern (i.e., 3-Hz generalized spike-wave of a prolonged duration, with usual clinical accompaniments of staring with behavioral arrest, or with variable accompaniment by oral and manual automatisms such as blinking, lip smacking, or hand-fumbling movements. Figure courtesy of Erik K. St. Louis, MD.



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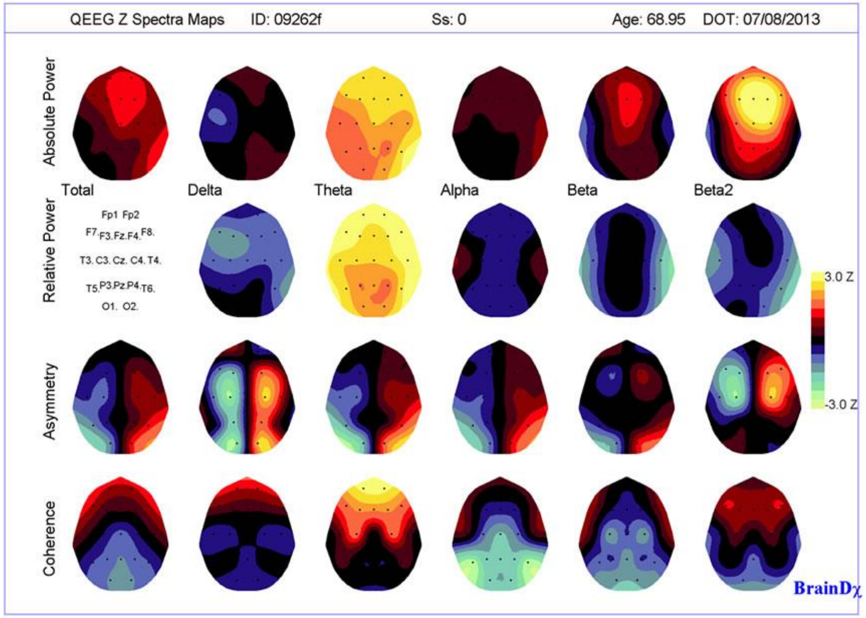
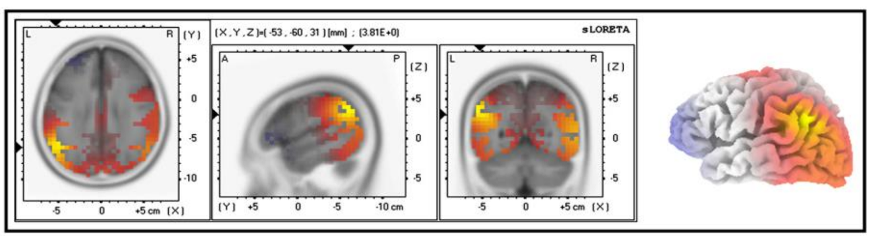
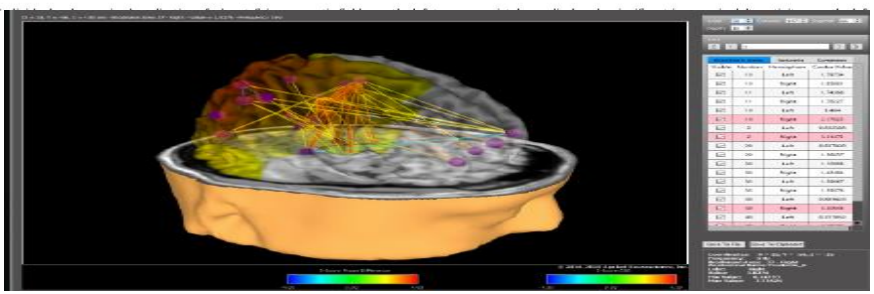
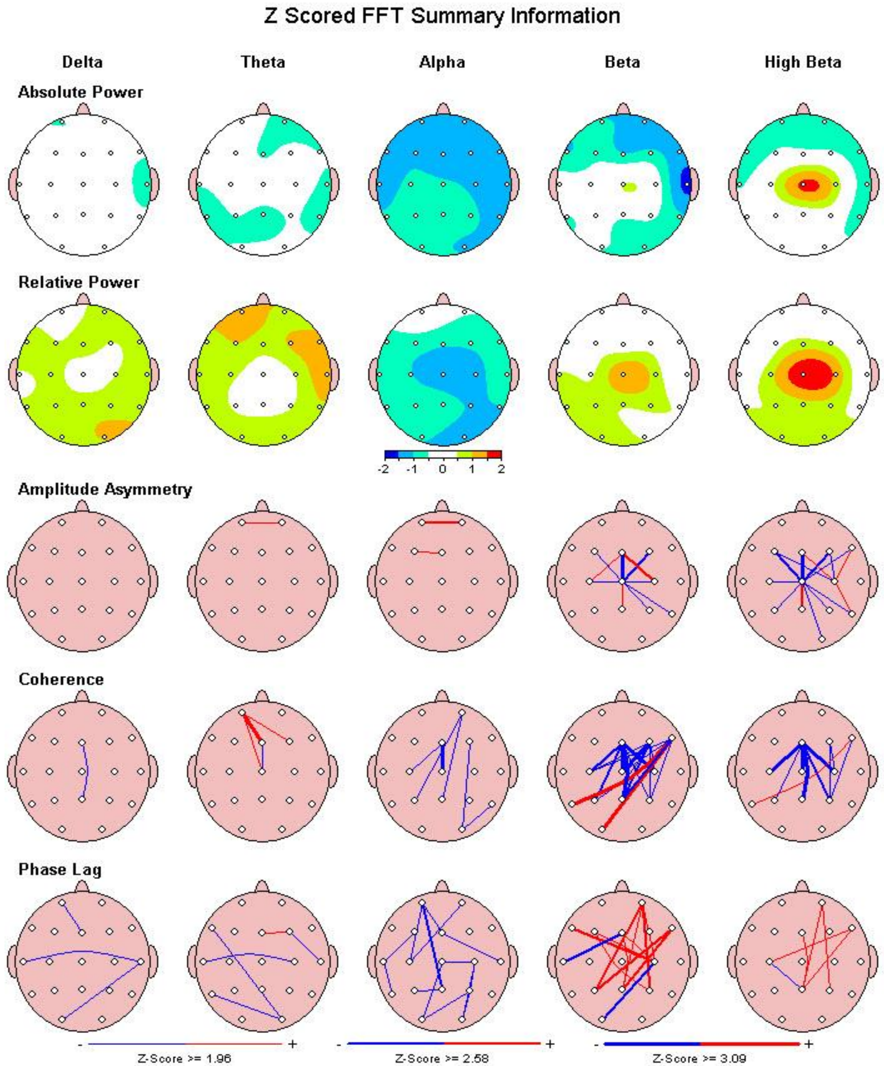
Standard QEEG Assessment









Austin Journal of Autism & Related Disabilities

QEEG and VARETA based Neurophysiological Indices of Brain Dysfunction in Attention Deficit and Autistic Spectrum Disorder

Robert J. Chabot[1], Robert Coben[2], Laurence Hirshberg[3] and David S. Cantor[4]*

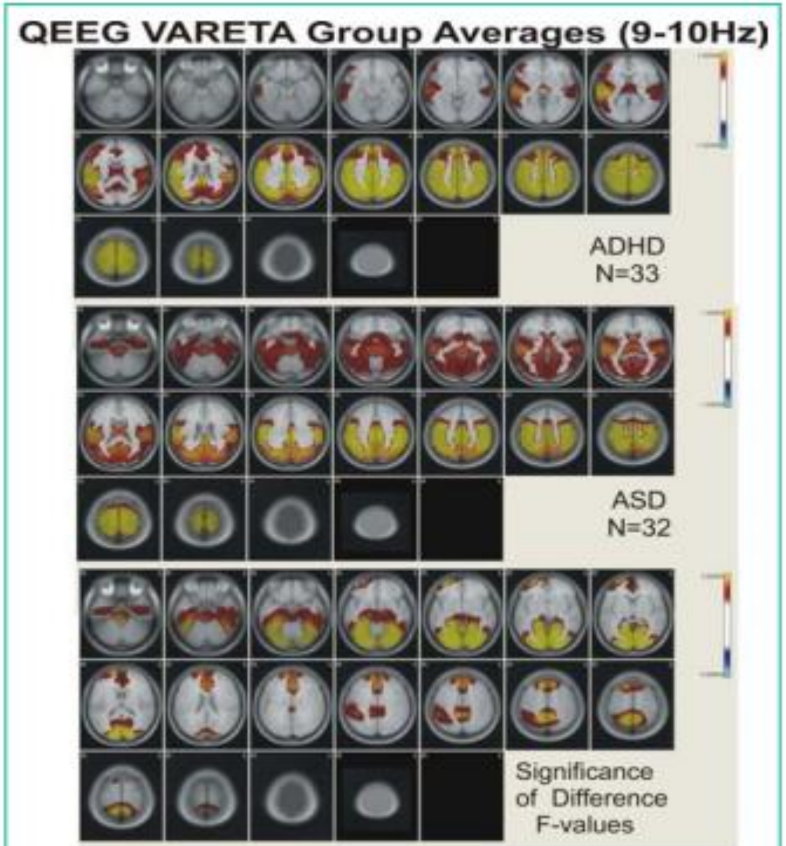


Figure 4: Figure showing VARETA structures and corresponding Z-scores in current density for the broad band 9-10 Hz activity.

Table 3: Brain Structures Showing Abnormal Function using VARETA in Children with Attention Deficit Disorder and Autistic Spectrum Disorder.

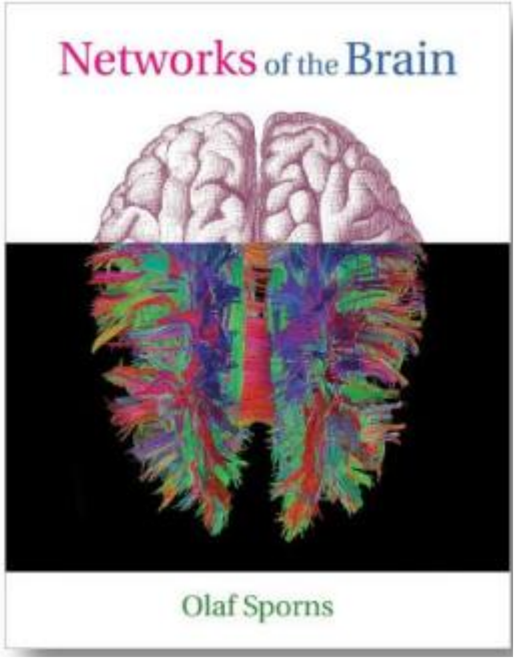
Sub Cortical & Cortical Structures showing VARETA Abnormality	Attention Deficit Disorder	Autistic Spectrum Disorder	Significant Differences
Cerebellum	X	X	ADHD less
Thalamus	X	X	None
Caudate	X	X	None
Hippocampus	X	X	None
Inf. Mid. Sup. Temporal	ALL	Mid & Sup	ASD less
Inf. Mid. Sup. Frontal	ALL	Mid	ASD less
Precentral Gyrus	X		ASD less
Postcentral Gyrus	X	X	None
Inf. Mid. Sup. Occipital	X	Superior	ADHD less
Lat Mid Occipital/ Temporal		X	ADHD less
Sup. Parietal	X	X	ADHD less
Angular Gyrus	X	X	None
Supramarginal Gyrus		X	ADHD less
Cuneus	X	X	None
Lingual Gyrus	X	N	None
Cingulate	Anterior & Posterior	Posterior	None

Standard vs More Complex EEG/QEEG Analyses

- Method of Artifacting: Manual vs ICA/Computer assisted
- Degree of cleaning in EEG
- Isolation of waveforms vs looking at everything
- More detailed analysis of source localized activity
- Sources for components vs a source for all of the EEG
- Viewing the brain as one location operating a function vs. systems of interacting hubs
- CONNECTIVITY

Types of Neural Connectivity

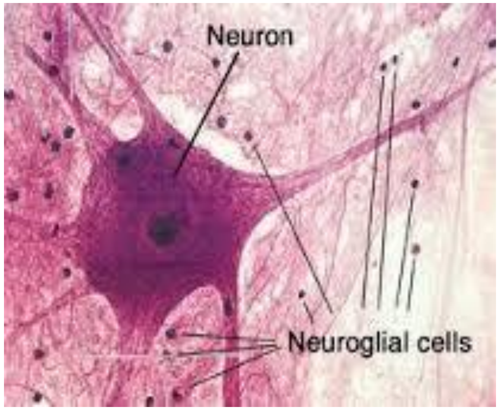
- ***Structural Connectivity***
- ***Functional Connectivity***
- ***Effective Connectivity***

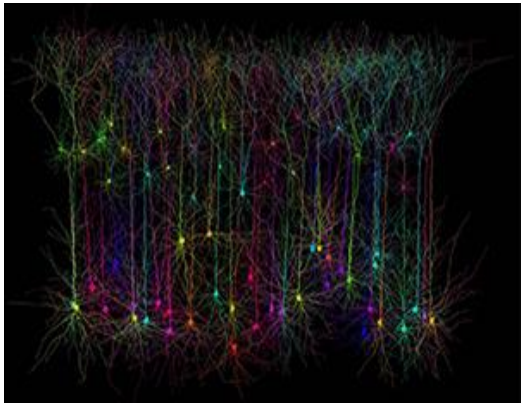


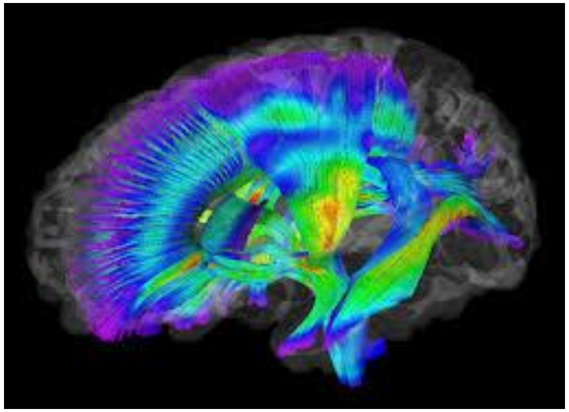
Sporns, O. (2010). *Networks of the Brain*. MIT press.

Structural Connectivity

◎A set of physical or anatomical connections linking neural elements.

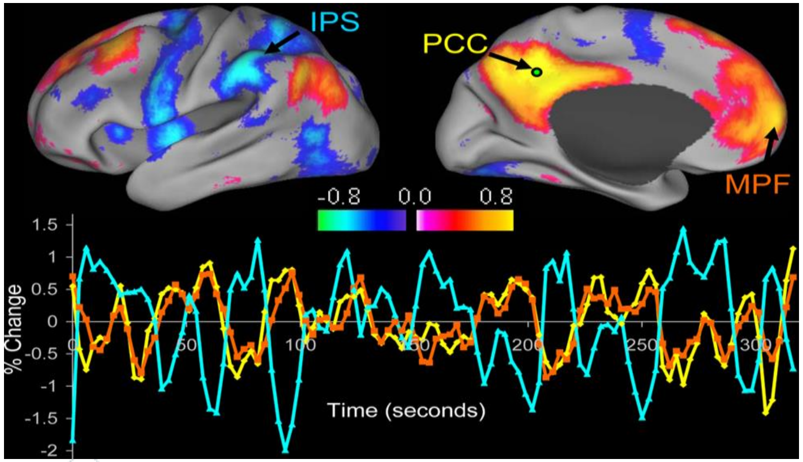


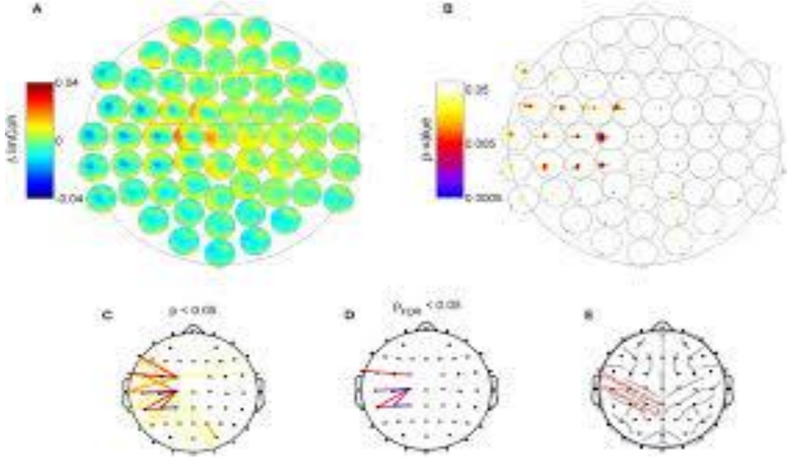




Functional Connectivity

◎Patterns of deviations from statistical independence between distributed and spatially remote neuronal units. The basis of this is time series data from neural recordings. Their relation is taken as neuronal coupling and often takes the form of correlation, coherence, phase locking or comodulation. There is no causal relationship, effect or interaction.



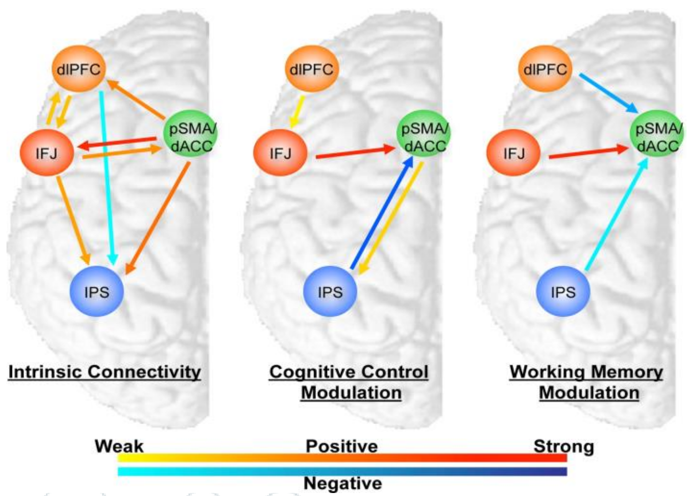


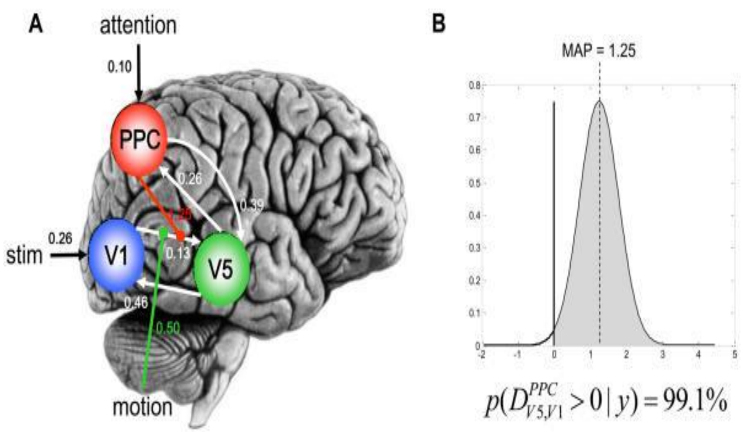
Effective Connectivity

◎Network and causal effects between neural elements.

◎Inferred through statistical techniques such as time series analyses and statistical modeling that assess causality and interaction.

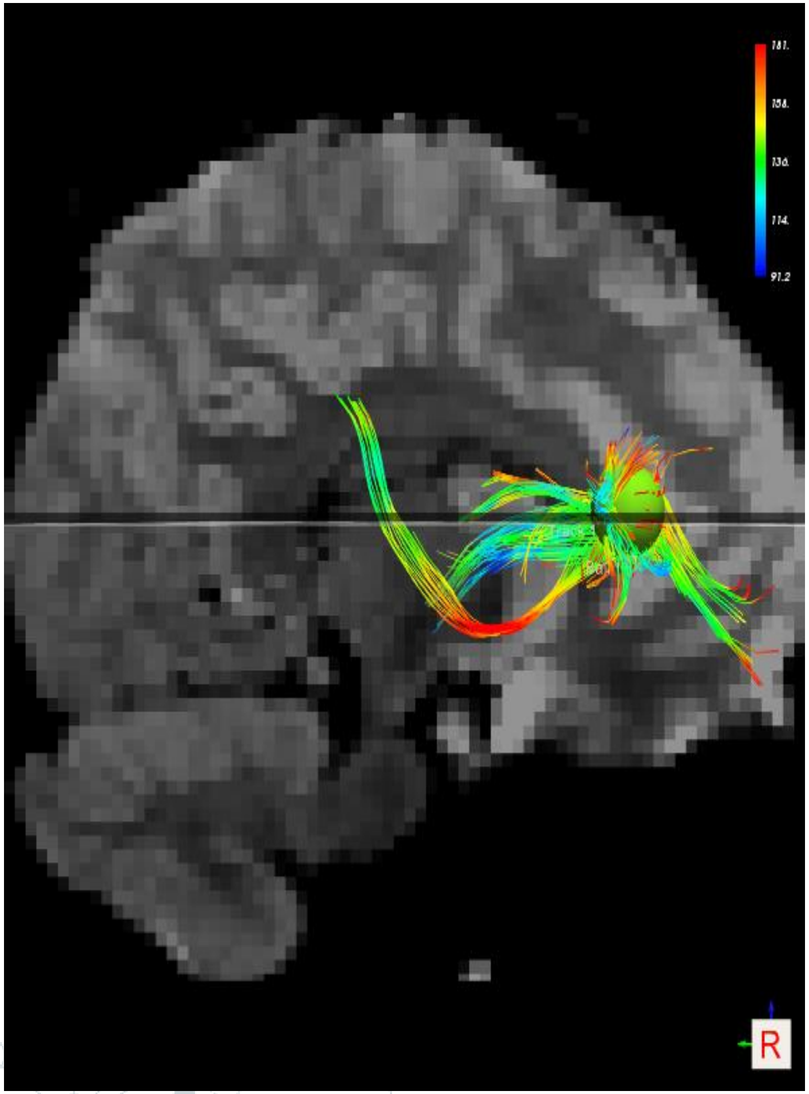
◎Requires complex data processing and modeling techniques such as ICA, Partial Directed Coherence and Granger Causality.

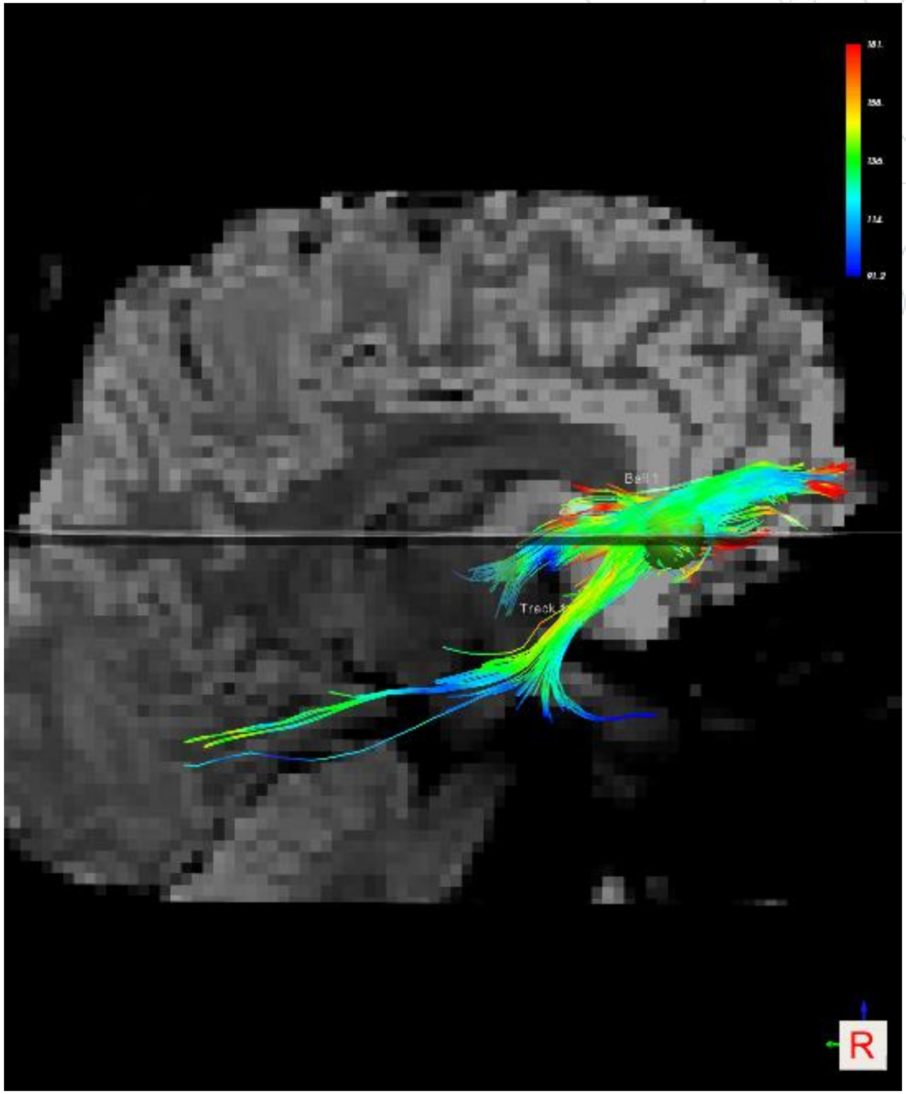


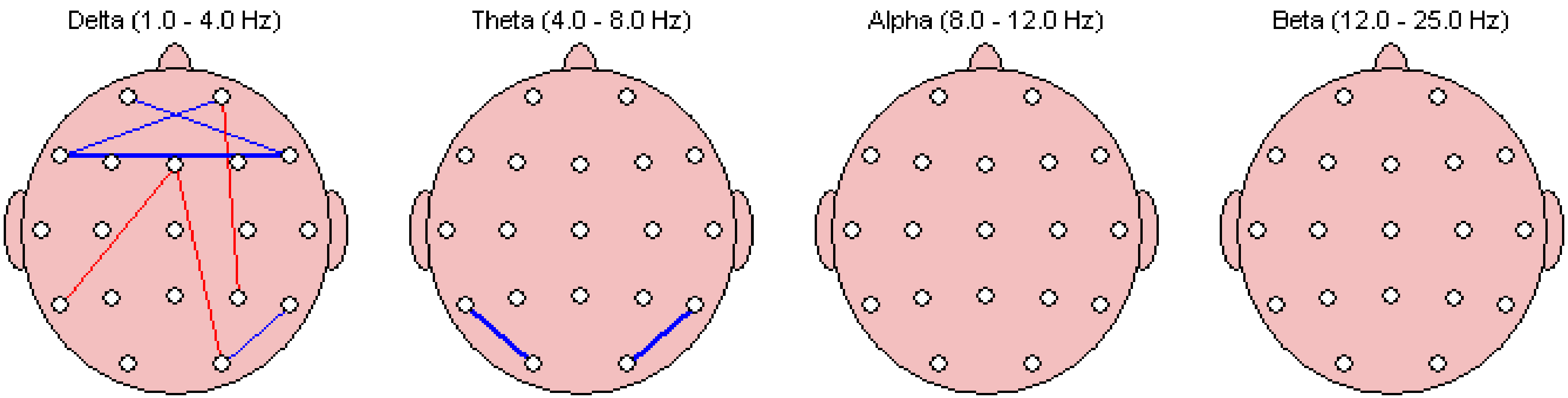


Multivariate Autoregressive Models (MVAR)

Comparing levels of connectivity



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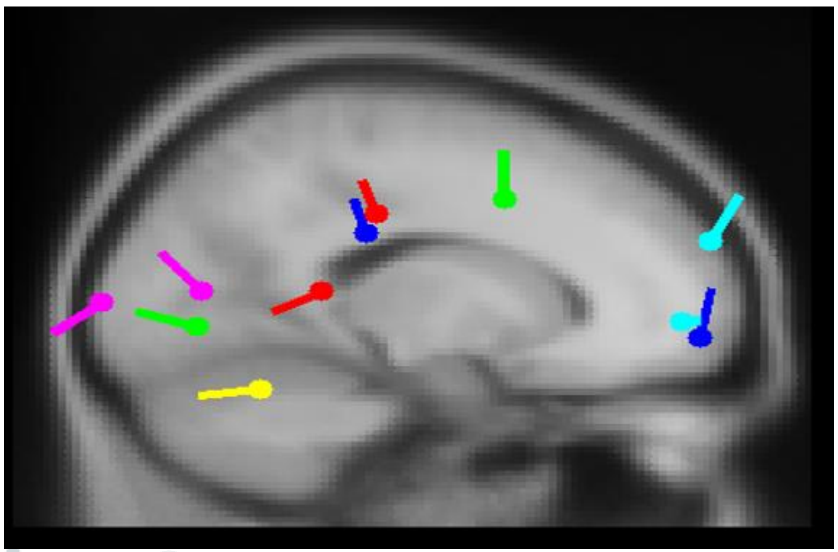
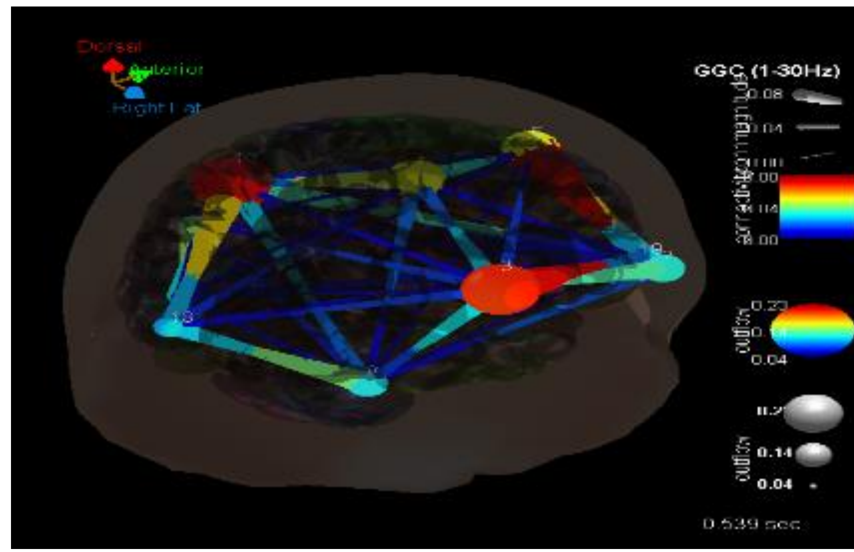
Theta (4.0 - 8.0 Hz)
Alpha (8.0 - 12.0 Hz)
Beta (12.0 - 25.0 Hz)

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Med Biol Eng Comput (2011) 49:521–529
DOI 10.1007/s11517-011-0739-x

SPECIAL ISSUE - REVIEW

Review of the methods of determination of directed connectivity from multichannel data

Katarzyna J. Blinowska

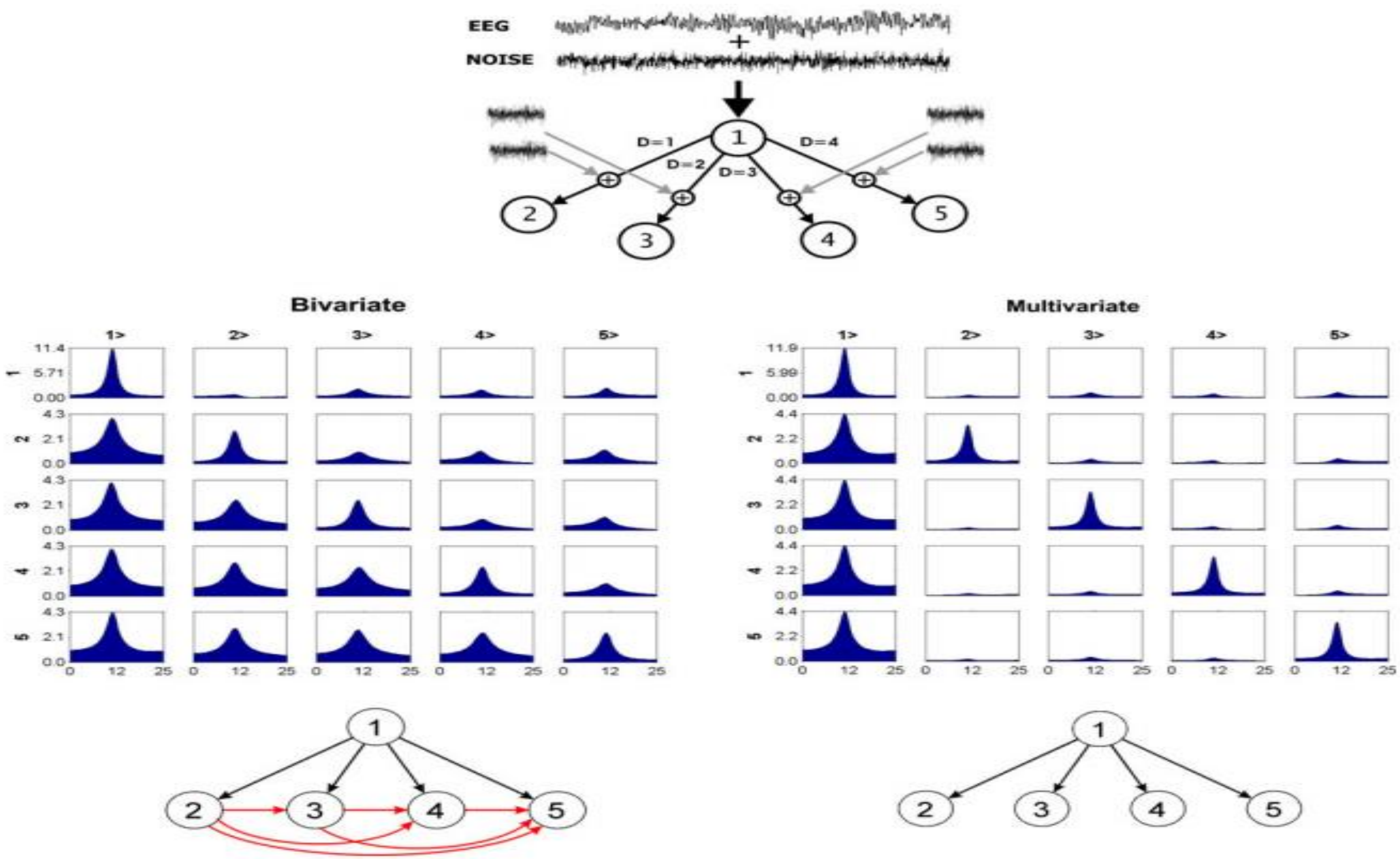


Fig. 1 Comparison of bivariate and multivariate methods of estimation of directed connectivity. *Top* simulation scheme (*D* delay value, at each step white noise is added). *Bottom* connectivity measures, at the *left* bivariate, at the *right* multivariate. Propagation from the channel marked above the column to the channel marked at *left*. In each *box* DTF is shown as a function of frequency. At the diagonal power spectra. At the very *bottom* obtained connections schemes

OPINION ARTICLE

Front. Neural Circuits, 26 September 2018 | https://doi.org/10.3389/fncir.2018.00076

Is Graph Theoretical Analysis a Useful Tool for Quantification of Connectivity Obtained by Means of EEG/MEG Techniques?

Maciej Kaminski[1*†] and Katarzyna J. Blinowska[1,2†]

[1]Department of Biomedical Physics, Faculty of Physics, University of Warsaw, Warsaw, Poland
[2]Institute of Biocybernetics and Biomedical Engineering of Polish Academy of Sciences, Warsaw, Poland

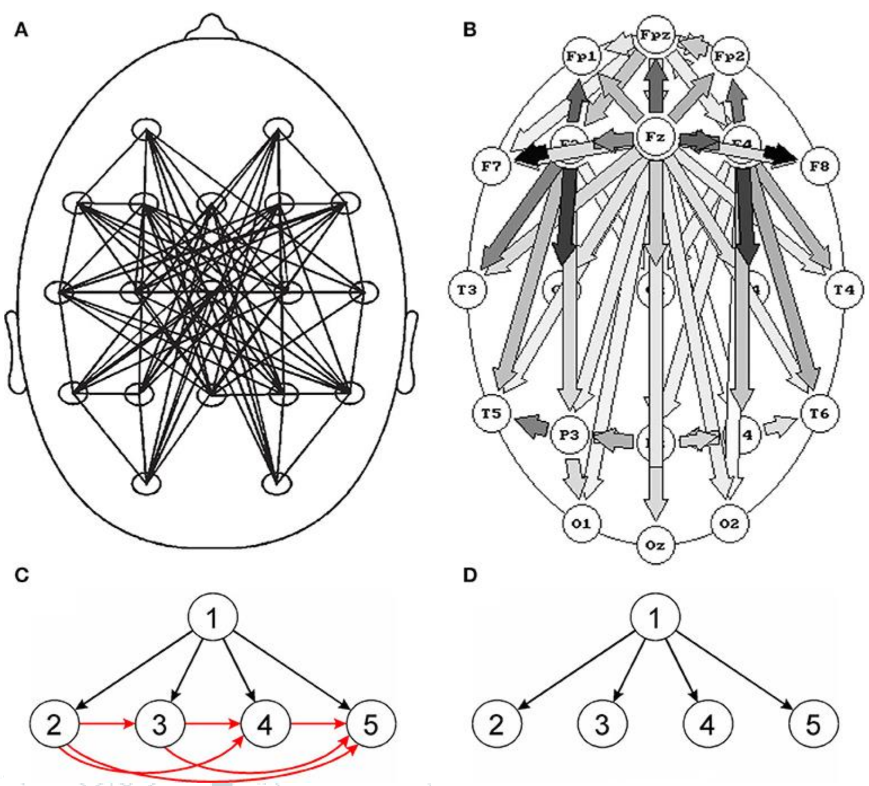
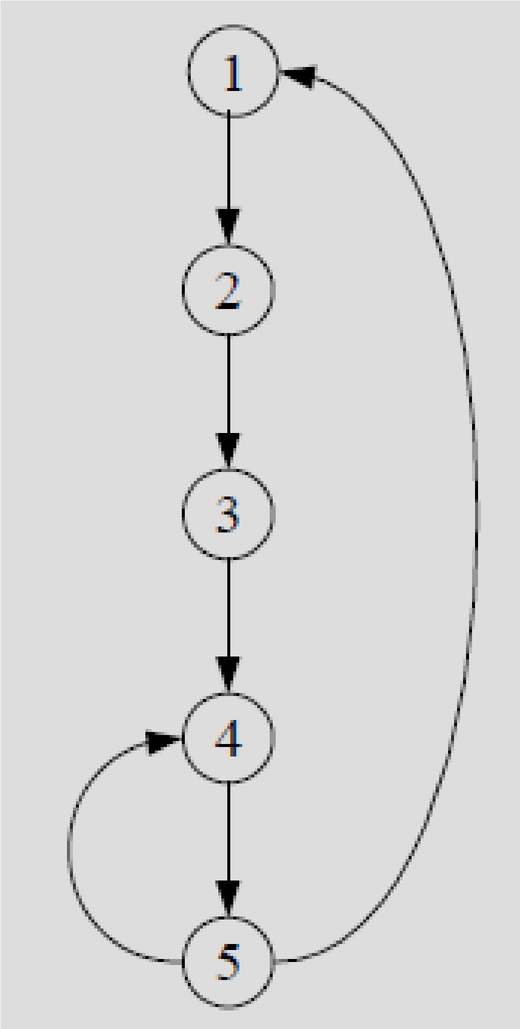
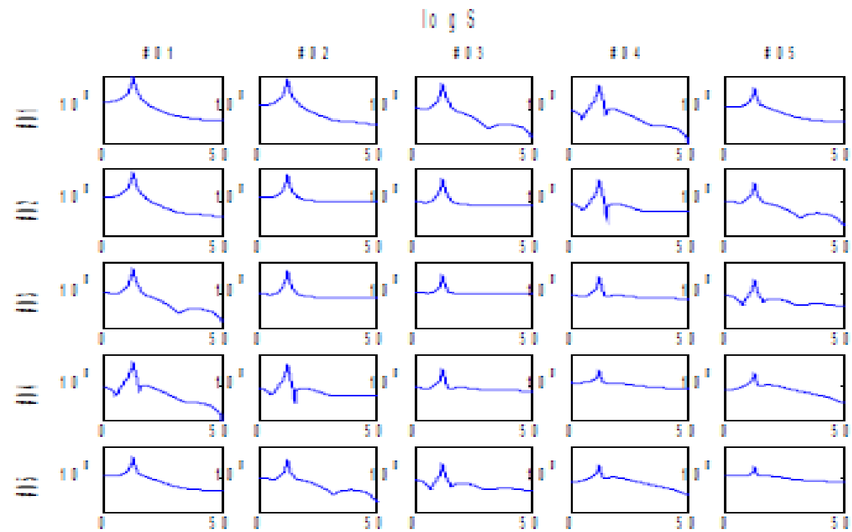


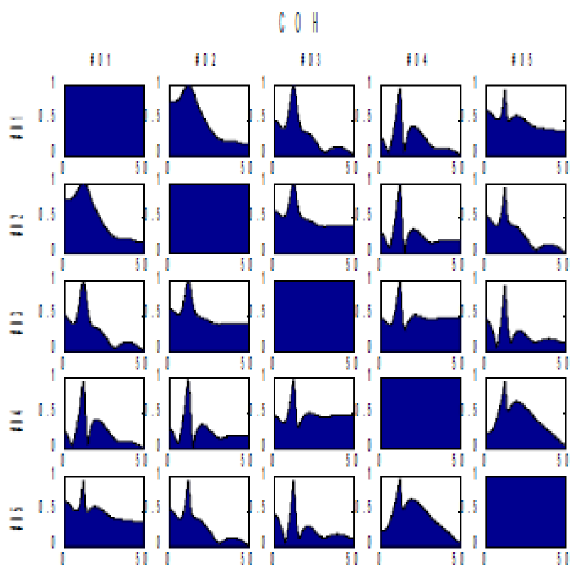
Figure 1. Comparison of bivariate and multivariate connectivity measures. Top images: connectivity patterns for slow wave sleep (stage 3/4), **(A)** obtained using the bivariate measure (SL), **(B)** obtained using the multivariate measure (DTF). Although in **(A)** undirected and in **(B)** directed connections are shown, however the main difference between the pictures are: disorganized pattern of connections in **(A)** and clear-cut pattern of connections compatible with physiological evidence in **(B)**. Bottom images—propagation patterns for a simulation which assumes a propagation of activity from electrode 1 to electrodes 2, 3, 4, and 5; **(C)**—pattern obtained for a bivariate measure (coherence) and **(D)**—for a multivariate measure (DTF). For the bivariate connectivity measure, false connections are created resulting from common driving. **(A)** Reproduced from Leistedt et al. (2009). **(B)** Reproduced from Kaminski et al. (1997) (with permission).

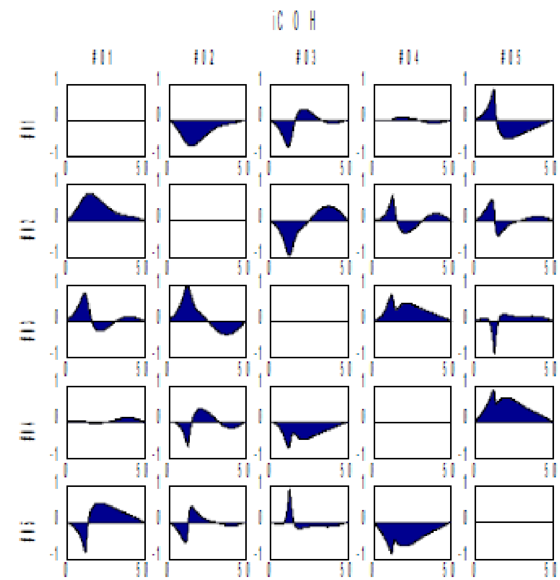


Auto- & Crossspectra

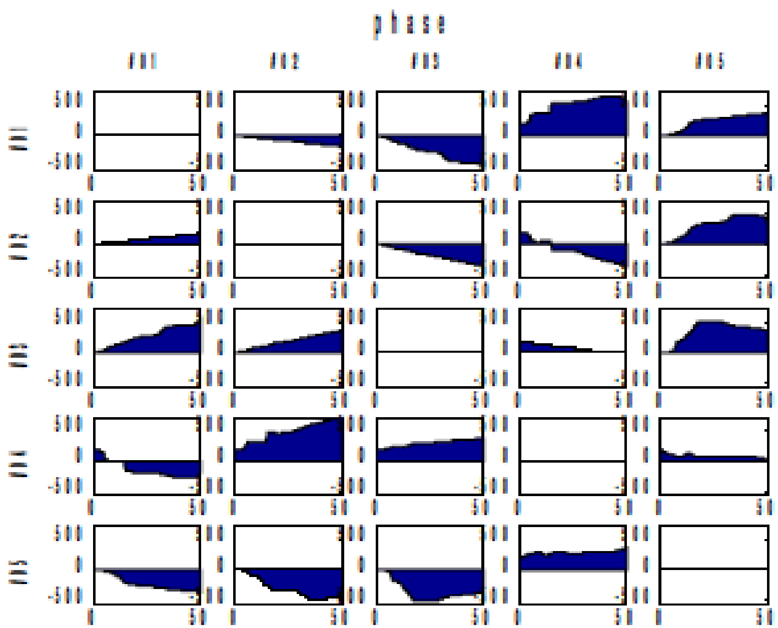


Coherency, Coherence (COH)

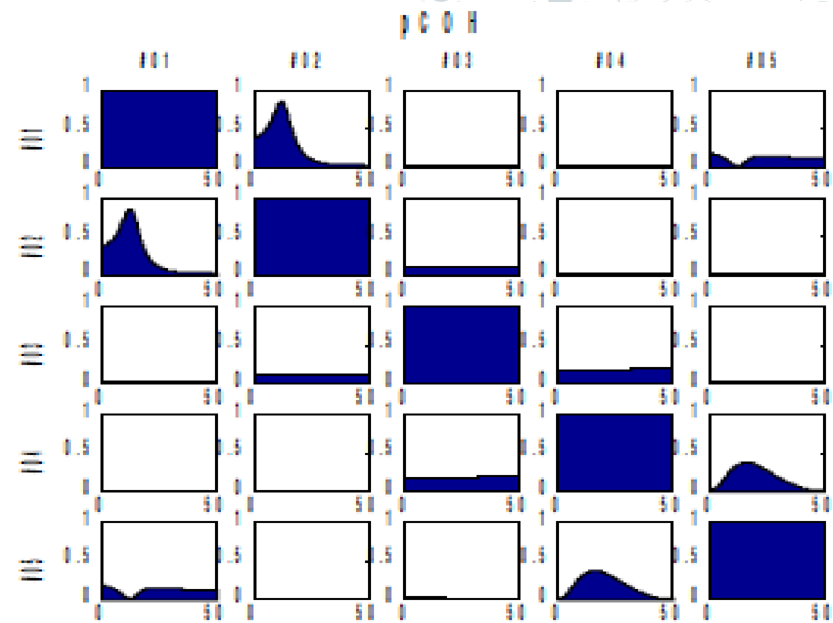




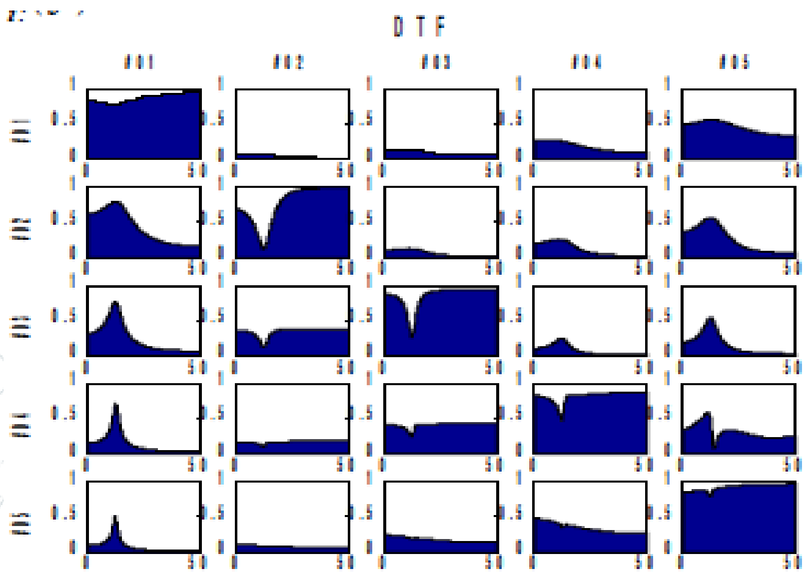
Phase differences and time delay



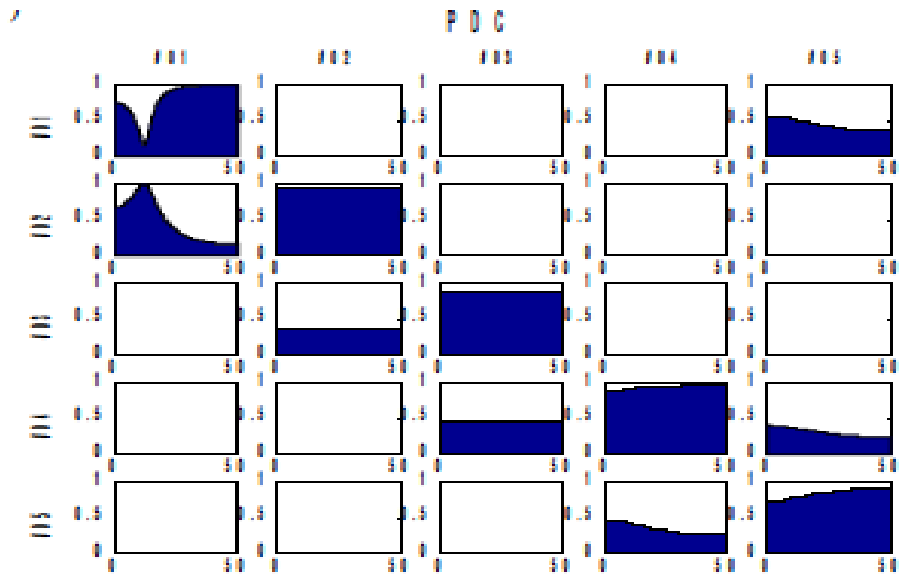
partial Coherence (pCOH)



Directed Transfer Function (DTF)



Partial Directed Coherence (PDC)



Using quantitative and analytic EEG methods in the understanding of connectivity in autism spectrum disorders: a theory of mixed over- and under-connectivity

Robert Coben[1,2]*, Iman Mohammad-Rezazadeh[3,4] and Rex L. Cannon[5]

[1] Neurorehabilitation and Neuropsychological Services, Massapequa Park, NY, USA
[2] Integrated Neuroscience Services, Fayetteville, AR, USA
[3] Center for Mind and Brain, University of California, Davis, CA, USA
[4] Semel Institute for Neuroscience and Human Behavior, University of California, Los Angeles, CA, USA
[5] Psychoeducational Network, Knoxville, TN, USA

Frontiers in Human Neuroscience www.frontiersin.org February 2014 | Volume 8 | Article 45 | 1

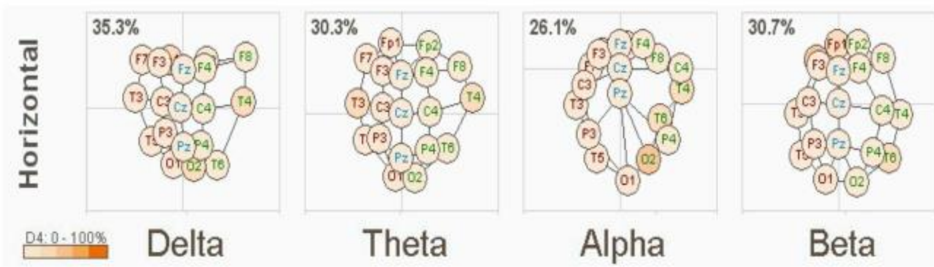


FIGURE 1 | NeuroRep Multivariate Connectivity analyses showing eigen images in the horizontal place across delta, theta, alpha, and beta frequencies. Observable features include; (1) right hemisphere (temporal) hypocoherences across all frequency bands, (2) hypercoherences in the alpha band over prefrontal regions, and (3) right parietal-posterior temporal hypercohences in the theta and alpha frequency bands.

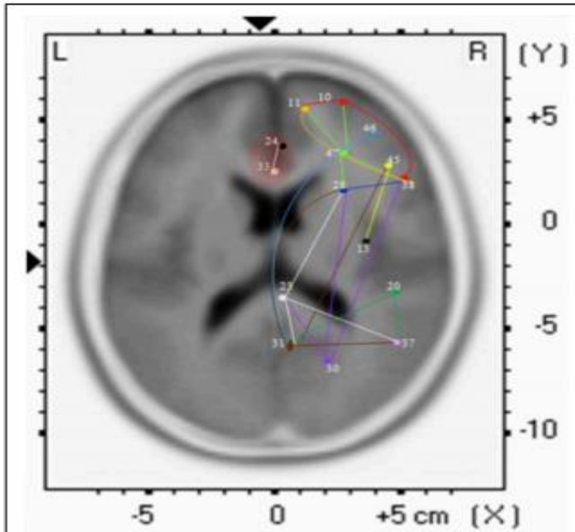


FIGURE 3 | Each of the 15 ROIs for this case study are represented in a different color. The lines indicate significant correlations between the colored ROI and other regions. The color of the line is the same as the ROI in relation to its functional connectivity with other ROIs.

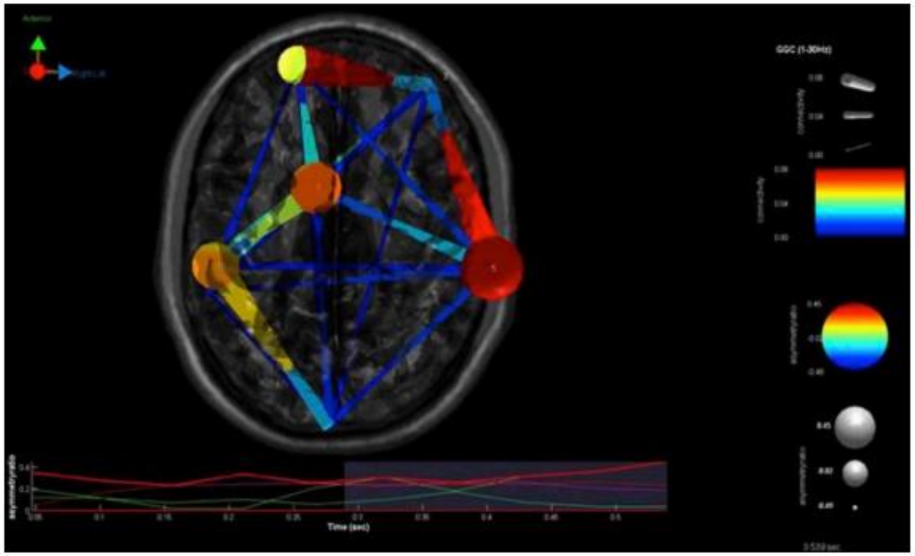
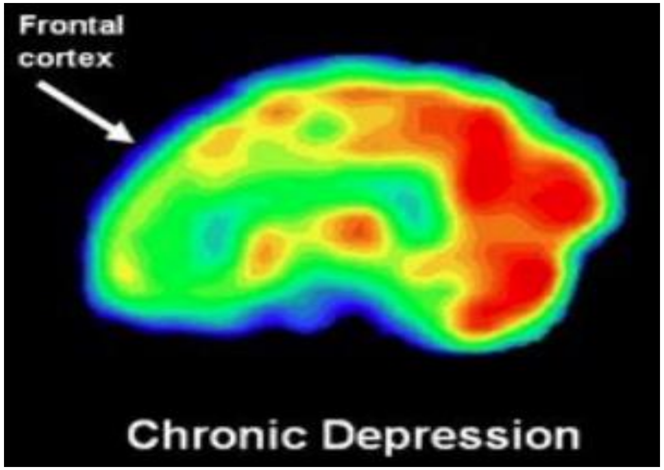
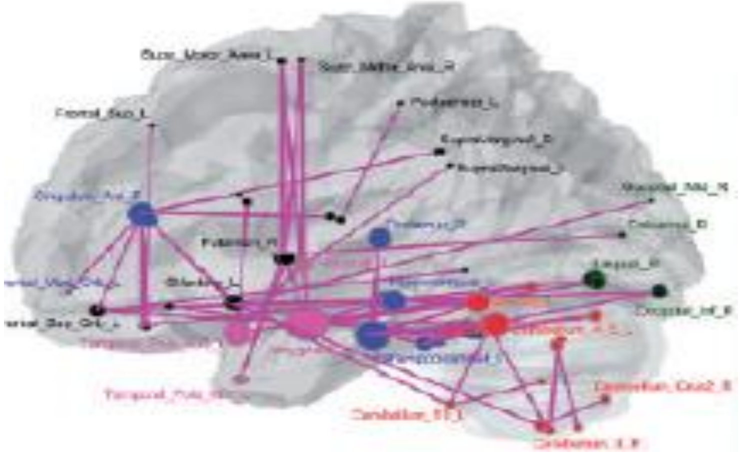
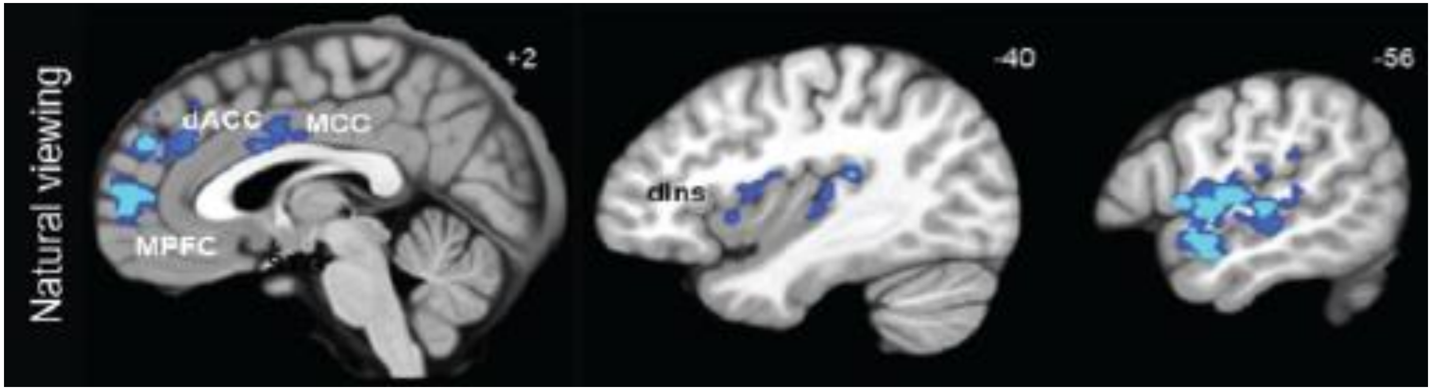


FIGURE 5 | SIFT/Granger (GGC) causality brain image. Levels of greater connectivity are shown with thicker lines and brighter colors. Direction of causality is indicated by the key in the upper left hand corner. ICs and their localization are listed as part of **Table 3**.

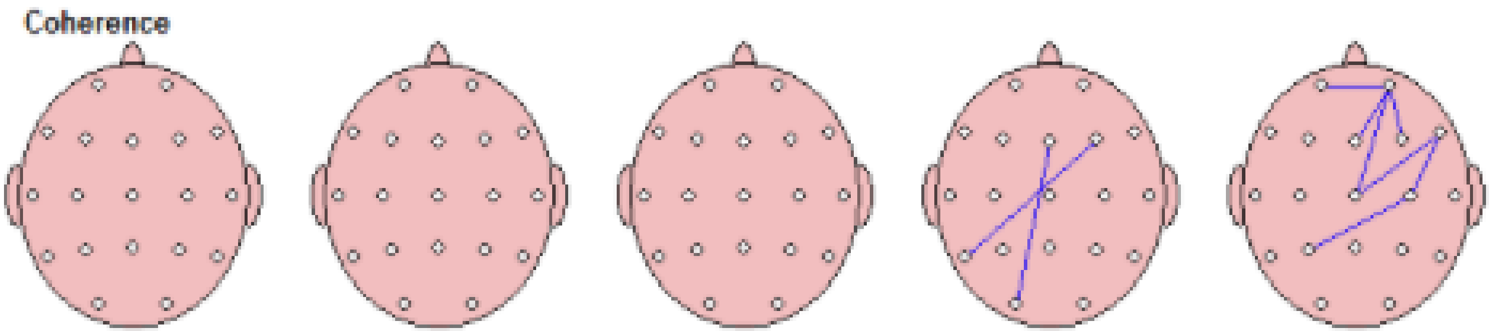
Exemplar: Major Depression

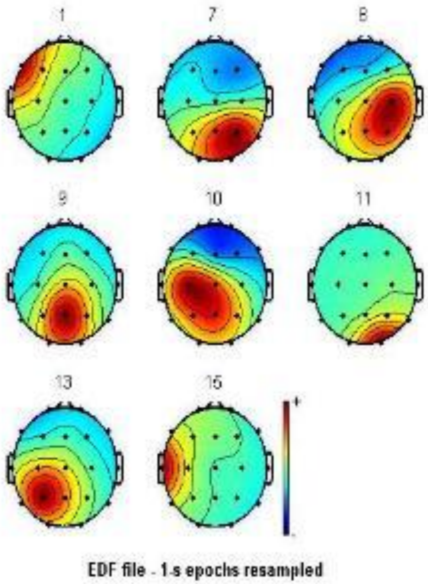


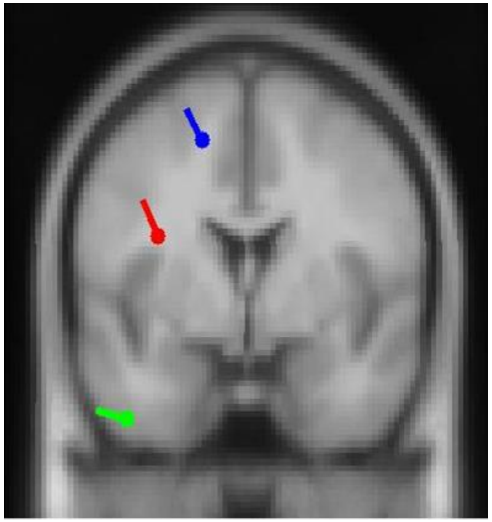


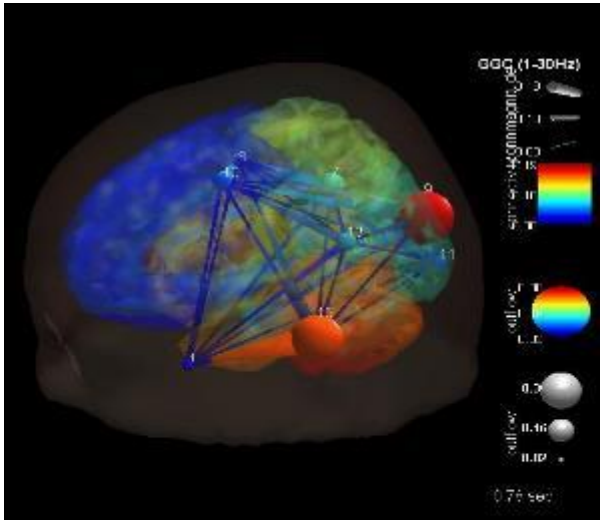


Exemplar: Major Depression

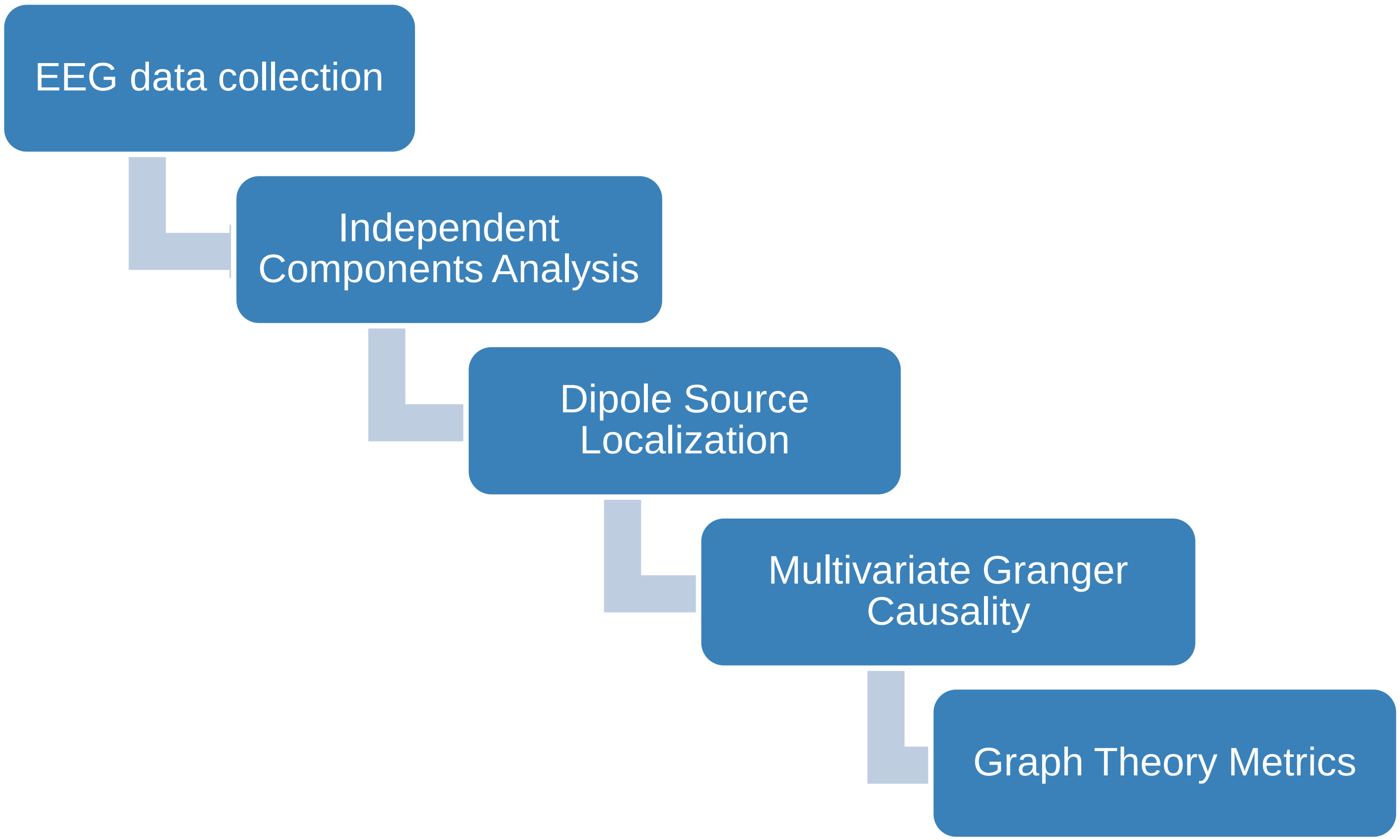








Novel EEG Analysis pipeline focused on effective connectivity assessment



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- UCSD Swartz Center for Computational Neuroscience
- University of Oxford
- UCLA Semmel Neuroscience Institute
- MGH/Harvard Medical School
- Georgetowwn University Medical Center
- University of Michigan Neuroscience Department

Journal of Neuroscience Methods
Volume 134, Issue 1, 15 March 2004, Pages 9-21

EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis

Arnaud Delorme, Scott Makeig

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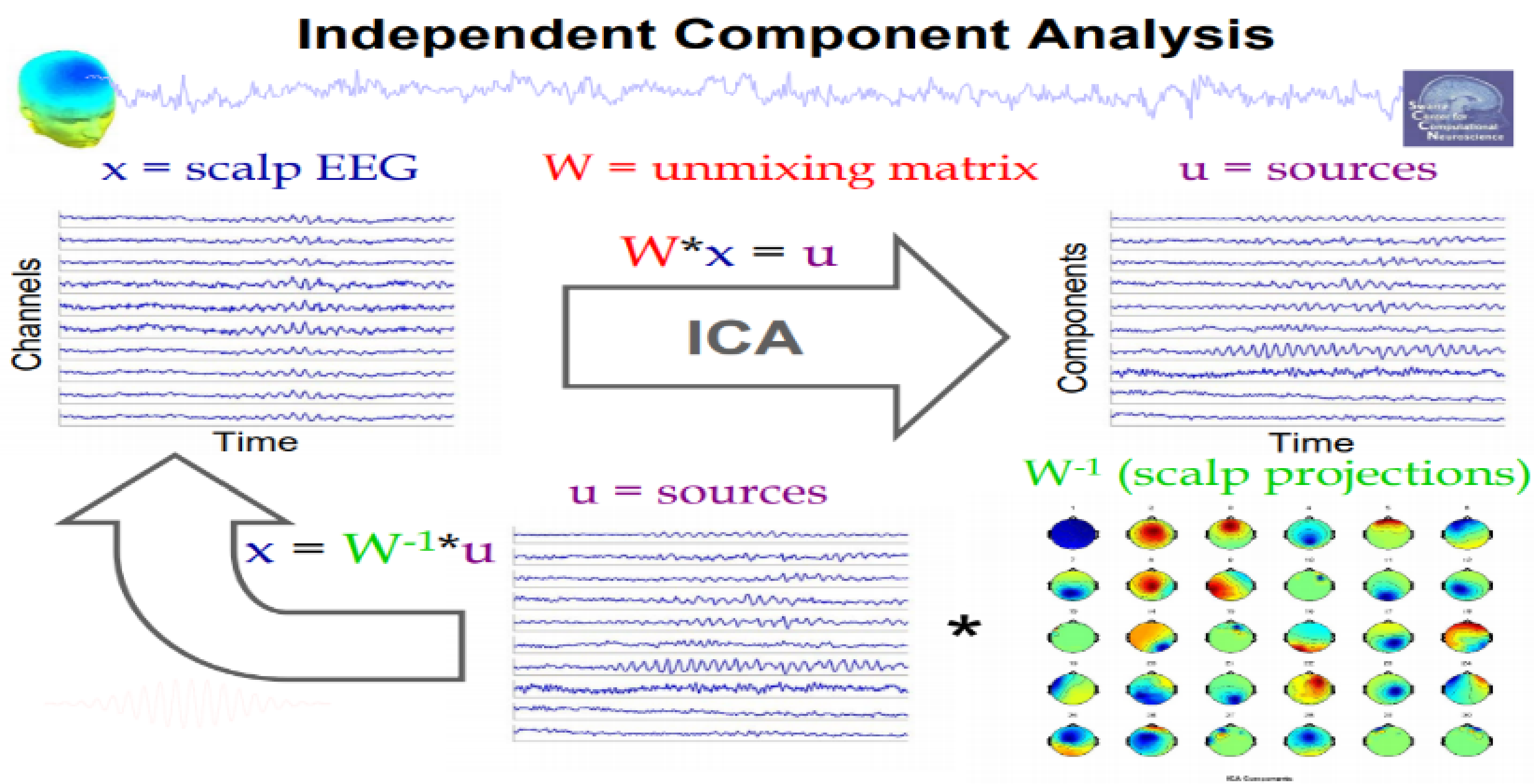

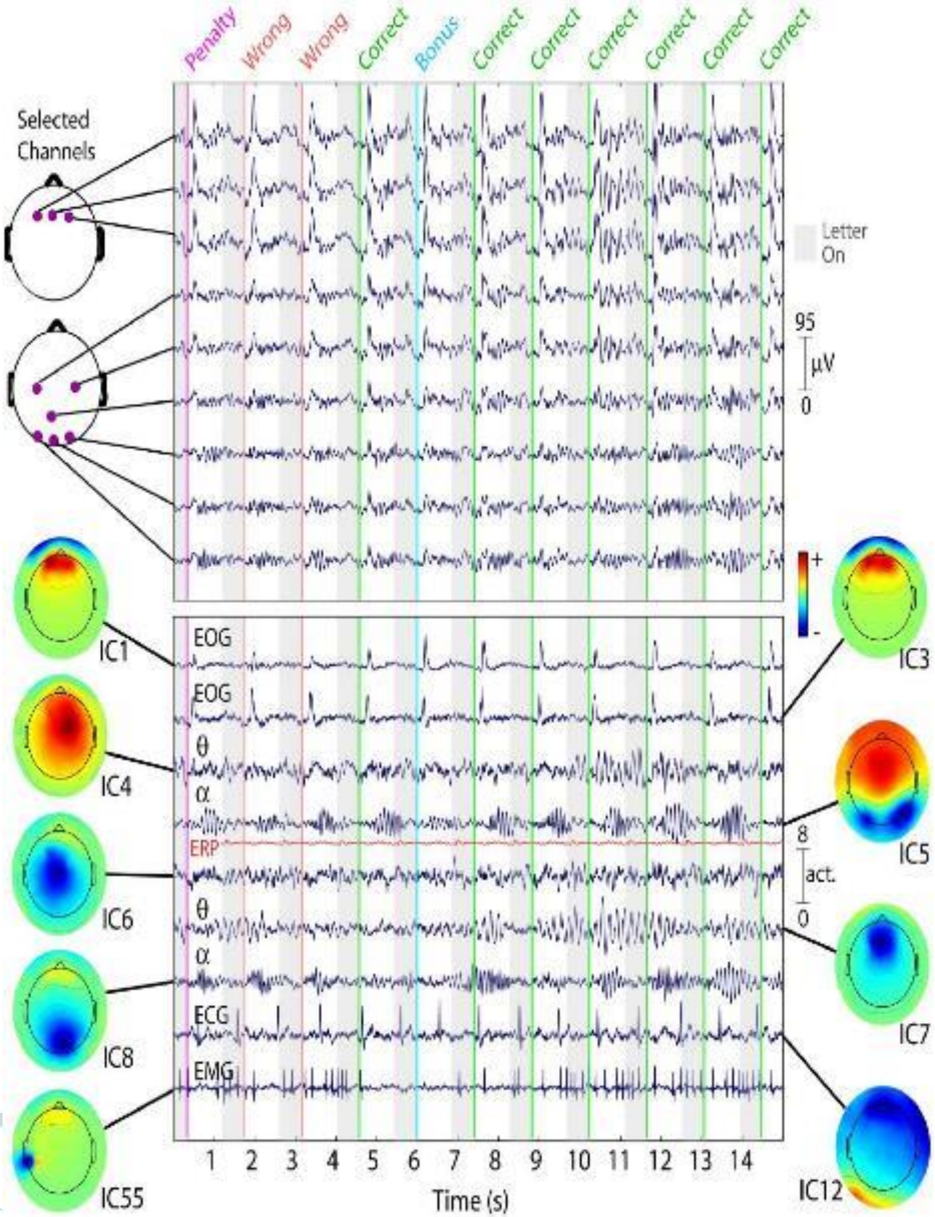
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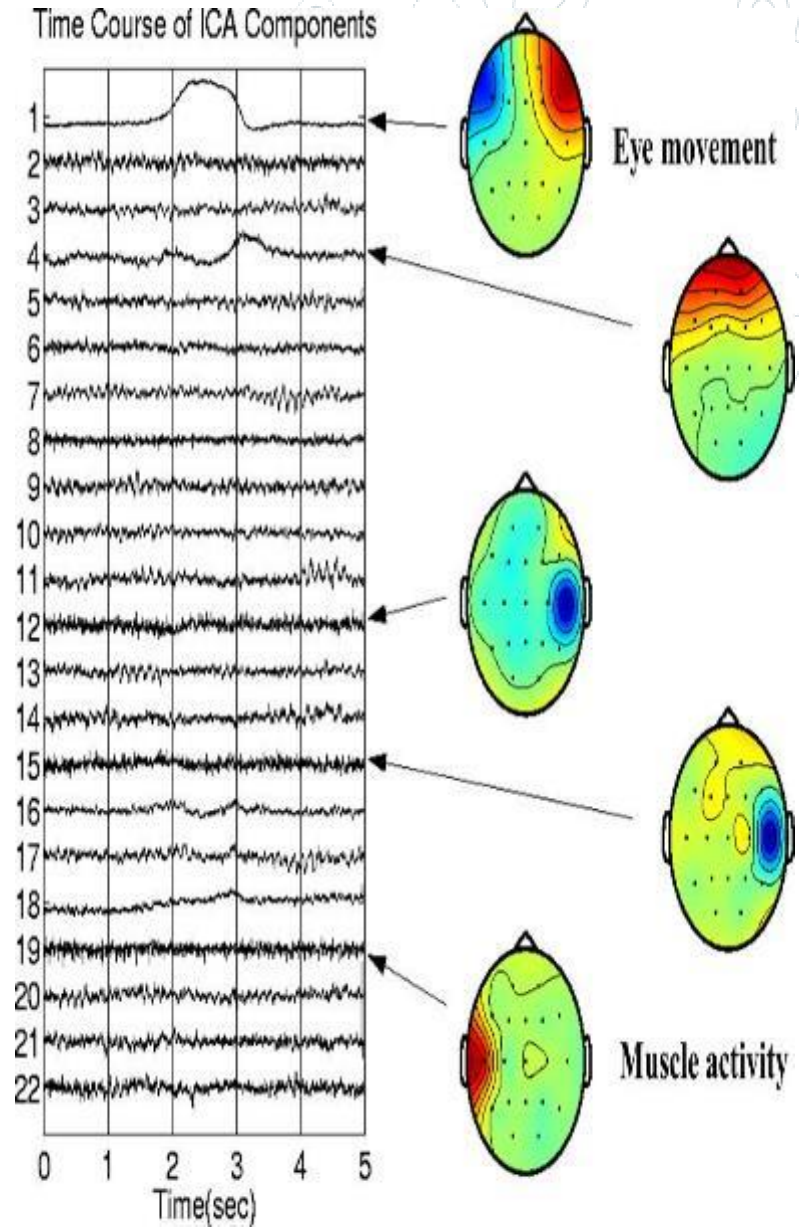
Time Course of ICA Components
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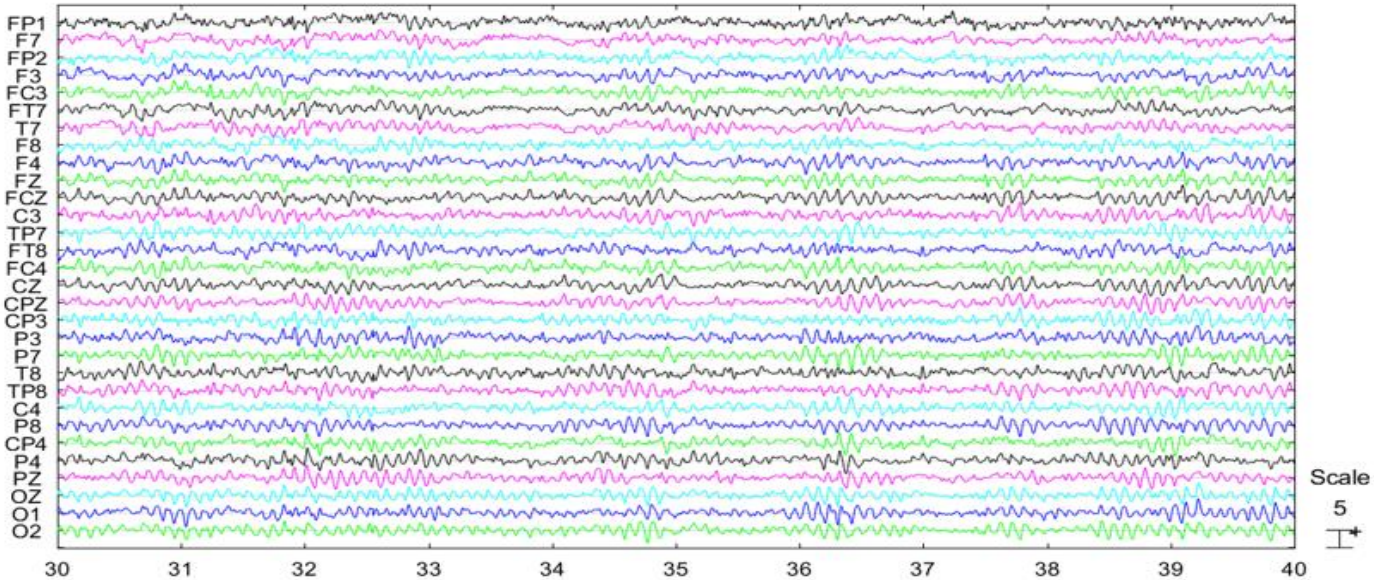
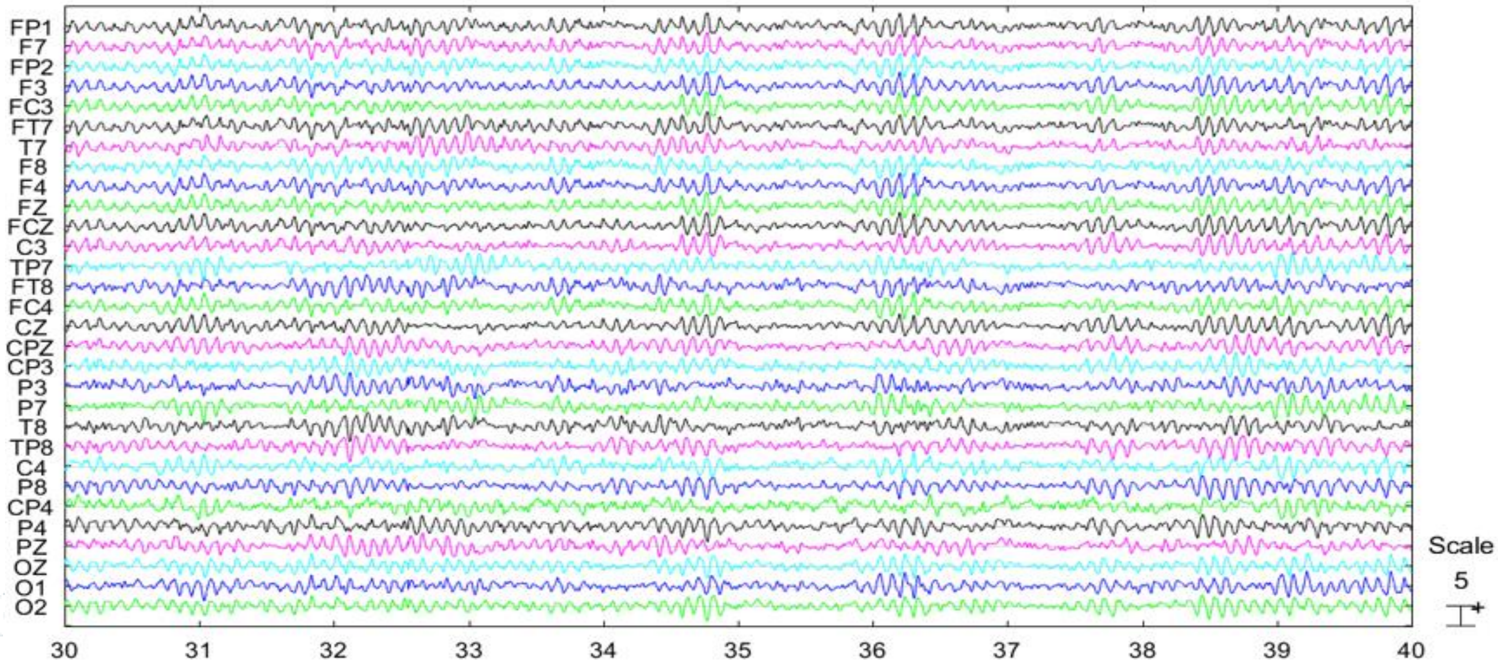
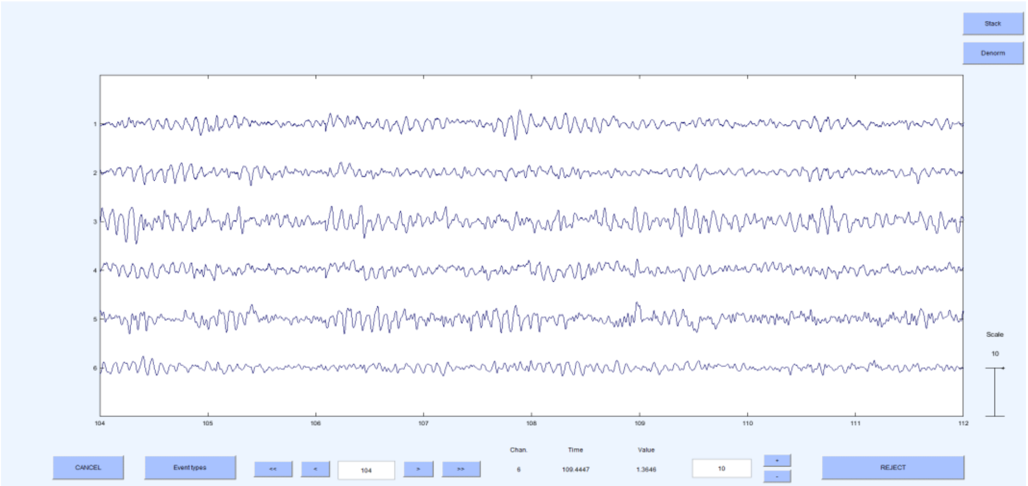
21
22
0 1 2 3 4 5
Time(sec)
Eye movement
Muscle activity

Example: 25 year old woman with a history of emotional abuse as a child and adult. Presents with anxiety, panic, nightmares and dissociation.






Stack
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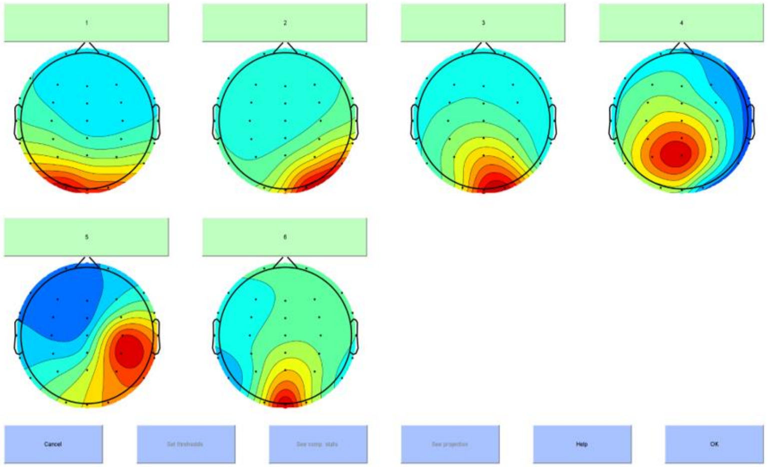
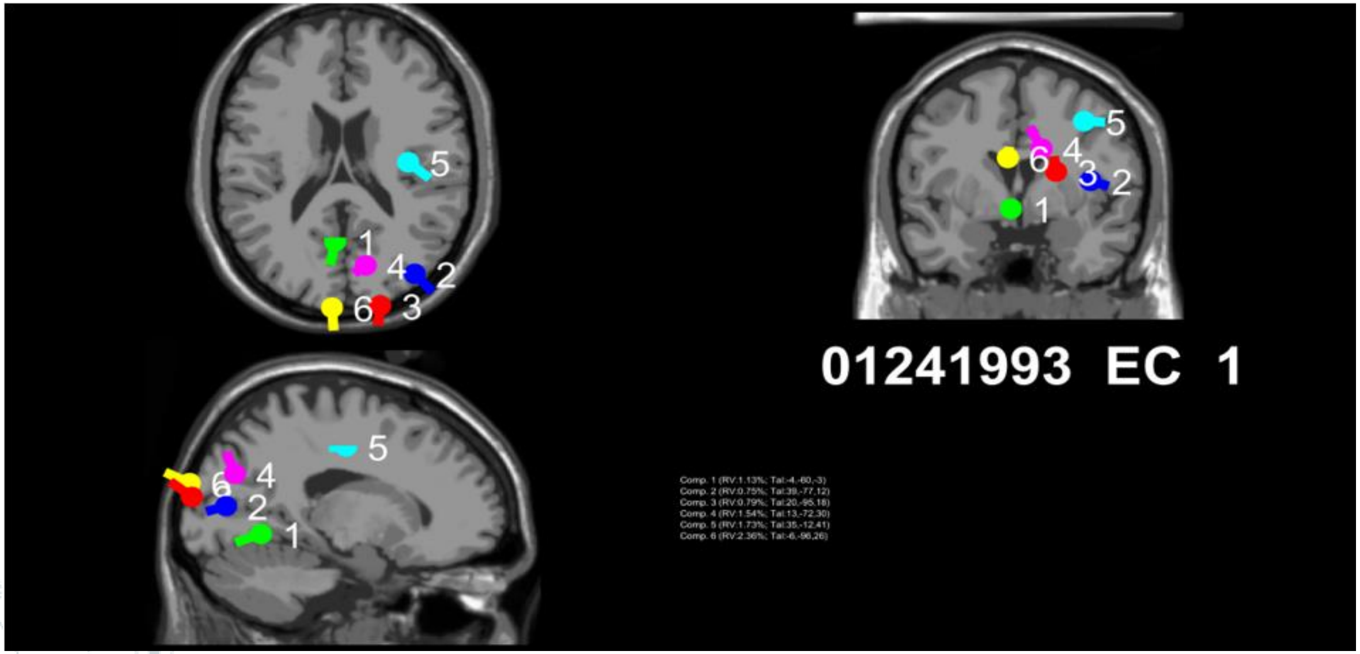
10
CANCEL
Event types
104
Chan.
Time
Value
6
109.4447
1.3646
10
REJECT


Cancel
Help
OK


01241993 EC 1
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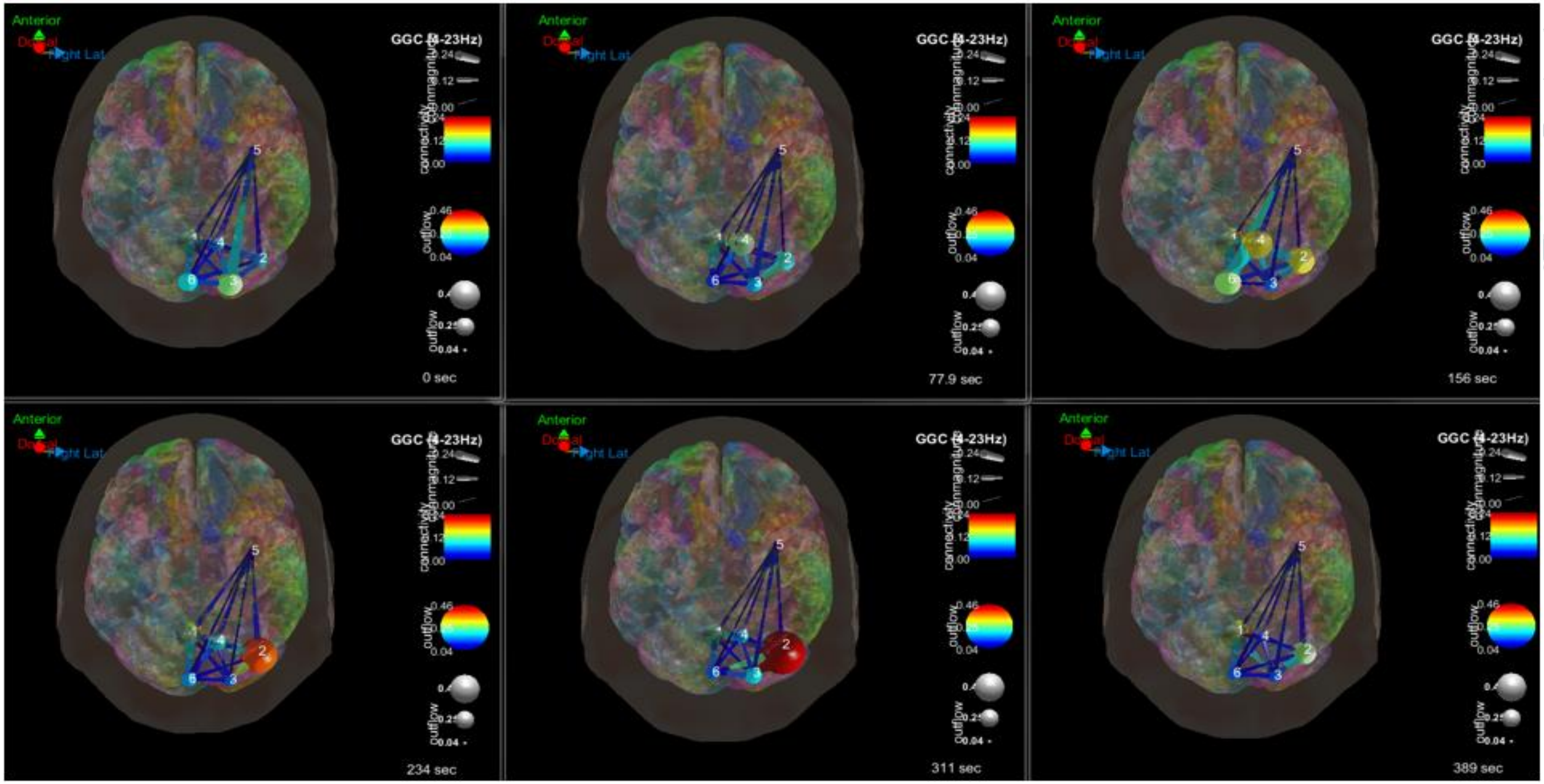
Comp. 2 (RV:0.75%; Tal:39,-77,12)
Comp. 3 (RV:0.79%; Tal:20,-95,18)
Comp. 4 (RV:1.54%; Tal:13,-72,30)
Comp. 5 (RV:1.73%; Tal:35,-12,41)
Comp. 6 (RV:2.36%; Tal:-6,-96,26)



Graph Theory Metrics

Time Range	Freq Range	Clust Coeff	Path Length	Global Eff	Radius	Diameter
281-352s	4-23Hz	0.031157467	37.27736431	0.044989651	39.41305	91.9196607

Graph Theory: Network Dynamics

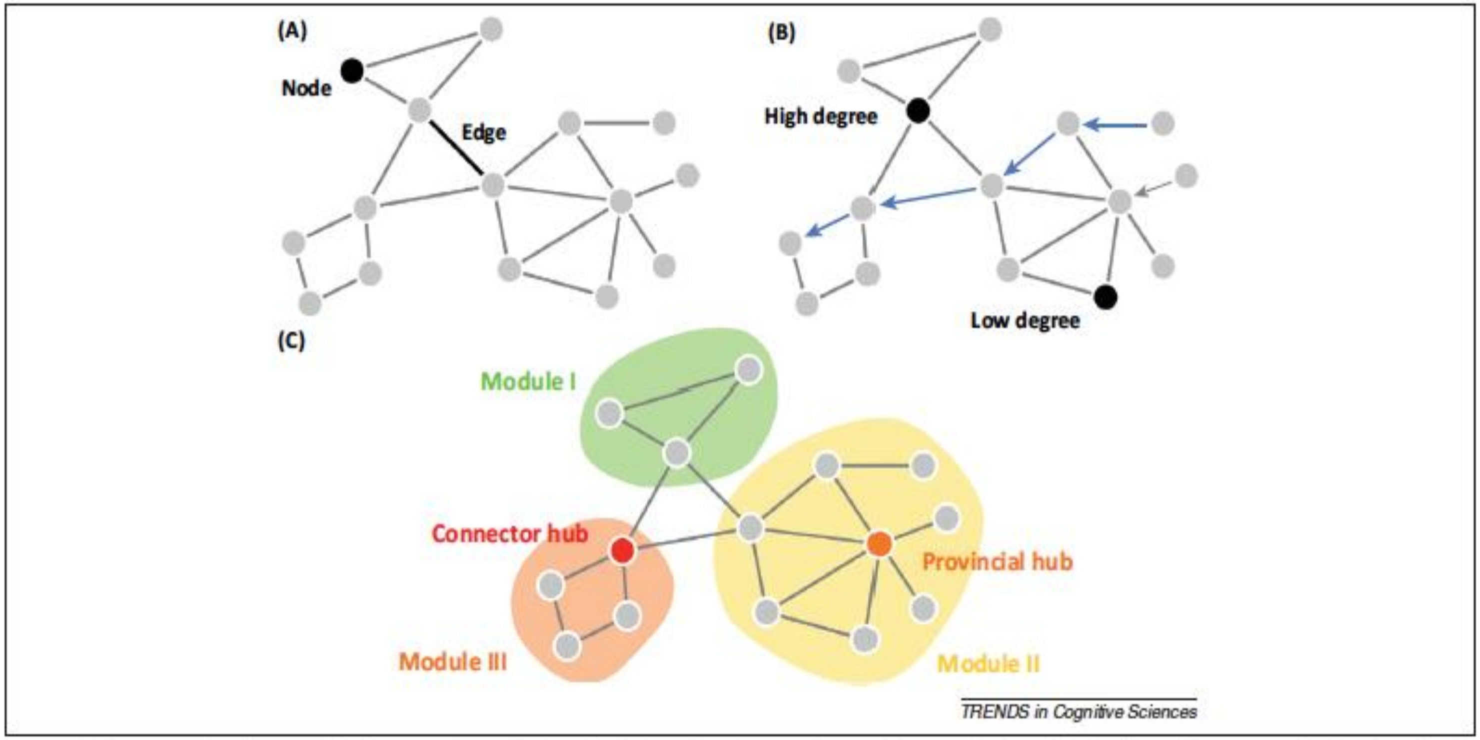
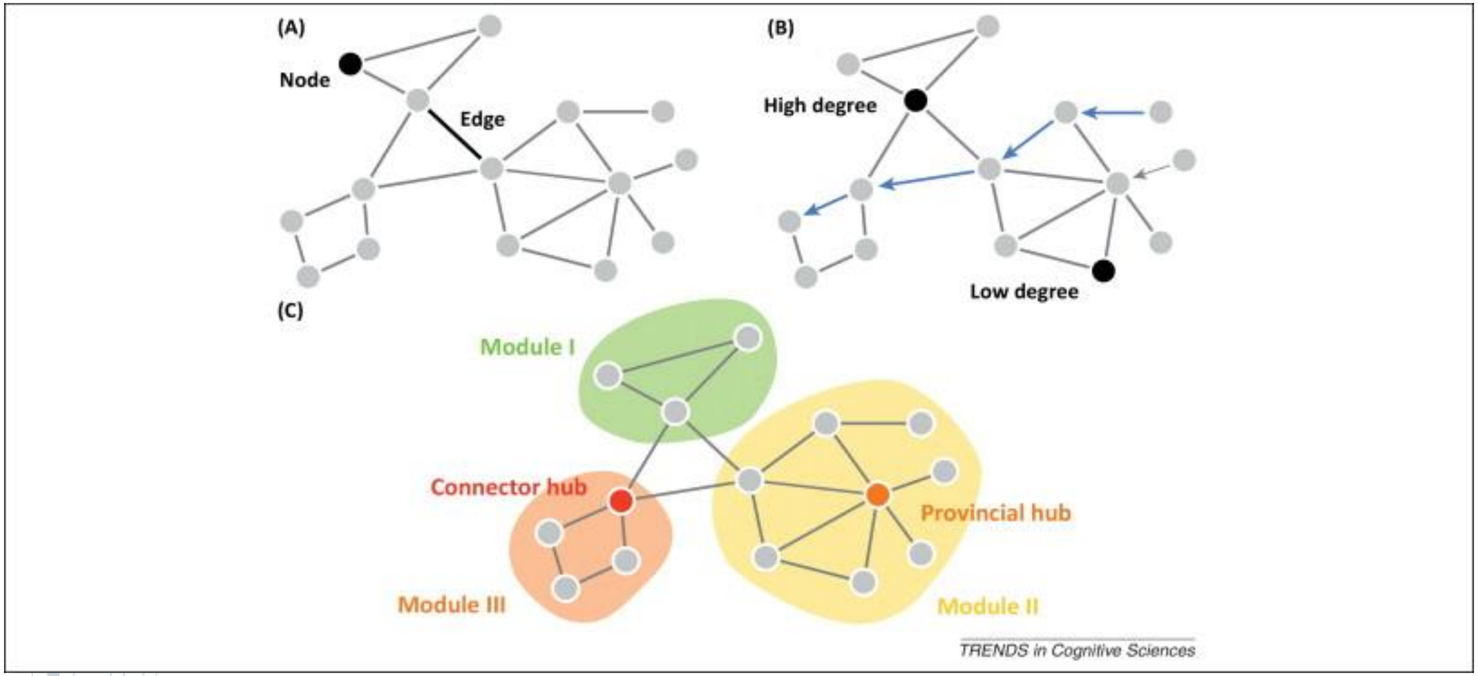
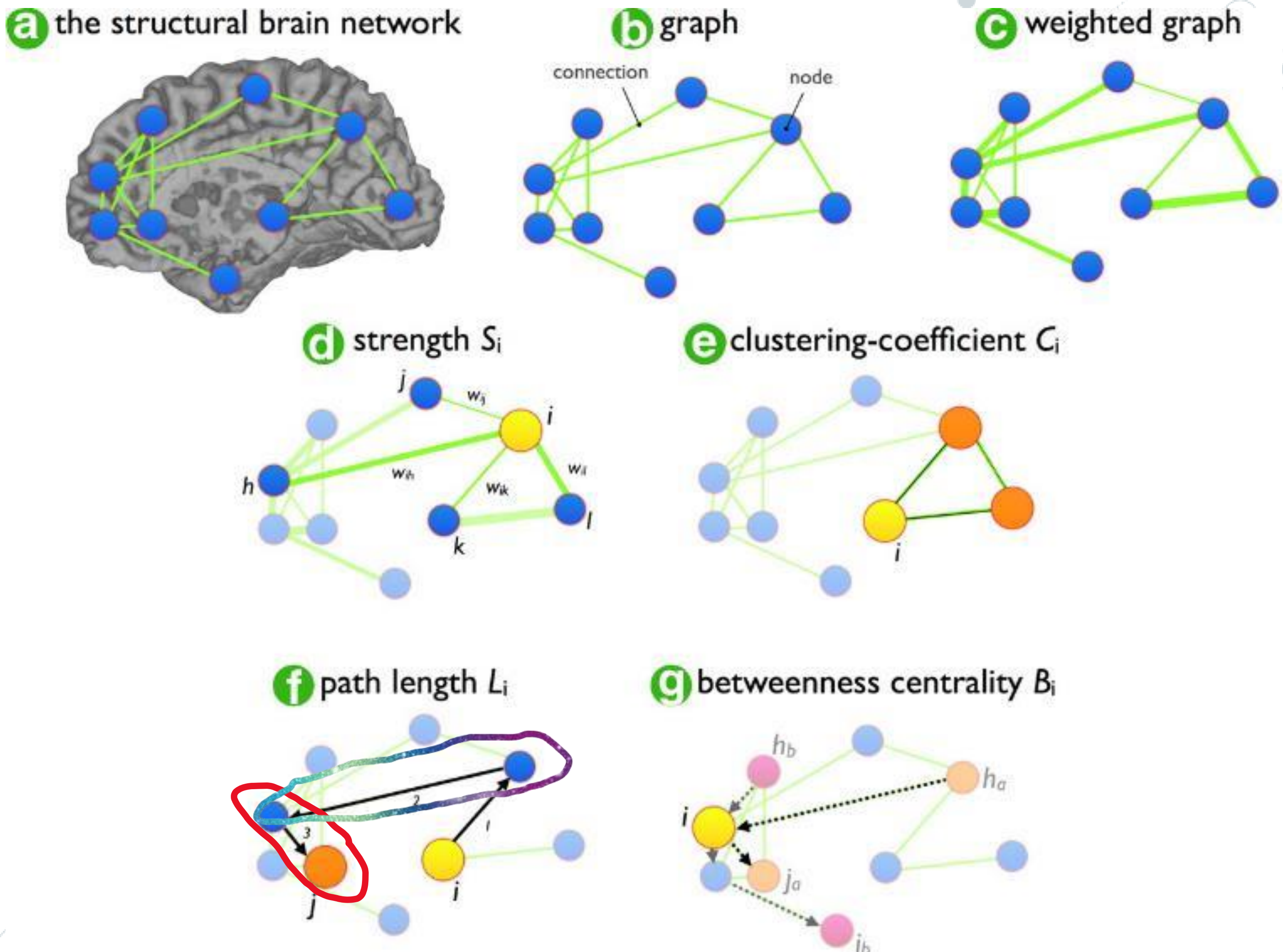


Figure 1. Basic network attributes. **(A)** Brain networks can be described and analyzed as graphs comprising a collection of nodes (describing neurons/brain regions) and a collection of edges (describing structural connections or functional relationships). The arrangement of nodes and edges defines the topological organization of the network. **(B)** A path corresponds to a sequence of unique edges that are crossed when traveling between two nodes in the network. Low-degree nodes are nodes that have a relatively low number of edges; high-degree nodes (often referred to as hubs) are nodes that have a relatively high number of edges. **(C)** A module includes a subset of nodes of the network that show a relatively high level of within-module connectivity and a relatively low level of intermodule connectivity. 'Provincial hubs' are high-degree nodes that primarily connect to nodes in the same module. 'Connector hubs' are high-degree nodes that show a diverse connectivity profile by connecting to several different modules within the network.

Graph Elements

- Hubs: A node with links that exceeds average.
- Low vs High Degree Hubs.
- Provincial Hubs.
- Modules.
- Connector Hubs.





Radius Diameter

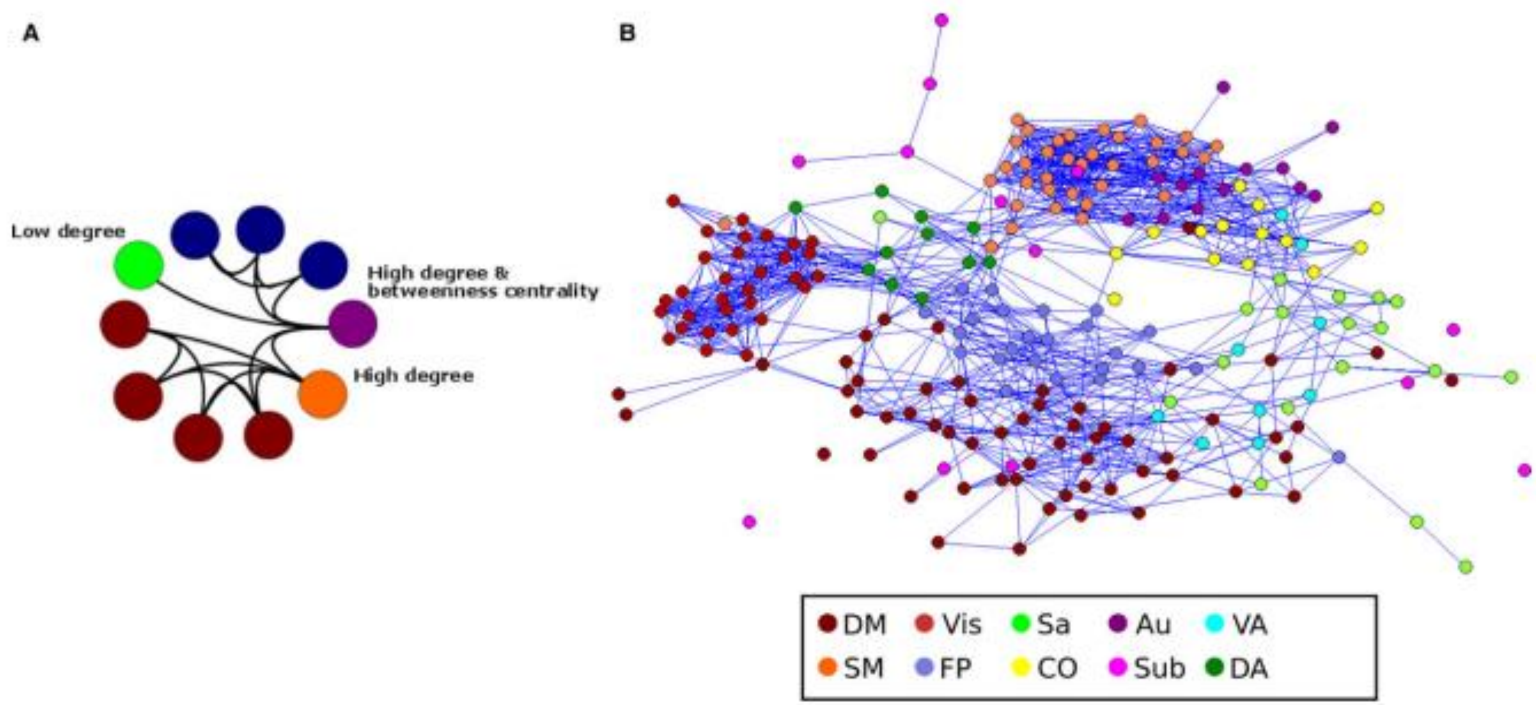
Acta Pædiatrica ISSN 0803-5253

REVIEW ARTICLE

The functional brain connectome of the child and autism spectrum disorders

Katell Mevel[1], Peter Fransson (Peter.Fransson@ki.se)[2]

1.Laboratory for the Psychology of Child Development and Education (LaPsyDÉ), CNRS UMR 8240, Sorbonne Paris Cité, GIP Cyceron, Université de Caen Normandie, Université Paris Descartes, Paris, France
2.Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden



Case Review 1

The patient is a 52-year-old female who presented with struggles with depression, fatigue, anxiety, night sweats over the past 30 years. Just before joining the air force her grandfather hung himself. During her service she had a “breakdown” and couldn’t cope. She was seen by a military psychiatrist and discharged.

She has had individual, group psychotherapy in the past and is currently taking Paxil and Flexeril (Zyprexa and Ambien in the past).

She has had 4 separate psychiatric hospitalizations, 3 for 30 days and one for 3 months. There is a family history of depression, anxiety and bipolar disorder.

MILLON CLINICAL MULTIAXIAL INVENTORY-IV

PROFILE SUMMARY

HIGH-POINT CODE = 7 4B 4A
BR ADJUSTMENTS = A/CC

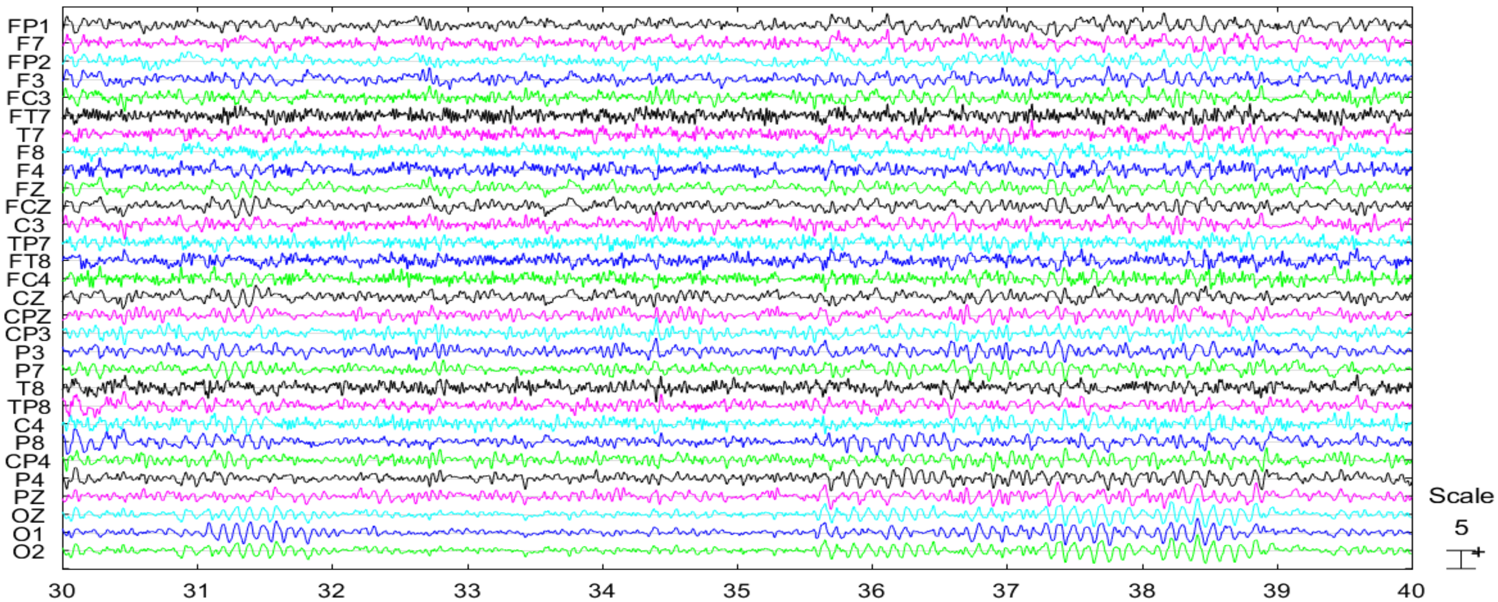
INVALIDITY (V) = 0
INCONSISTENCY (W) = 5

VALIDITY		Score Raw	BR	Profile of BR Scores (0 / 35 / 75 / 100)
Modifying Indices				Low / Average / High
Disclosure	X	27	45	
Desirability	Y	15	69	
Debasement	Z	11	64	

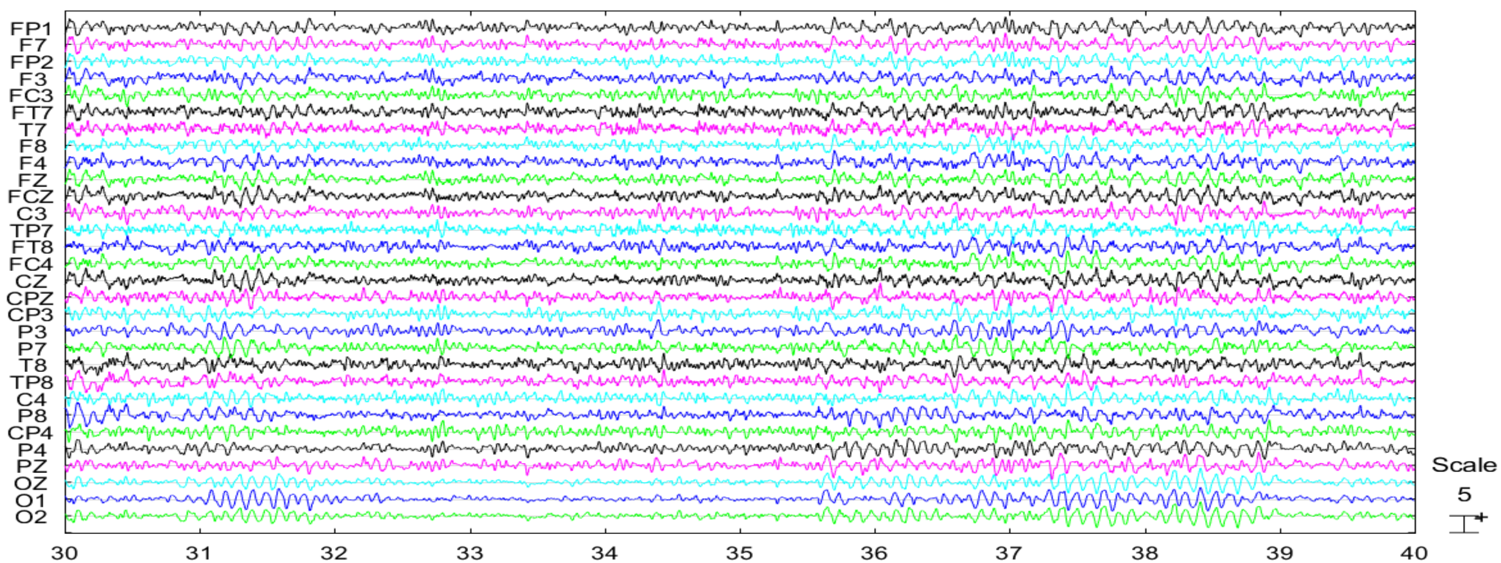
PERSONALITY		Score Raw	PR	BR	Profile of BR Scores (0 / 60 / 75 / 85 / 115)
Clinical Personality Patterns					Style / Type / Disorder
Schizoid	1	1	10	9	
Avoidant	2A	5	35	40	
Melancholic	2B	8	46	55	
Dependent	3	3	27	30	
Histrionic	4A	11	48	60	
Turbulent	4B	12	55	63	
Narcissistic	5	4	38	48	
Antisocial	6A	0	6	0	
Sadistic	6B	0	5	0	
Compulsive	7	17	65	67	
Negativistic	8A	5	40	50	
Masochistic	8B	2	21	19	
Severe Personality Pathology					
Schizotypal	S	1	13	9	
Borderline	C	2	25	15	
Paranoid	P	9	75	71	

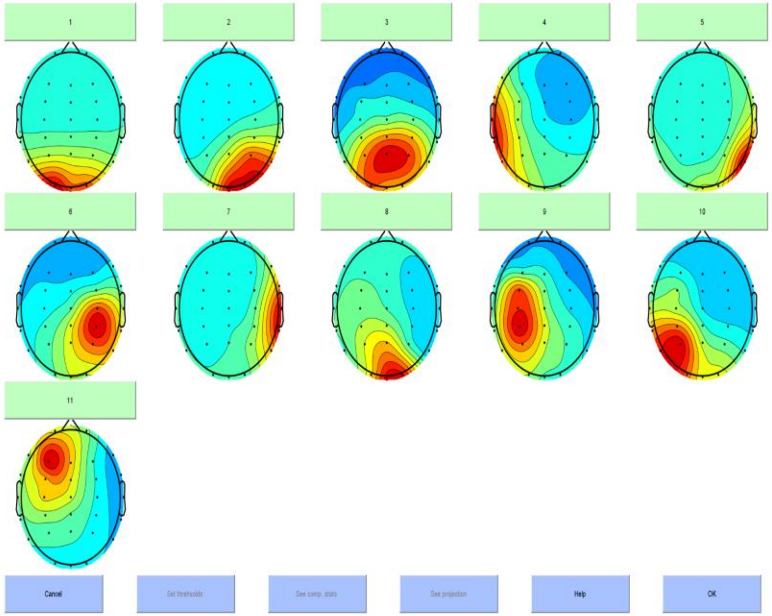
PSYCHOPATHOLOGY		Score Raw	PR	BR	Profile of BR Scores (0 / 60 / 75 / 85 / 115)
Clinical Syndromes					Present / Prominent
Generalized Anxiety	A	12	86	94	
Somatic Symptom	H	11	83	78	
Bipolar Spectrum	N	5	43	60	
Persistent Depression	D	9	48	60	
Alcohol Use	B	0	14	0	
Drug Use	T	0	10	0	
Post-Traumatic Stress	R	15	93	95	
Severe Clinical Syndromes					
Schizophrenic Spectrum	SS	5	38	43	
Major Depression	CC	11	68	79	
Delusional	PP	2	63	62	

10121966 EC 1 PRE IC REJ



10121966 EC 1 POST IC REJ





1
2
3
4
5
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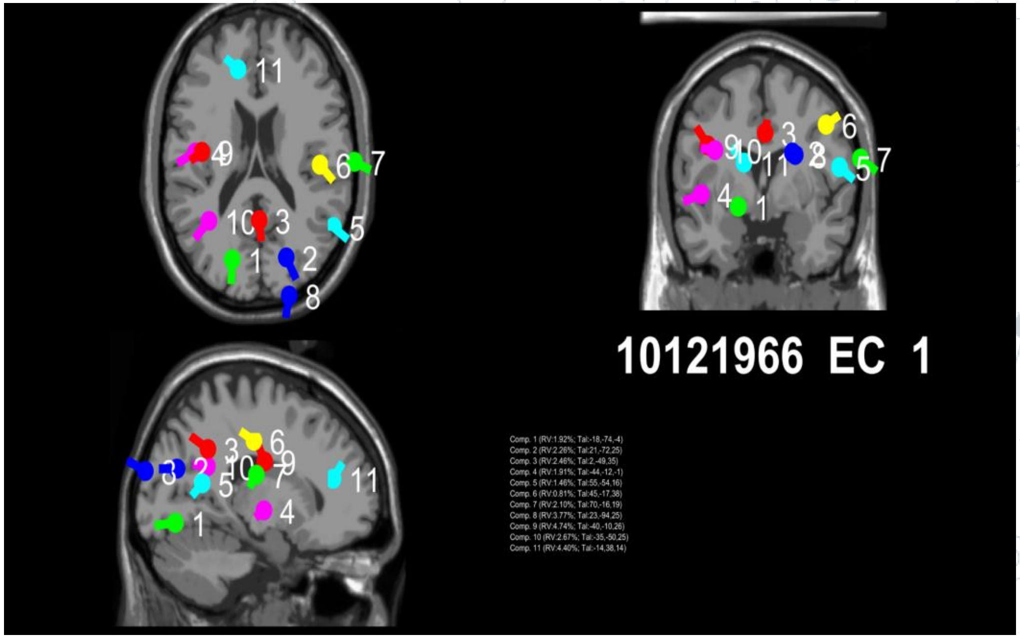
7
8
9
10
11
Cancel
Help
OK



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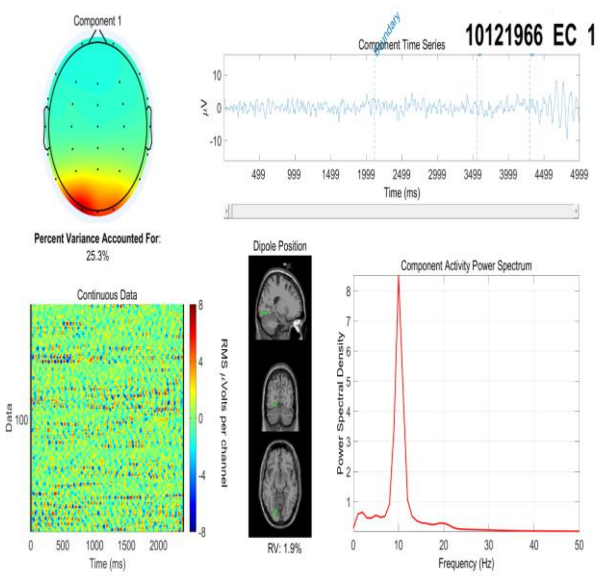
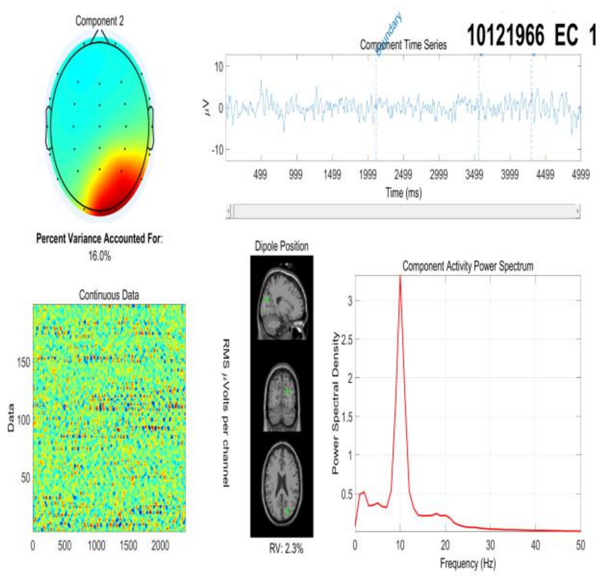
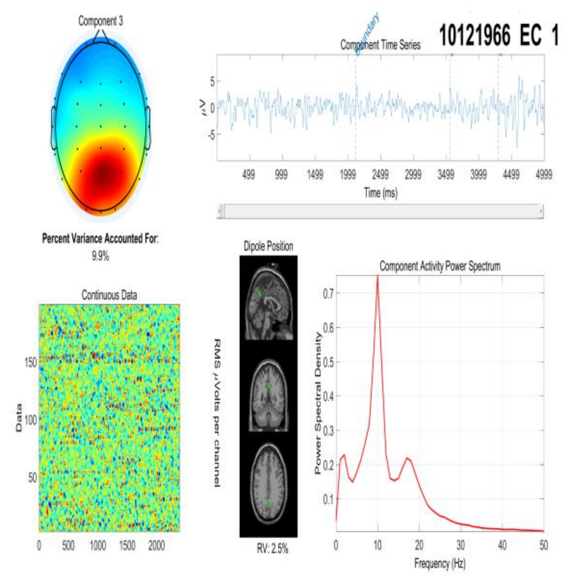
Comp. 3 (RV:2.46%; Tal:2,-49,35)
Comp. 4 (RV:1.91%; Tal:-44,-12,-1)
Comp. 5 (RV:1.46%; Tal:55,-54,16)
Comp. 6 (RV:0.81%; Tal:45,-17,38)
Comp. 7 (RV:2.10%; Tal:70,-16,19)
Comp. 8 (RV:3.77%; Tal:23,-94,25)
Comp. 9 (RV:4.74%; Tal:-40,-10,26)
Comp. 10 (RV:2.67%; Tal:-35,-50,25)
Comp. 11 (RV:4.40%; Tal:-14,38,14)



Component 1
10121966 EC 1
Component Time Series
Time (ms)
Percent Variance Accounted For:
25.3%
Continuous Data
Data
Time (ms)
RMS μVolts per channel
Dipole Position
RV: 1.9%
Component Activity Power Spectrum
Power Spectral Density
Frequency (Hz)

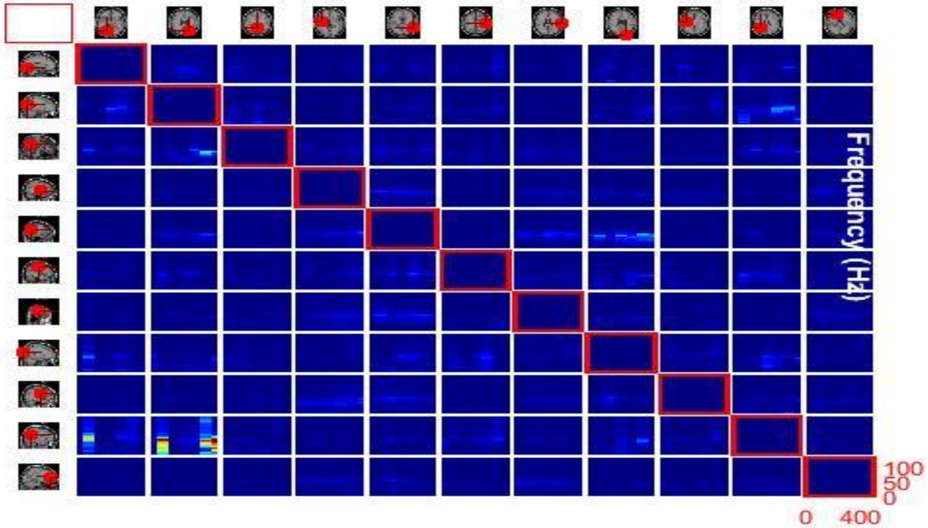


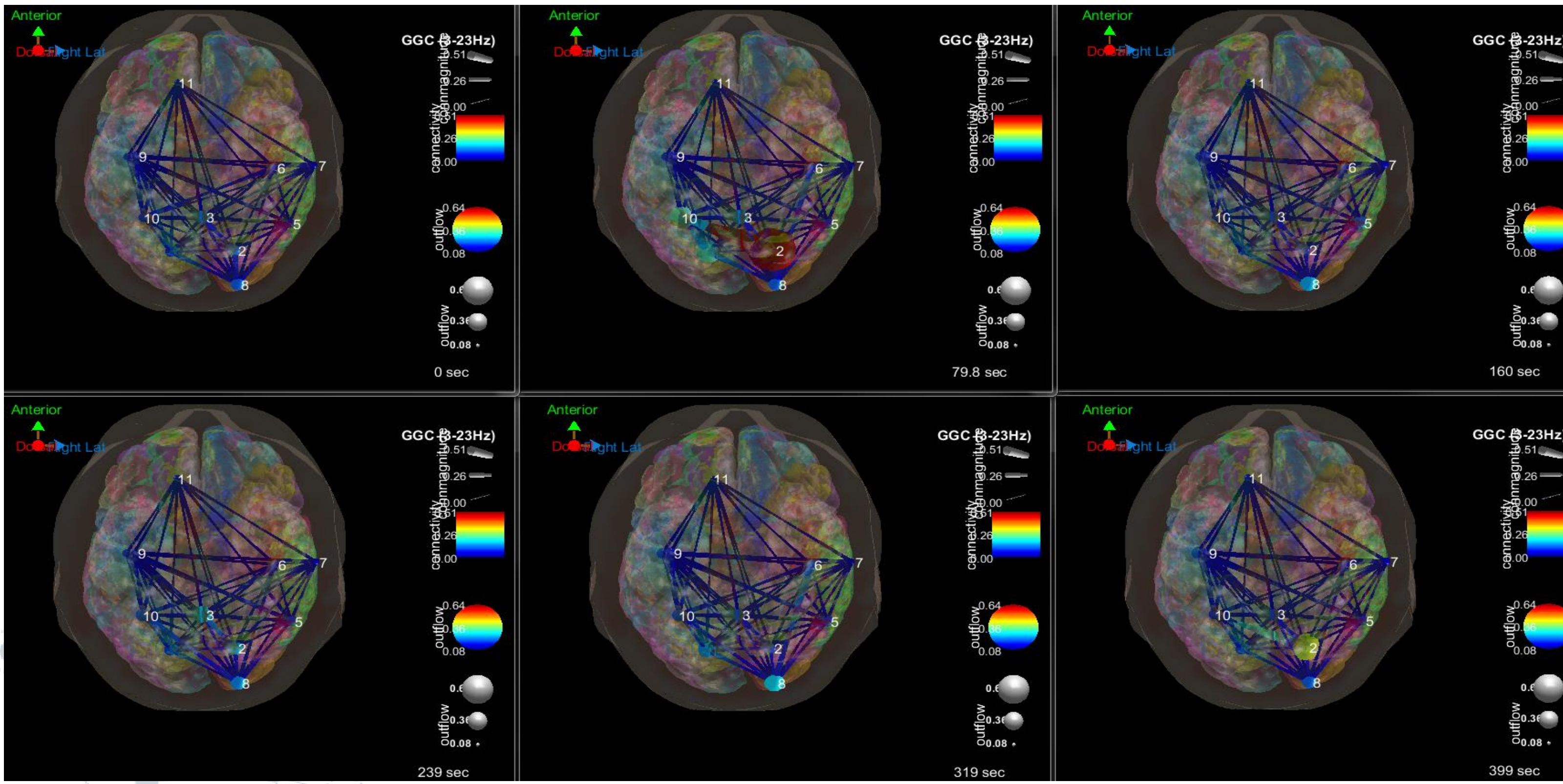
Component 2
10121966 EC 1
Component Time Series
Time (ms)
Percent Variance Accounted For:
16.0%
Continuous Data
Data
RMS μVolts per channel
Dipole Position
RV: 2.3%
Component Activity Power Spectrum
Power Spectral Density
Frequency (Hz)

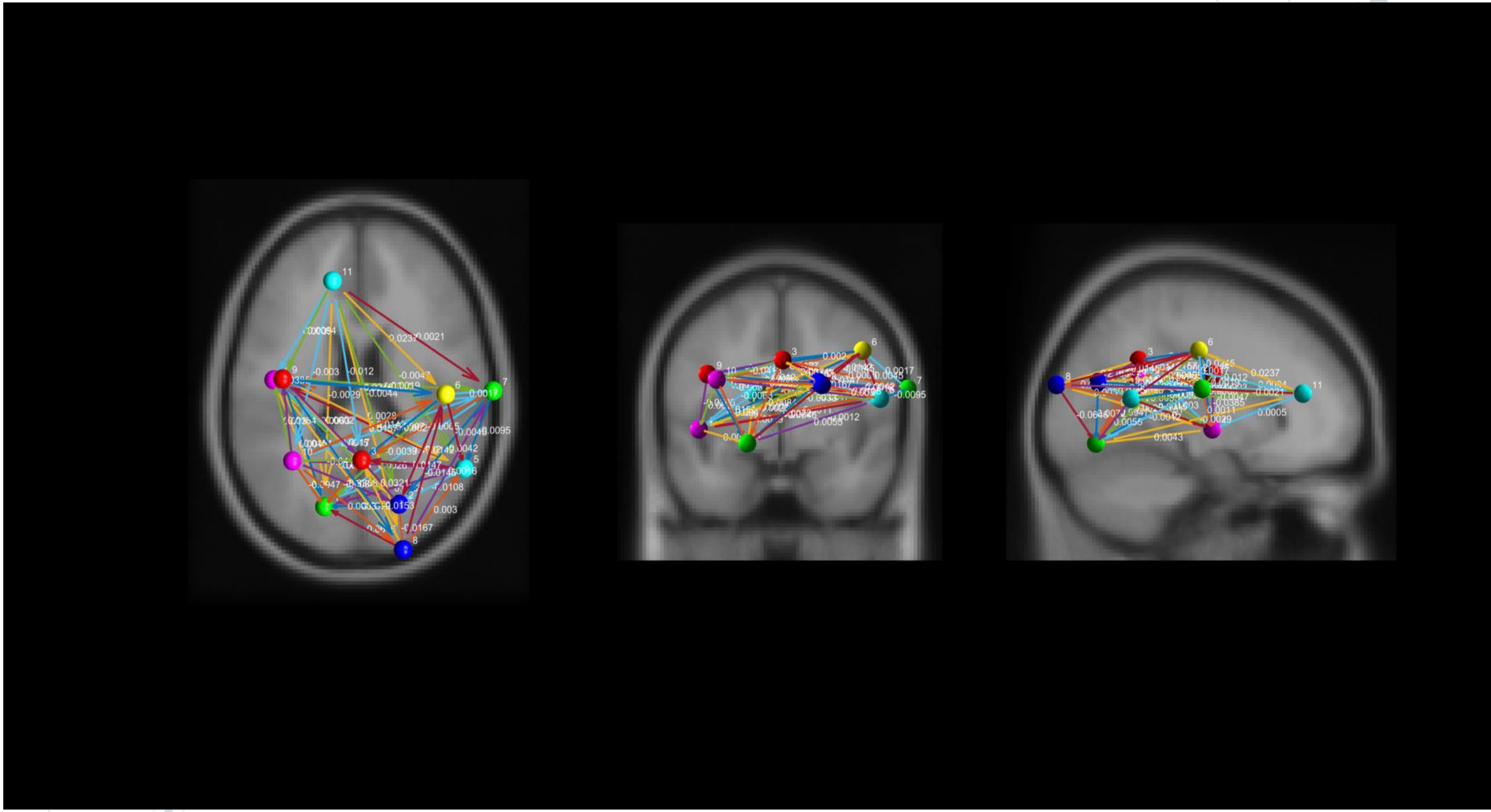


Component 3
10121966 EC 1
Component Time Series
Time (ms)
Percent Variance Accounted For:
9.9%
Continuous Data
Data
RMS μVolts per channel
Dipole Position
RV: 2.5%
Component Activity Power Spectrum
Power Spectral Density
Frequency (Hz)

Record Number	X coor	Y coor	Z coor	Hits	Level 1	Level 2	Level 3	Level 4	Level 5
1	-17.9689	-76.3006	-9.54066	457	Left Cerebrum	Occipital Lobe	Lingual Gyrus	Gray Matter	Brodmann area 18
				371	Left Cerebellum	Posterior Lobe	Declive	Gray Matter	*
				214	Left Cerebrum	Occipital Lobe	Lingual Gyrus	White Matter	*
				197	Left Cerebrum	Occipital Lobe	Lingual Gyrus	*	*
				44	Left Cerebrum	Occipital Lobe	Fusiform Gyrus	Gray Matter	Brodmann area 19
2	21.29228	-75.068	23.15213	386	Right Cerebrum	Occipital Lobe	Cuneus	White Matter	*
				244	Right Cerebrum	Occipital Lobe	Cuneus	Gray Matter	Brodmann area 18
				171	Right Cerebrum	Occipital Lobe	Precuneus	White Matter	*
				163	Right Cerebrum	Occipital Lobe	Precuneus	Gray Matter	Brodmann area 31
				140	Right Cerebrum	Temporal Lobe	Sub-Gyral	White Matter	*
3	1.601619	-52.6508	34.94127	188	Right Cerebrum	Parietal Lobe	Precuneus	Gray Matter	Brodmann area 7
				178	Left Cerebrum	Parietal Lobe	Precuneus	Gray Matter	Brodmann area 7
				164	Right Cerebrum	Parietal Lobe	Precuneus	Gray Matter	Brodmann area 31
4	-44.7611	-11.9063	-2.00501	343	Left Cerebrum	Sub-lobar	Insula	Gray Matter	Brodmann area 13
				297	Left Cerebrum	Temporal Lobe	Superior Temporal Gyrus	Gray Matter	Brodmann area 22
				248	Left Cerebrum	Sub-lobar	Insula	White Matter	*
5	55.58425	-56.7925	14.32101	460	Right Cerebrum	Temporal Lobe	Superior Temporal Gyrus	White Matter	*
				241	Right Cerebrum	Temporal Lobe	Middle Temporal Gyrus	White Matter	*

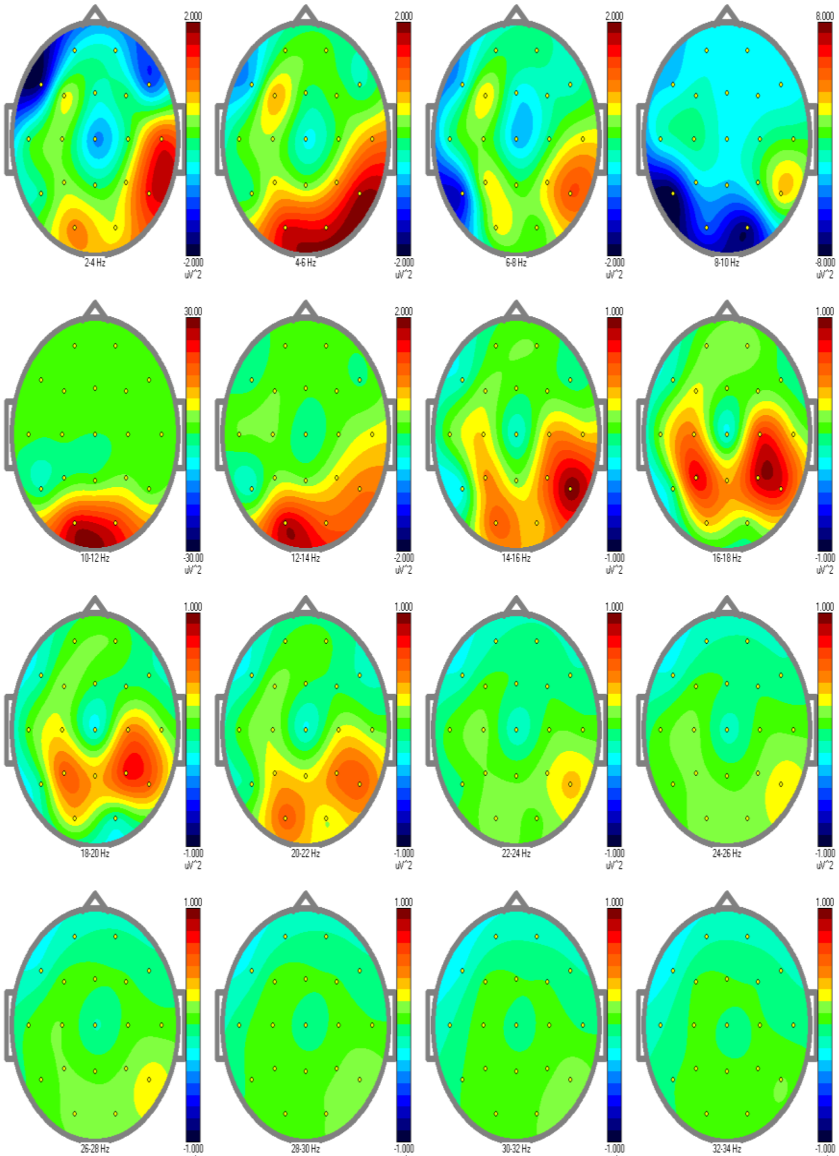

Frequency (Hz)
100
50
0
0
400


Anterior
connectivity
outflow
0 sec
79.8 sec
160 sec
239 sec
319 sec
399 sec

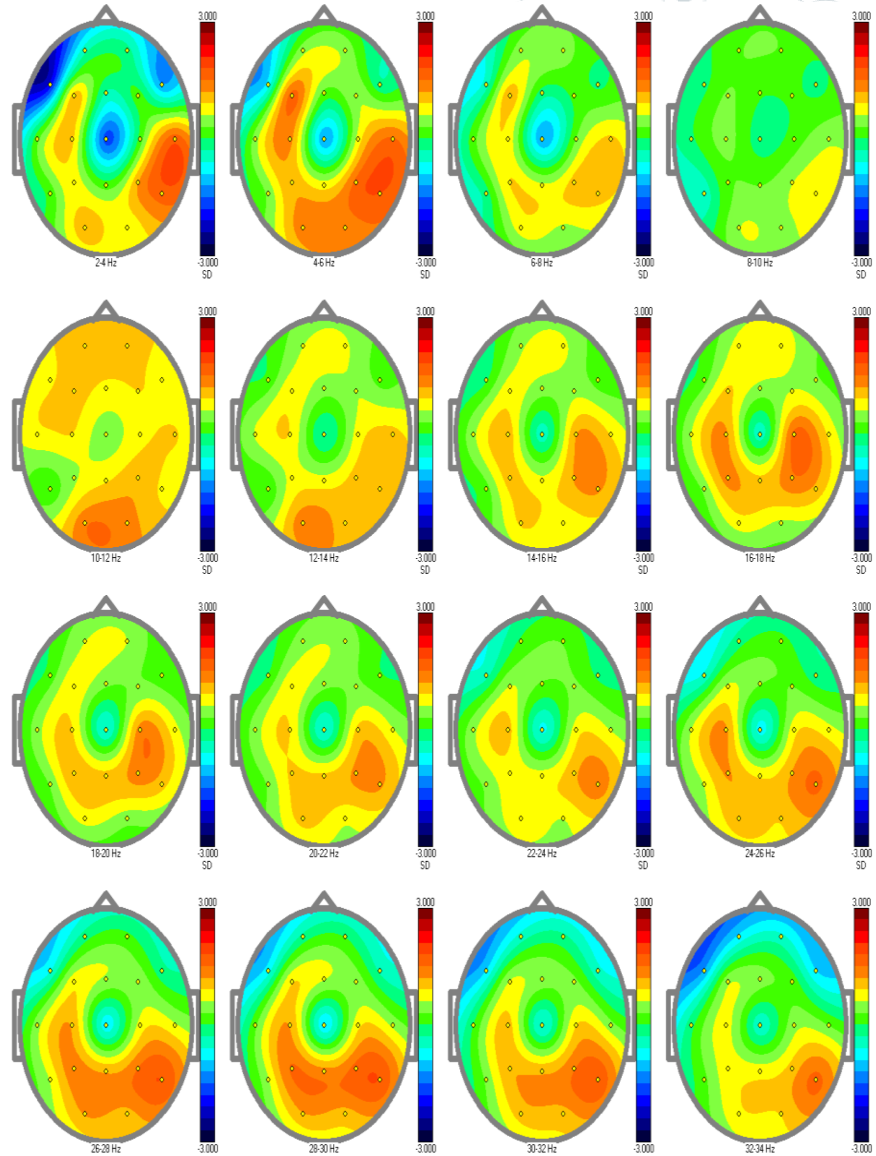


WinEEG

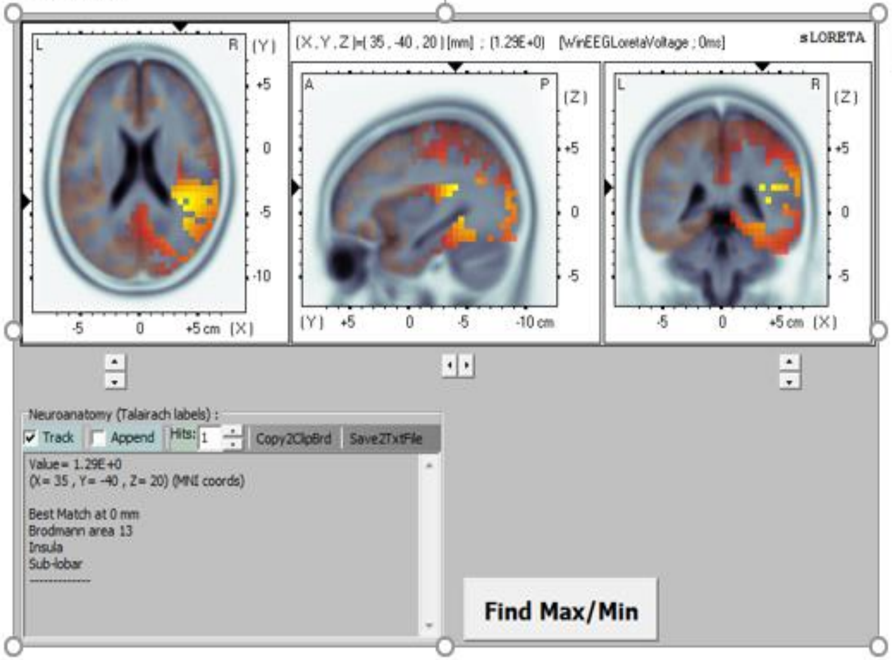
Raw Absolute Power

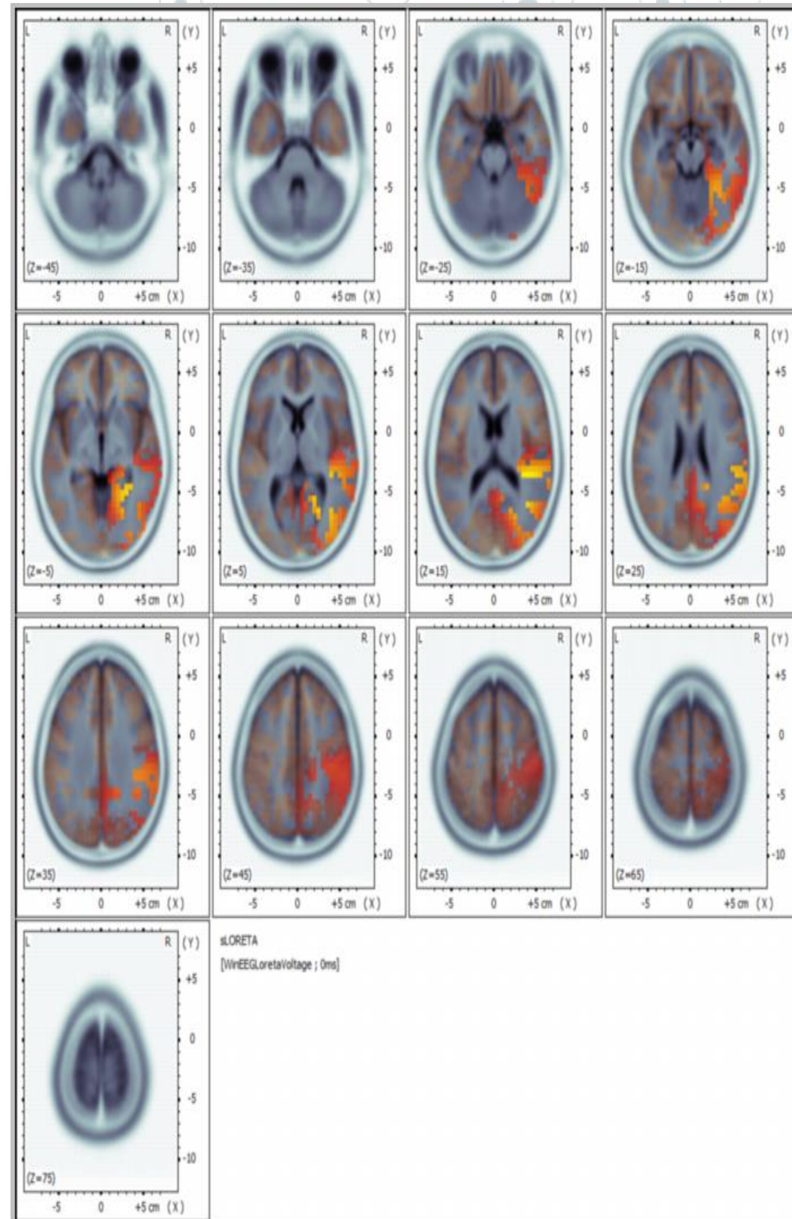


Z-Score Absolute Power

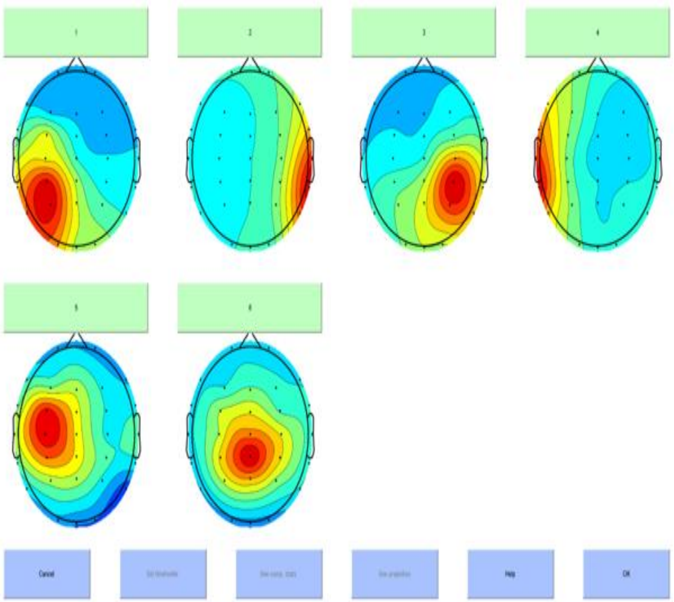


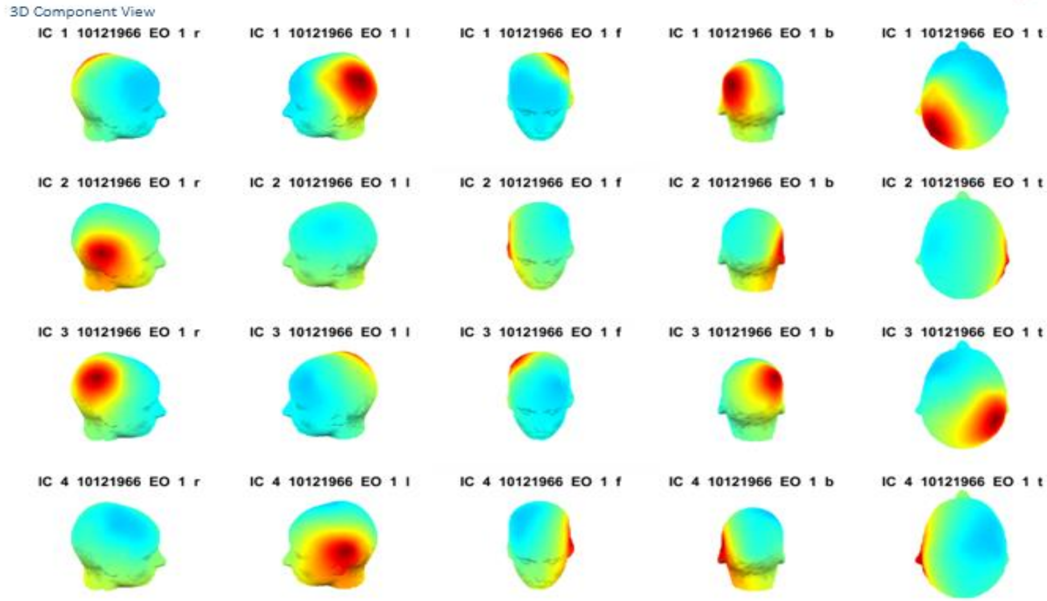
10-12 Hz range





Eyes Open




3D Component View
IC 1 10121966 EO 1 r
IC 1 10121966 EO 1 l
IC 1 10121966 EO 1 f
IC 1 10121966 EO 1 b
IC 1 10121966 EO 1 t
IC 2 10121966 EO 1 r
IC 2 10121966 EO 1 l
IC 2 10121966 EO 1 f
IC 2 10121966 EO 1 b
IC 2 10121966 EO 1 t
IC 3 10121966 EO 1 r
IC 3 10121966 EO 1 l
IC 3 10121966 EO 1 f
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IC 3 10121966 EO 1 t
IC 4 10121966 EO 1 r
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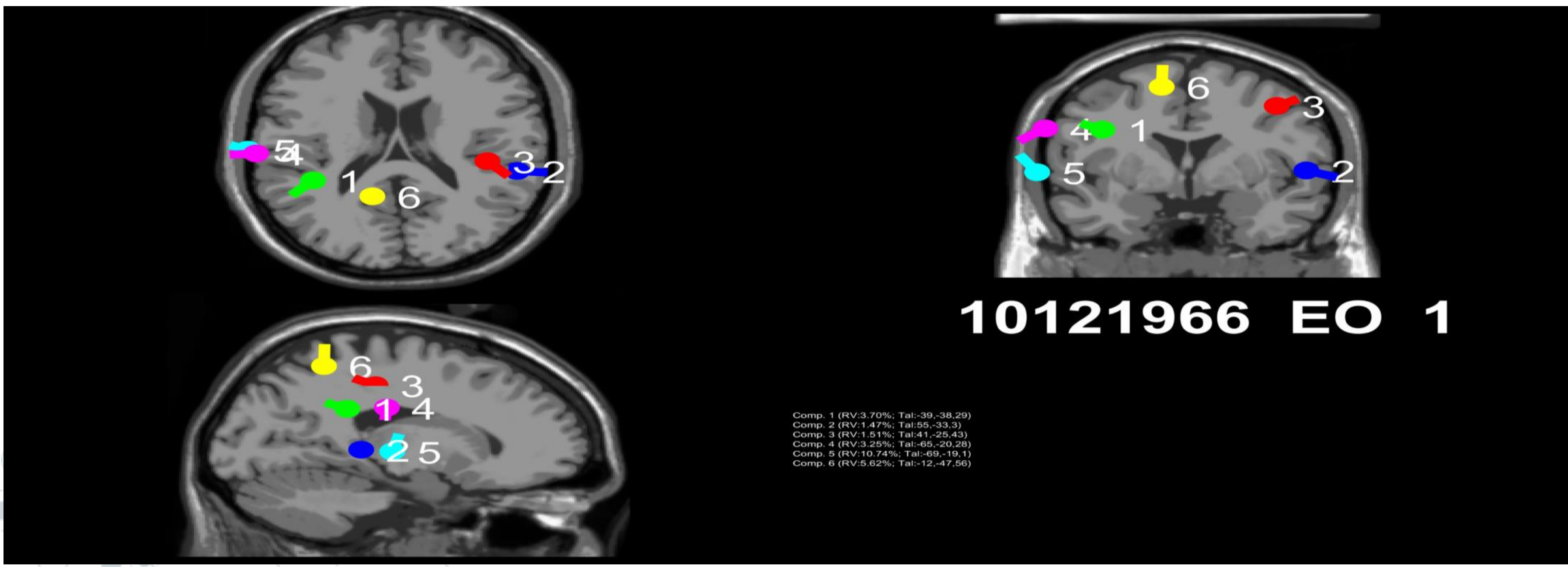
IC 4 10121966 EO 1 b
IC 4 10121966 EO 1 t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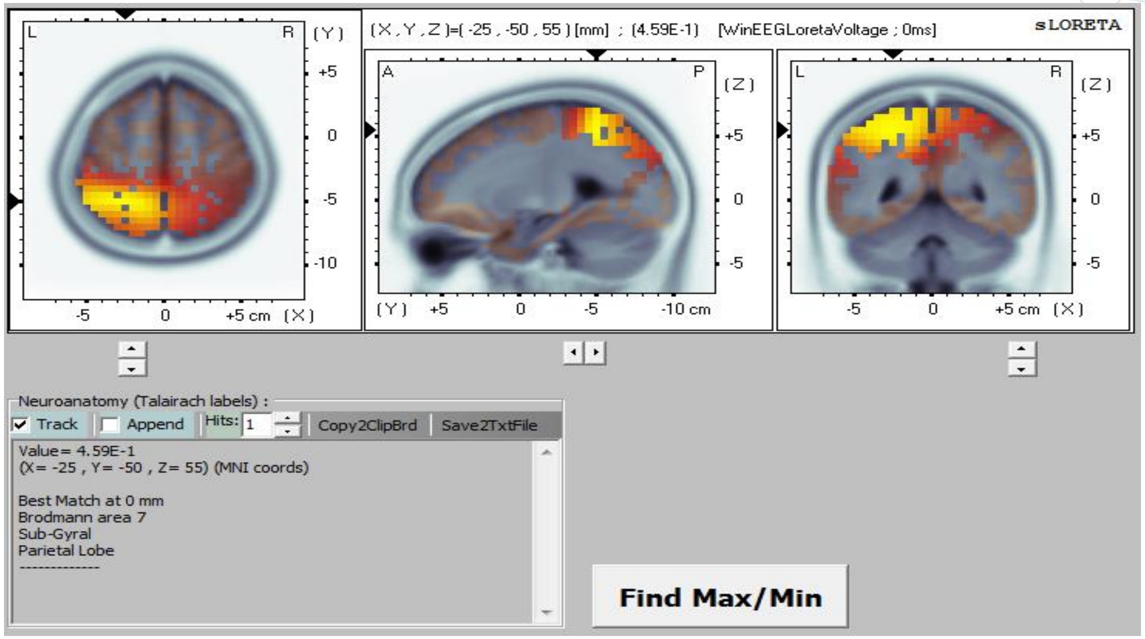
Comp. 2 (RV:1.47%; Tal:55,-33,3)
Comp. 3 (RV:1.51%; Tal:41,-25,43)
Comp. 4 (RV:3.25%; Tal:-65,-20,28)
Comp. 5 (RV:10.74%; Tal:-69,-19,1)
Comp. 6 (RV:5.62%; Tal:-12,-47,56)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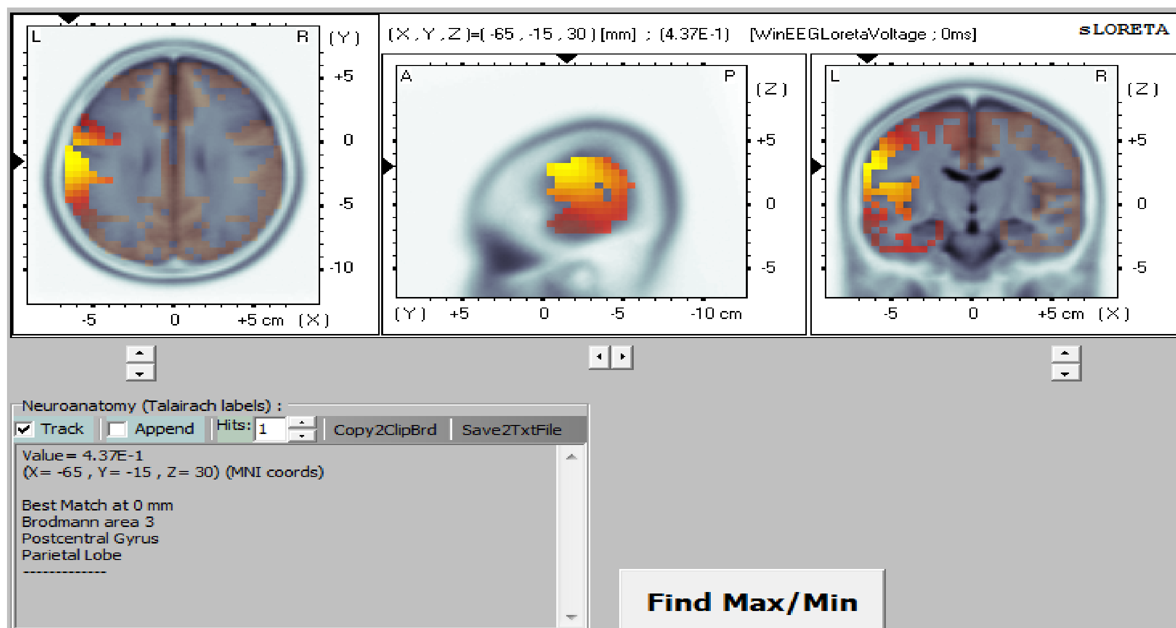
sLORETA
L
R
(Y)
+5
0
-5
-10
-5
0
+5 cm (X)
A
P
(Z)
+5
0
-5
(Y) +5
0
-5
-10 cm
L
R
(Z)
+5
0
-5
-5
0
+5 cm (X)
Neuroanatomy (Talairach labels) :
Track
Append
Hits: 1
Copy2ClipBrd
Save2TxtFile
Value= 4.59E-1
(X= -25 , Y= -50 , Z= 55) (MNI coords)
Best Match at 0 mm
Brodmann area 7
Sub-Gyral
Parietal Lobe

Find Max/Min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sLORETA
L
R
(Y)
+5
0
-5
-10
-5
0
+5 cm (X)
A
P
(Z)
+5
0
-5
(Y) +5
0
-5
-10 cm
L
R
(Z)
+5
0
-5
-5
0
+5 cm (X)
Neuroanatomy (Talairach labels) :
Track
Append
Hits: 1
Copy2ClipBrd
Save2TxtFile
Value= 4.37E-1
(X= -65 , Y= -15 , Z= 30) (MNI coords)
Best Match at 0 mm
Brodmann area 3
Postcentral Gyrus
Parietal Lobe

Find Max/Min

Case Review 2

The patient is a 10-year-old female who presented with symptoms of impulsivity, poor auditory processing, speech articulation, behavioral problems, attachment issues and expressing unwanted thoughts about sexual contact. This has included wanting to touch others in inappropriate ways.

She was adopted through the foster care system after her foster home was shut down due to allegations of sexual abuse. Prior to this, she was abandoned by her mother at 4 months and then reared in a foster home until 20 months when she was then adopted by her current parents.

She currently receives psychotherapy and EMDR treatment. She is in the 4th grade and is being home schooled as she cannot be around other children at this time. She has struggled with reading, spelling and math.

Presenting difficulties included depression, intense anxiety, obsessive sexual thoughts toward family members and peers, thoughts about hurting her parents, and previous thoughts about hurting herself.

WISC®-V
Wechsler Intelligence Scale for Children®-Fifth Edition

Composite Score Summary

Composite		Sum of Scaled Scores	Composite Score	Percentile Rank	95% Confidence Interval	Qualitative Description	*SEM*
Verbal Comprehension	VCI	12	78	7	72-87	Very Low	3.97
Visual Spatial	VSI	7	64	1	59-75	Extremely Low	4.50
Fluid Reasoning	FRI	11	74	4	69-83	Very Low	3.97
Working Memory	WMI	12	76	5	70-86	Very Low	4.50
Processing Speed	PSI	24	111	77	101-119	High Average	5.41
Full Scale IQ	FSIQ	43	73	4	68-80	Very Low	3.00

Confidence intervals are calculated using the Standard Error of Estimation.

Color-Word Interference Test

	Raw Score	Scaled Score
Primary Measures: Completion Times		
Condition 1: Color Naming	45	9
Condition 2: Word Reading	26	12
Condition 3: Inhibition	159	2
Condition 4: Inhibition/Switching	94	9

TABLE OF SCORES

Woodcock-Johnson IV Tests of Achievement Form A and Extended (Norms based on age 10-5)

CLUSTER/Test	W	AE	RPI	SS (68% Band)
READING	473	7-10	30/90	78 (76-81)
BROAD READING	472	8-2	27/90	82 (79-85)
BASIC READING SKILLS	476	7-11	40/90	82 (79-85)
READING FLUENCY	481	8-10	50/90	88 (84-92)
MATHEMATICS	462	7-7	13/90	69 (66-73)
BROAD MATHEMATICS	472	8-1	26/90	76 (73-79)
MATH CALCULATION SKILLS	474	8-4	31/90	81 (77-84)
WRITTEN LANGUAGE	487	8-10	67/90	89 (86-92)
BROAD WRITTEN LANGUAGE	490	9-1	75/90	91 (88-93)
WRITTEN EXPRESSION	495	9-7	84/90	95 (92-99)

Scaled Scores

Score Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Comprehension of Instructions Total Score						+													
Phonological Processing Total Score						+													
Speeded Naming Total Completion Time							+												
Speeded Naming Combined Scaled Score						+													

Scaled Scores

Score Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Affect Recognition Total Score										+									

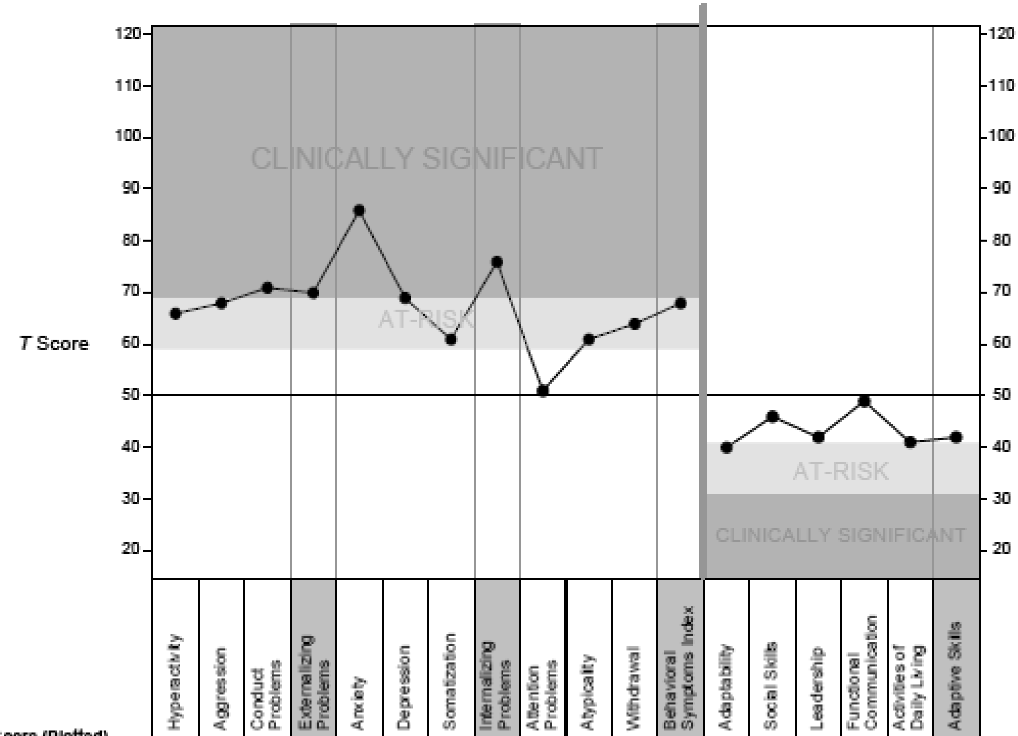
Percentile Ranks

Score Name	<2	2-10	11-25	26-75	>75
Affect Recognition Total Happy (H) Errors				+	
Affect Recognition Total Sad (S) Errors		+			
Affect Recognition Total Neutral (N) Errors				+	
Affect Recognition Total Fear (F) Errors		+			
Affect Recognition Total Angry (A) Errors			+		
Affect Recognition Total Disgust (D) Errors				+	
Theory of Mind Total Score		+			
Theory of Mind–Verbal Score			+		

Behavior Assessment System for Children, Third Edition (BASC™-3)

BASC-3 Parent Rating Scales - Child

CLINICAL AND ADAPTIVE *T*-SCORE PROFILE



	Hyperactivity	Aggression	Conduct Problems	Externalizing Problems	Anxiety	Depression	Somatization	Internalizing Problems	Attention Problems	Atypicality	Withdrawal	Behavioral Symptoms Index	Adaptability	Social Skills	Leadership	Functional Communication	Activities of Daily Living	Adaptive Skills
***T* Score (Plotted)**																		
● Clinical Combined	66	68	71	70	86	69	61	76	51	61	64	68	40	46	42	49	41	42
Percentile																		
Clinical Combined	93	94	96	96	99	94	87	98	51	85	89	95	17	34	23	45	19	24

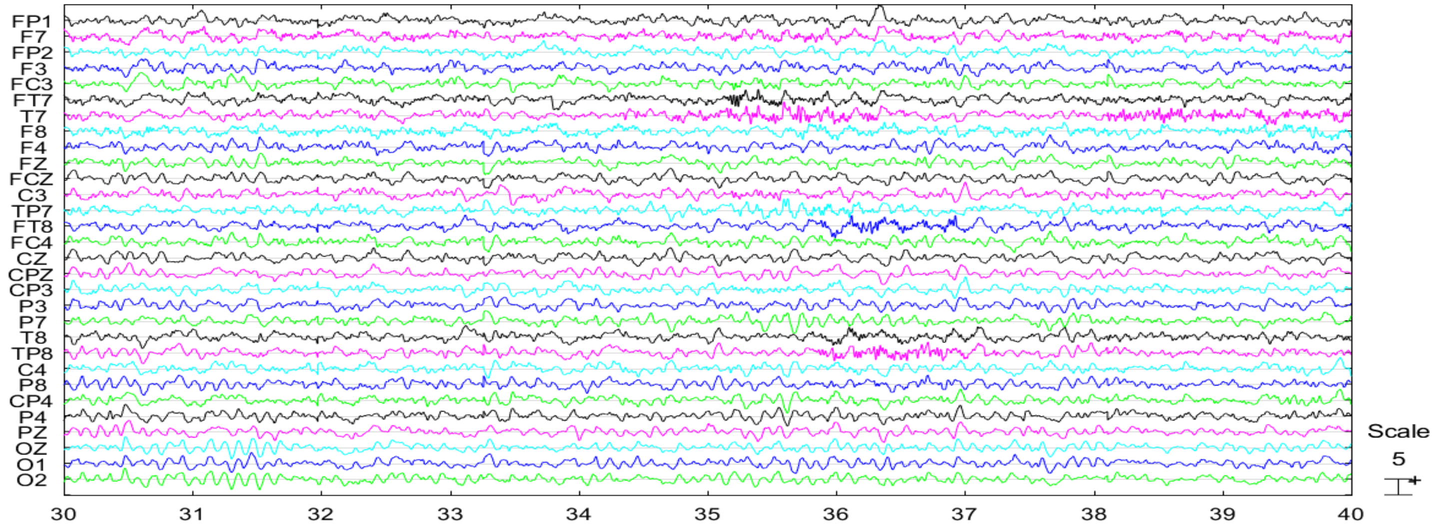
Trauma Symptom Checklist for Young Children™

TSCYC Clinical Scales

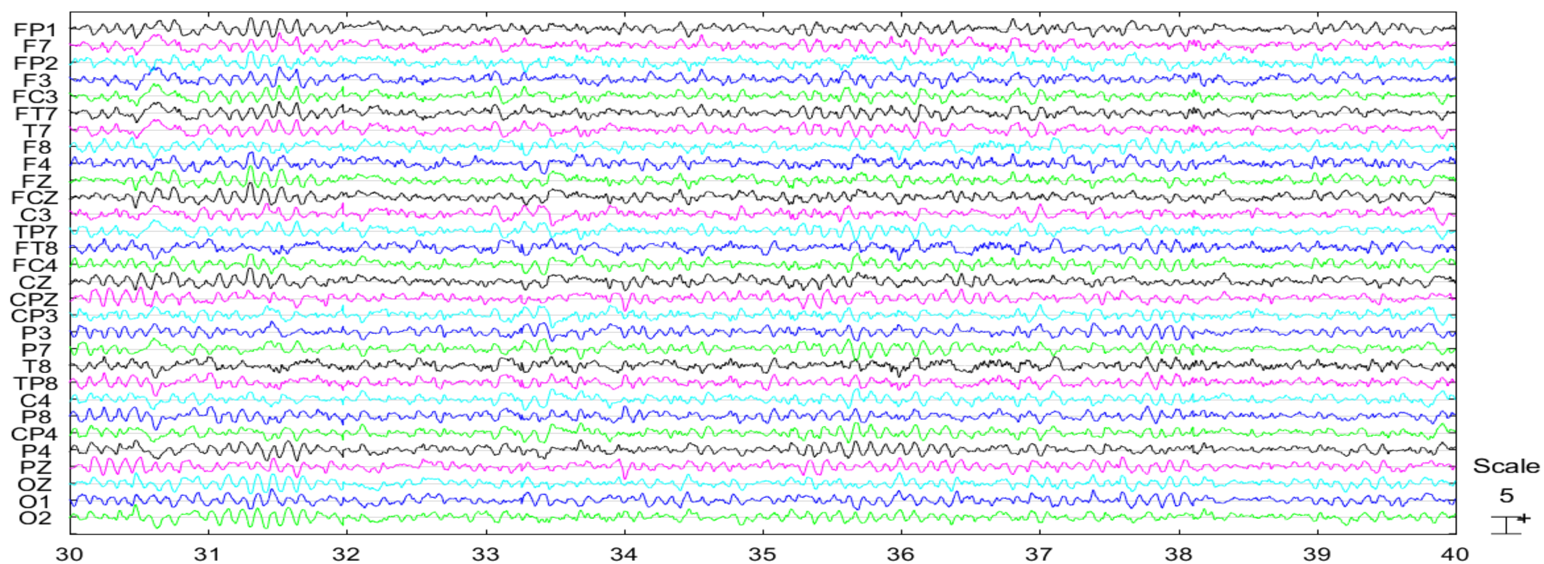
Scale	Raw score	*T* score	%ile
Anxiety (*ANX*)	28	95†	99
Depression (*DEP*)	25	87†	99
Anger/Aggression (*ANG*)	18	67	97
Posttraumatic Stress-Intrusion (*PTS-I*)	26	95†	99
Posttraumatic Stress-Avoidance (*PTS-AV*)	19	77†	98
Posttraumatic Stress-Arousal (*PTS-AR*)	35	107†	99
Posttraumatic Stress-Total (*PTS-TOT*)	80	97†	99
Dissociation (*DIS*)	13	53	78
Sexual Concerns (*SC*)	20	90†	99

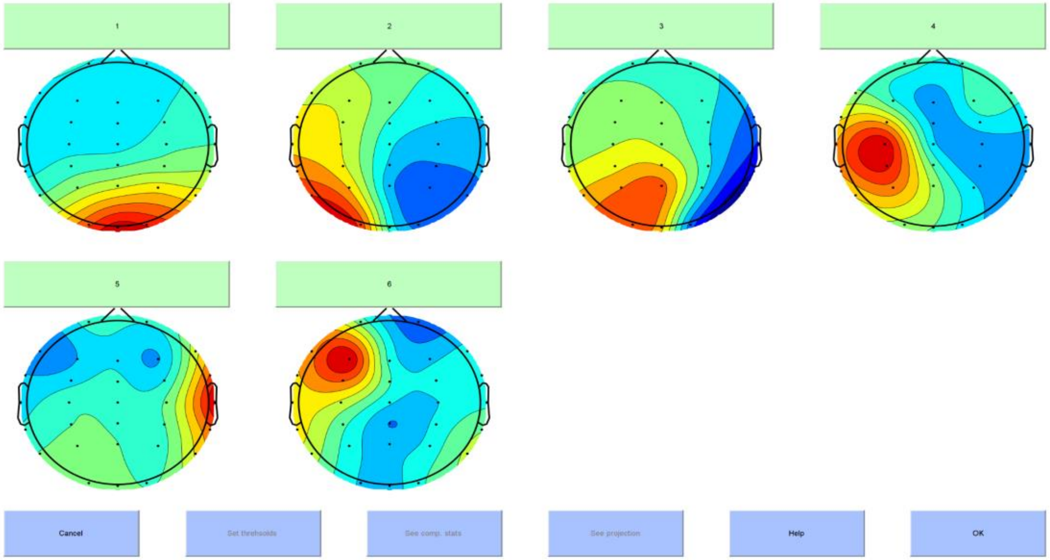
Note. "†" indicates *T* score is clinically significant.

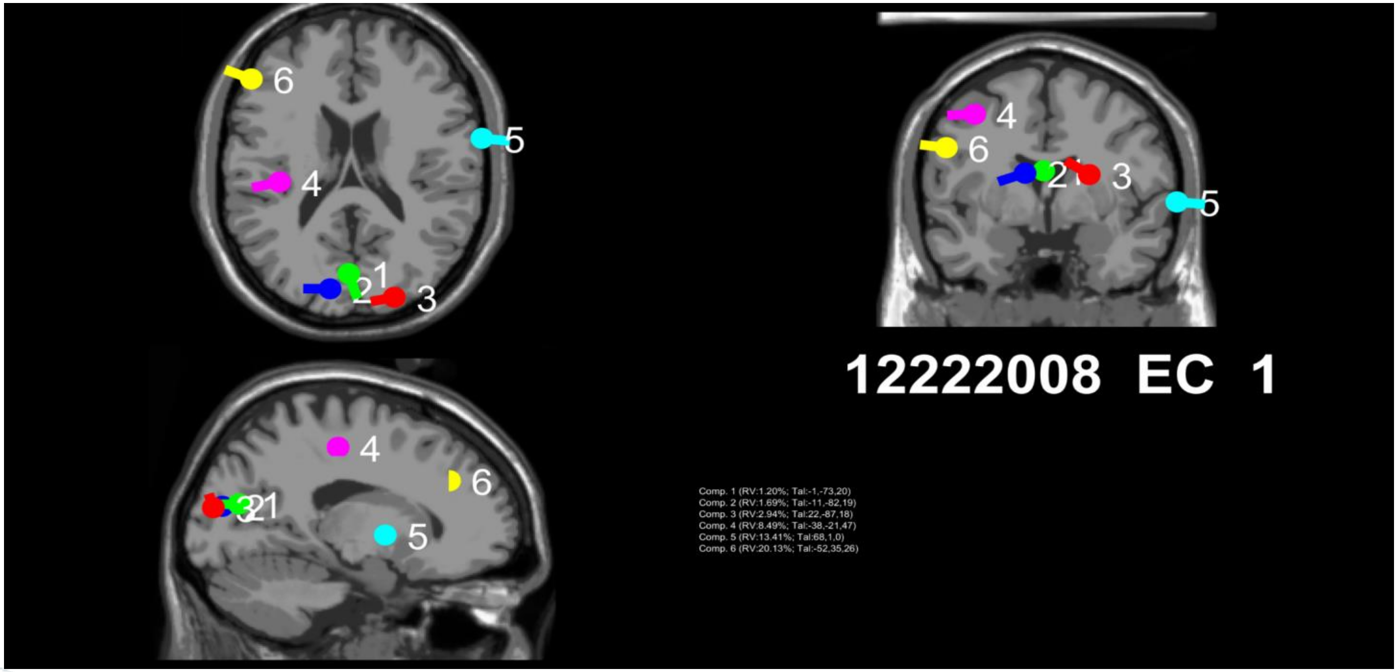
12222008 EC 1 PRE IC REJ

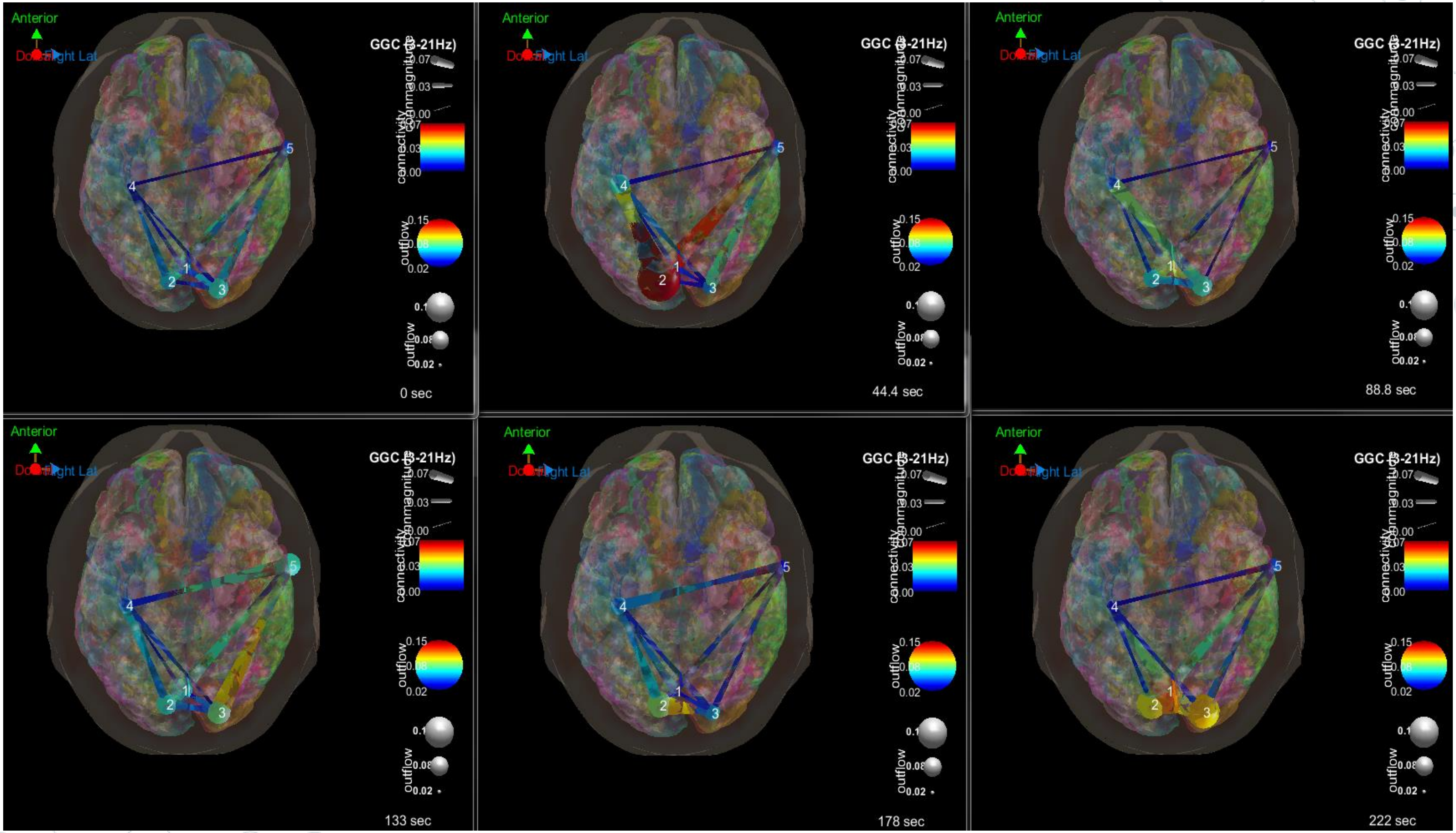


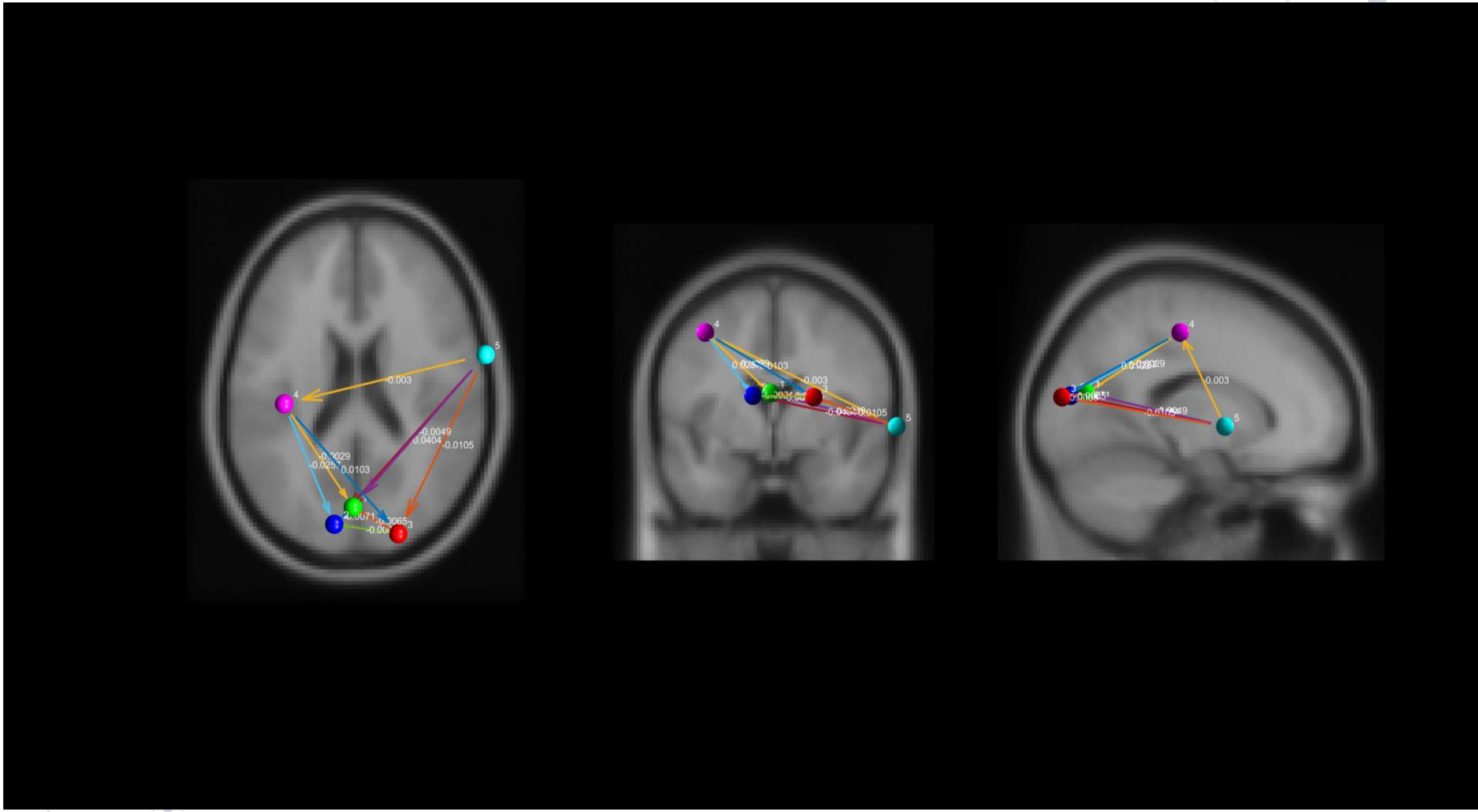
12222008 EC 1 POST IC REJ



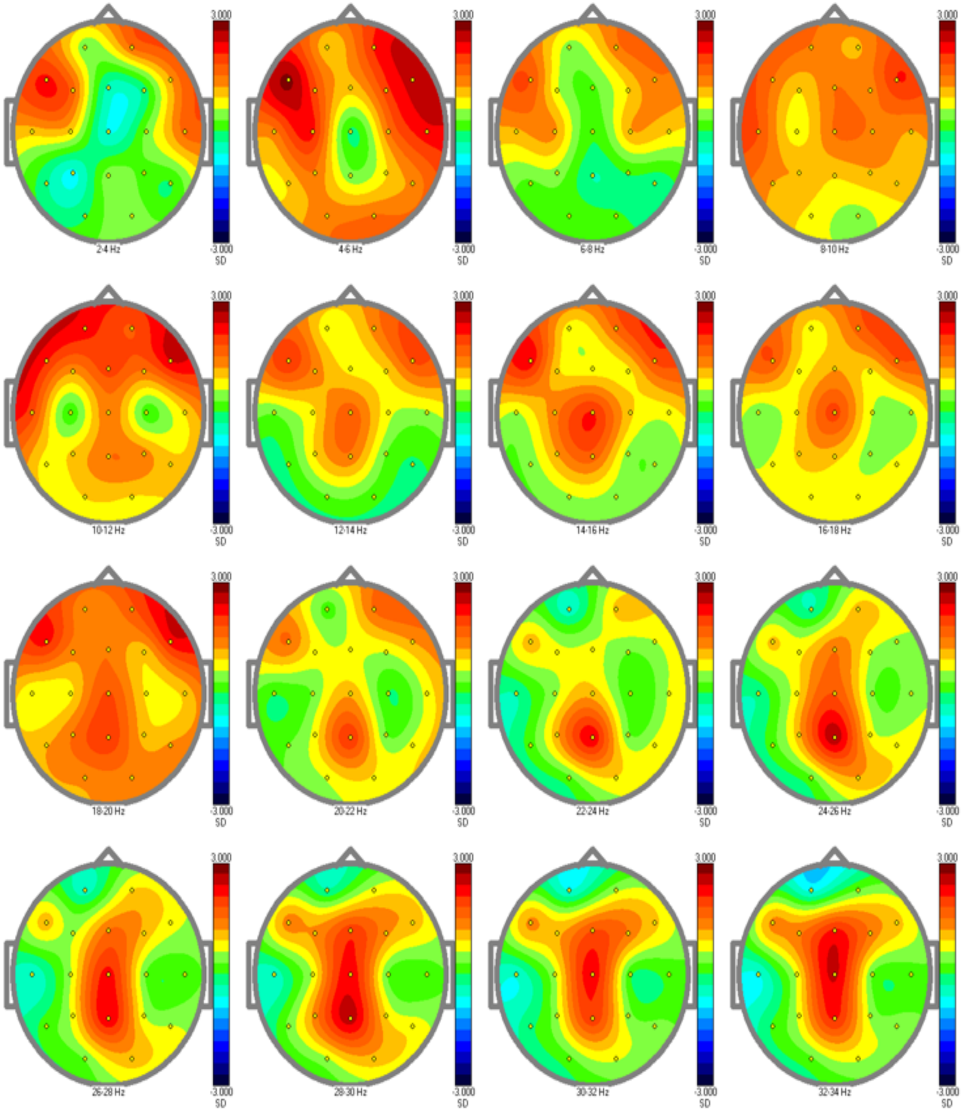

1
2
3
4
5
6
Cancel
Set threhsolds
See comp. stats
See projection
Help
OK

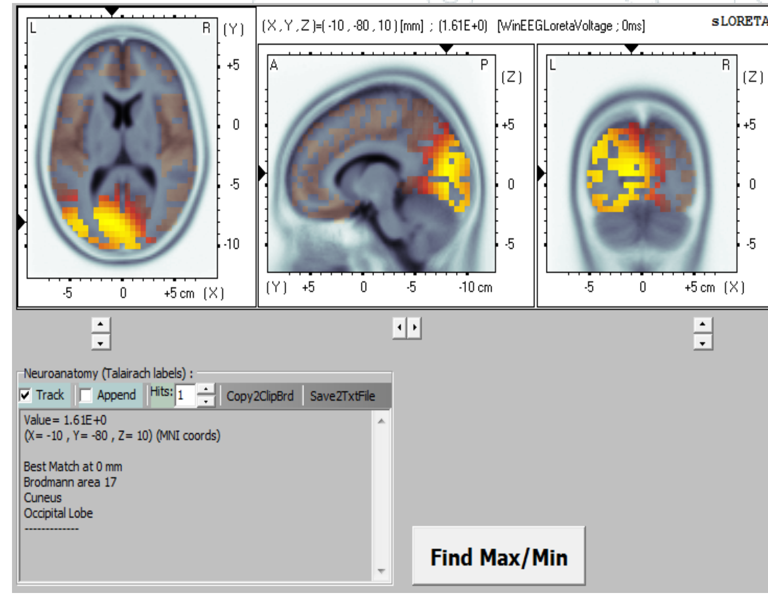

12222008 EC 1
Comp. 1 (RV:1.20%; Tal:-1,-73,20)
Comp. 2 (RV:1.69%; Tal:-11,-82,19)
Comp. 3 (RV:2.94%; Tal:22,-87,18)
Comp. 4 (RV:8.49%; Tal:-38,-21,47)
Comp. 5 (RV:13.41%; Tal:68,1,0)
Comp. 6 (RV:20.13%; Tal:-52,35,26)

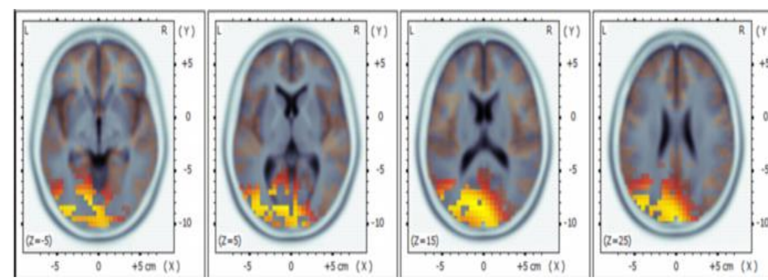

Anterior
connectivity
outflow
0 sec
44.4 sec
88.8 sec
133 sec
178 sec
222 sec


5
4
-0.003
-0.0049
-0.0105
-0.0029
0.0103
3

Z-Score Relative Power



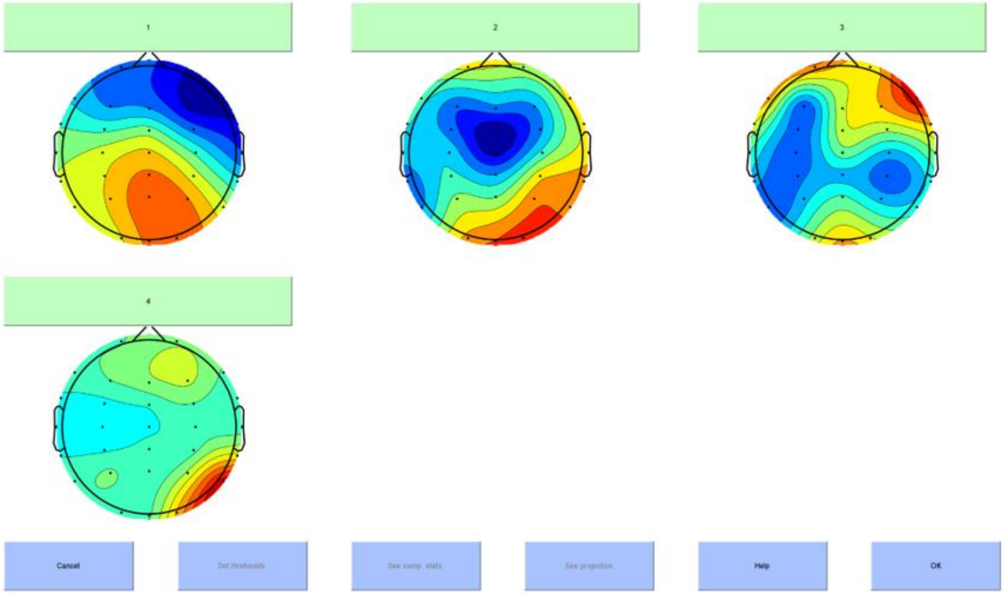


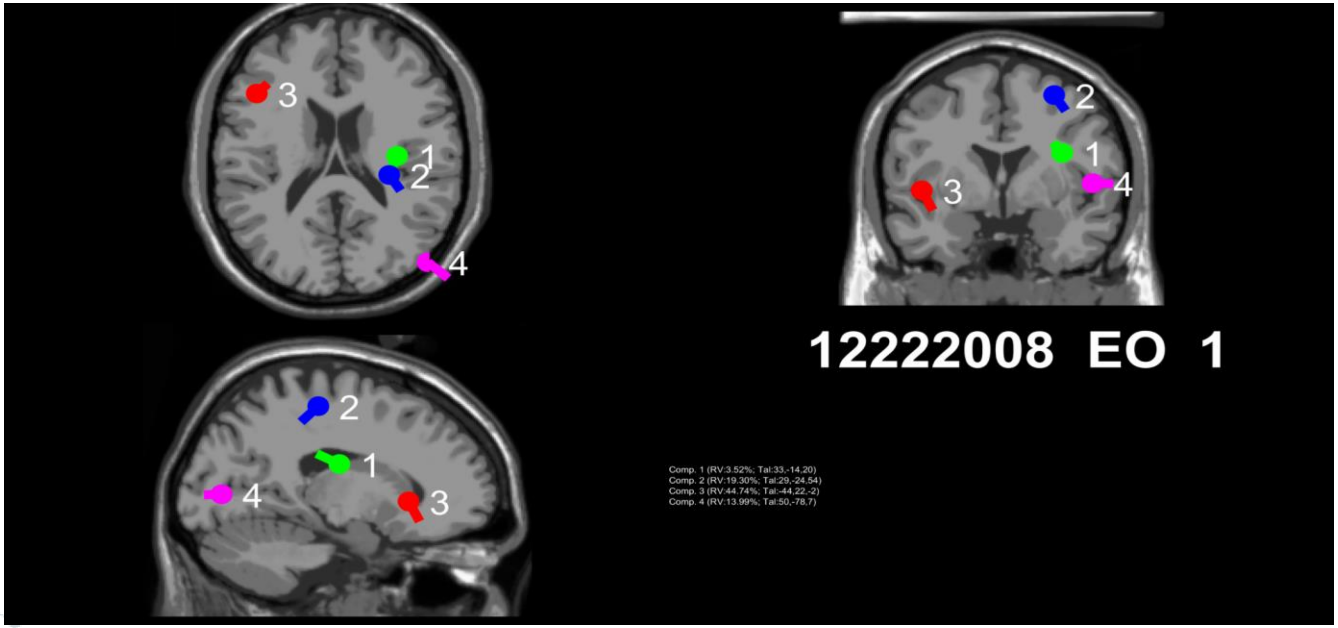


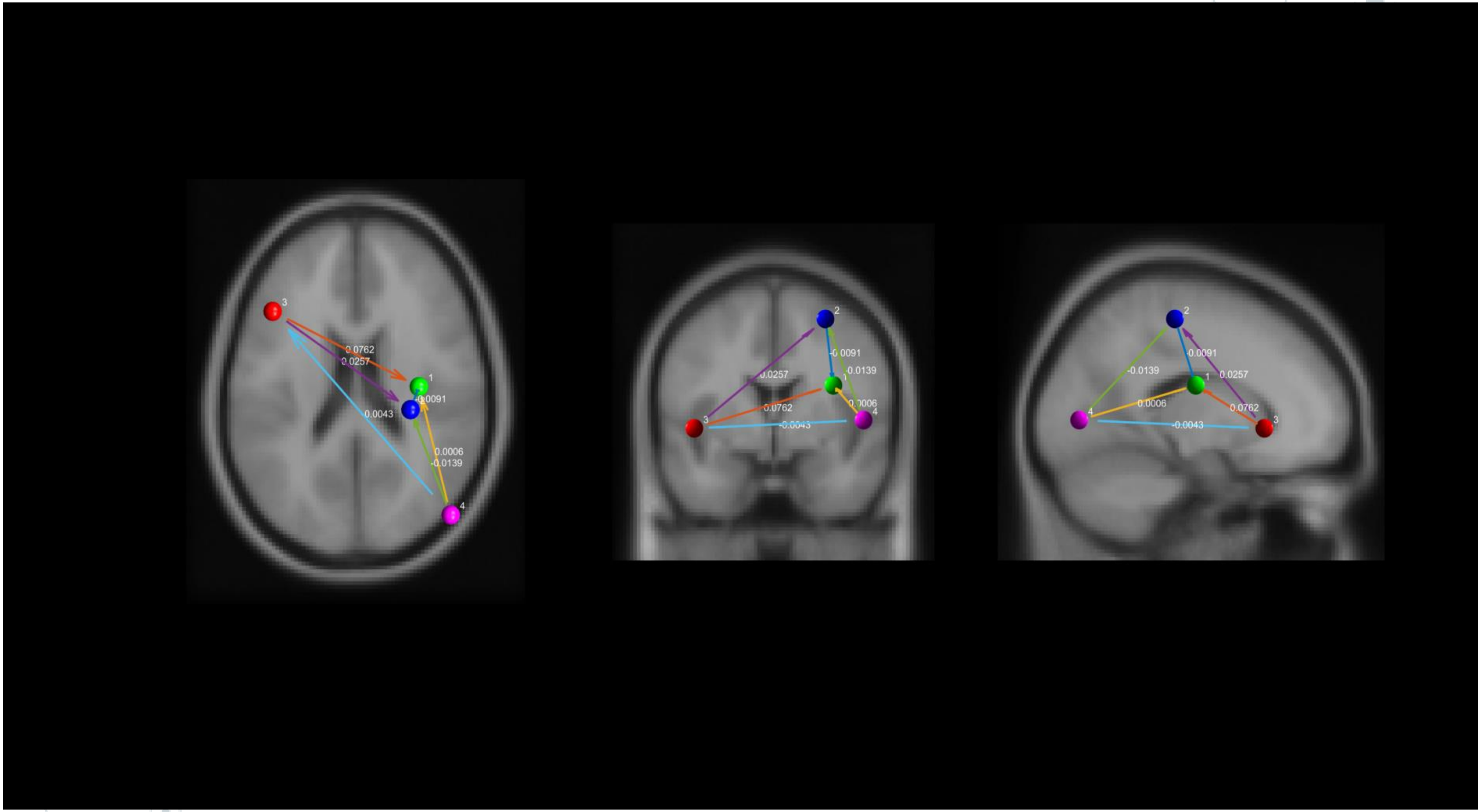
Eyes Open

ICA Component Maps

(after ICA rejection)

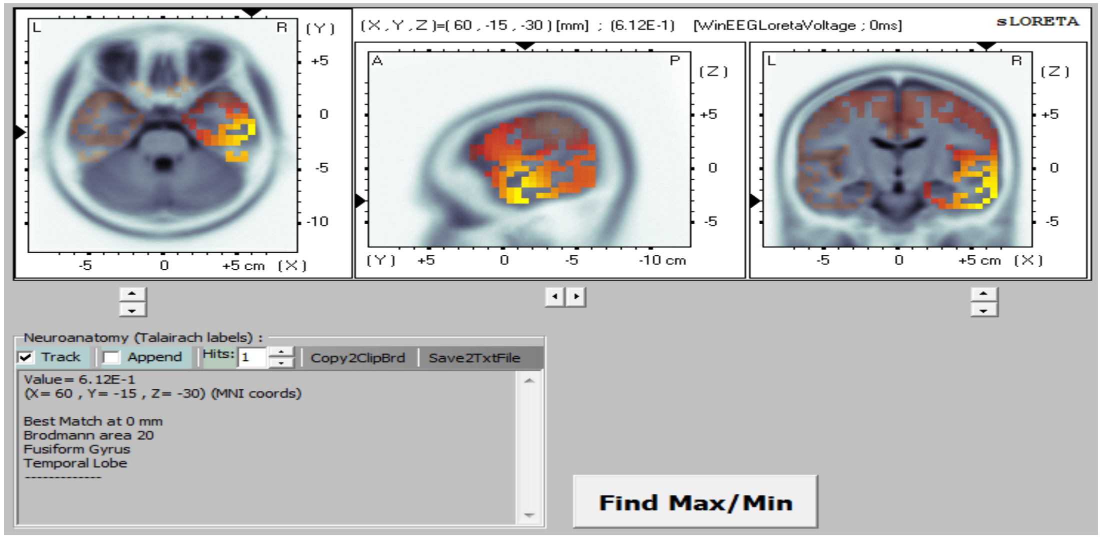


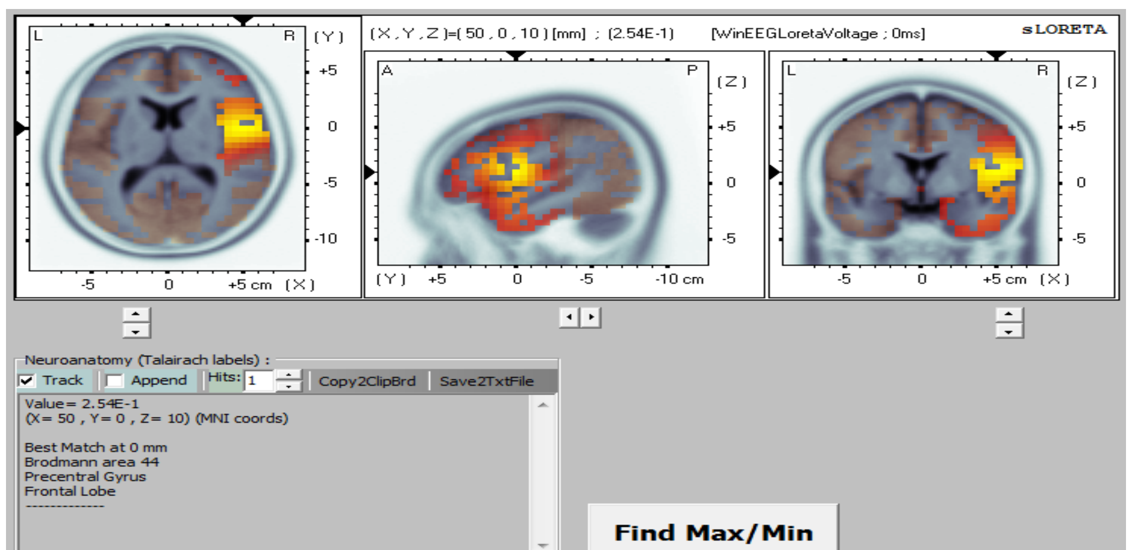




3
0.0762
0.0257
1
-0.0091
0.0043
0.0006
-0.0139
4
2
-0.0091
0.0139
0.0257
0.0762
0.0006
3
-0.0043
4
2
0.0091
-0.0139
1
0.0257
0.0006
0.0762
4
-0.0043
3

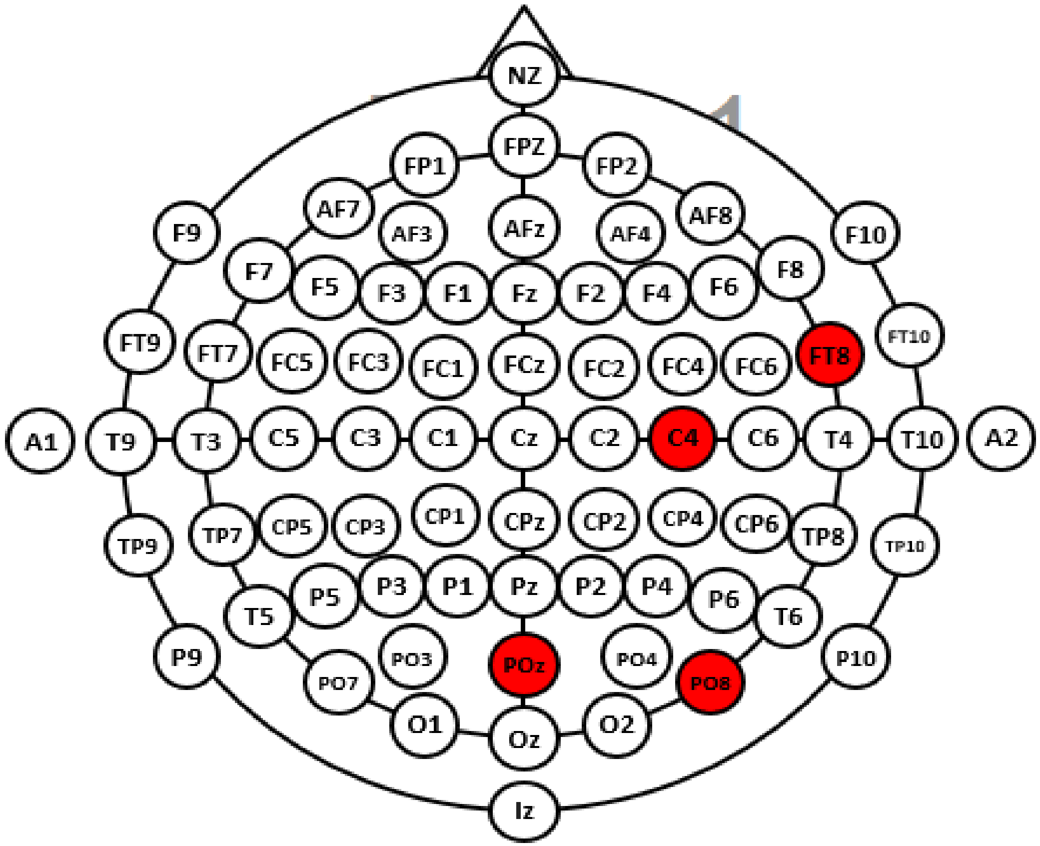
1	33.55876	-15.3927	21.46433	606	Right Cerebrum	Sub-lobar	Extra-Nuclear	White Matter	*
				356	Right Cerebrum	Sub-lobar	Insula	White Matter	*
2	29.1284	-27.052	56.88045	493	Right Cerebrum	Frontal Lobe	Precentral Gyrus	White Matter	*
				378	Right Cerebrum	Frontal Lobe	Precentral Gyrus	Gray Matter	Brodmann area 4





		[x] Four Channel →→→	[x] Avg	[x] U	[ ] D
[x] Initial	[ ] Single Channel		[ ] Mod	[ ] U	[ ] D
[ ] New	[ ] Coherence		[ ] Dev	[ ] U	[ ] D

Inhibit	2-6
Inhibit	9-14
Inhibit	24-32
Reward	2-20



Previous Protocol/# of sessions: PO2+PO8+C4+FT8 (15x)

Initial Treatment Goal:				
anxiety	no change	slightly improved	(improved)	much improved
being able to be around other kids	no change	slightly improved	improved	(much improved)
troubling thoughts	(no change)	slightly improved	improved	much improved
school	(no change)	slightly improved	improved	much improved

Positive Changes Noted:

She has been able to return to our homeschool co-op and particapate in activities with boundaries in place. She has expressed feeling less anxious. She still deals with troubling thoughts but seems to handle them better. Her attachment to me has improved as well. She is continueing her counselling at home with Jodie Tipton.

Continued Areas of Concern:

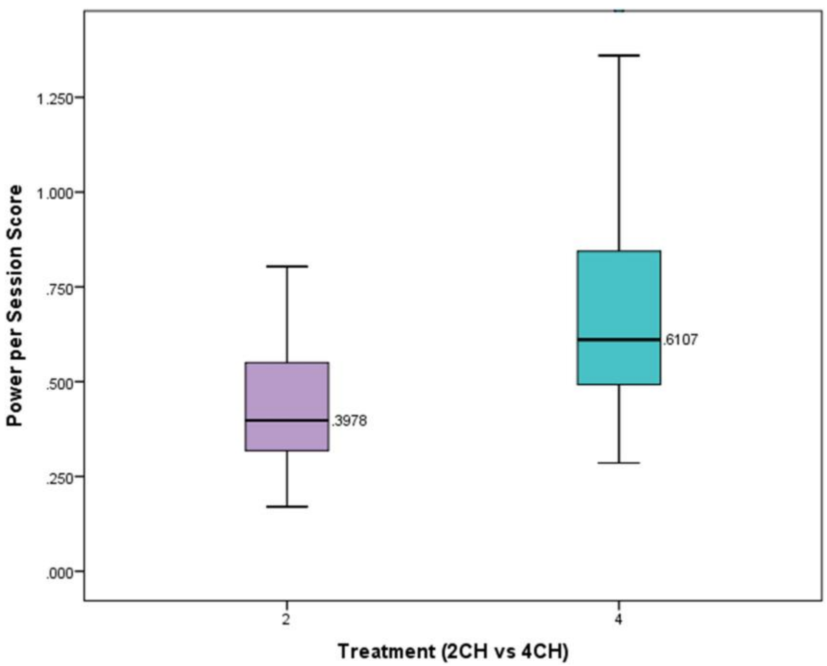
She still has troubling thoughts and feels anxious at times about being close to other people. She worries about "what if she touches them". She still needs "safe boundaries" at home and school. She still has feelings of depression. She still struggles with school work.

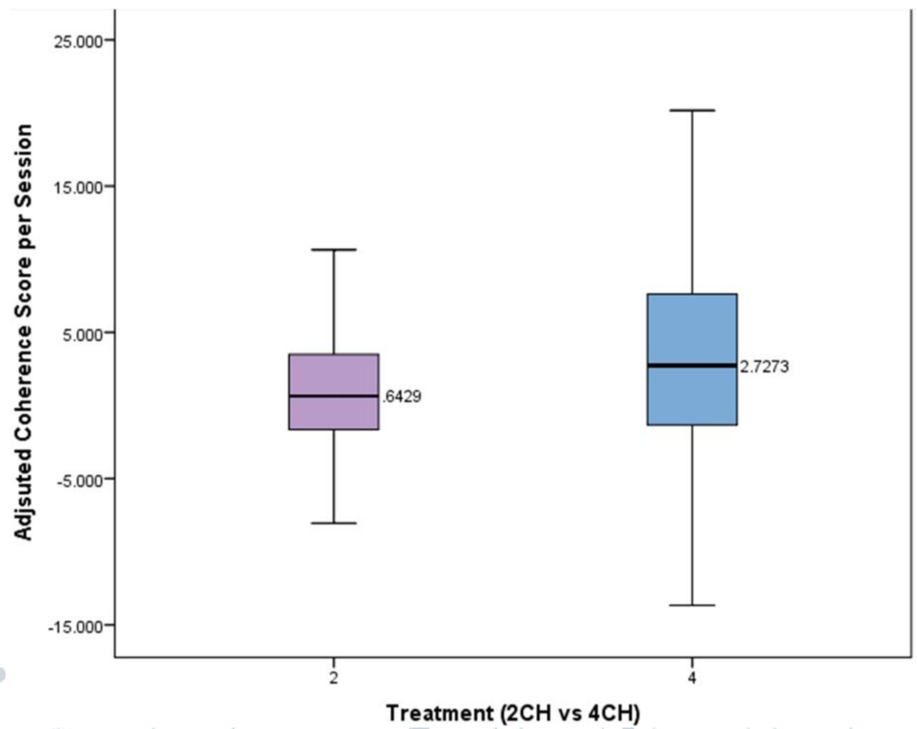
TECHNOLOGY REPORT ARTICLE
Front. Neurosci., 11 October 2018 | https://doi.org/10.3389/fnins.2018.00729

Four Channel Multivariate Coherence Training: Development and Evidence in Support of a New Form of Neurofeedback

Robert Coben[1*], Morgan Middlebrooks[1], Howard Lightstone[2] and Madeleine Corbell[3]

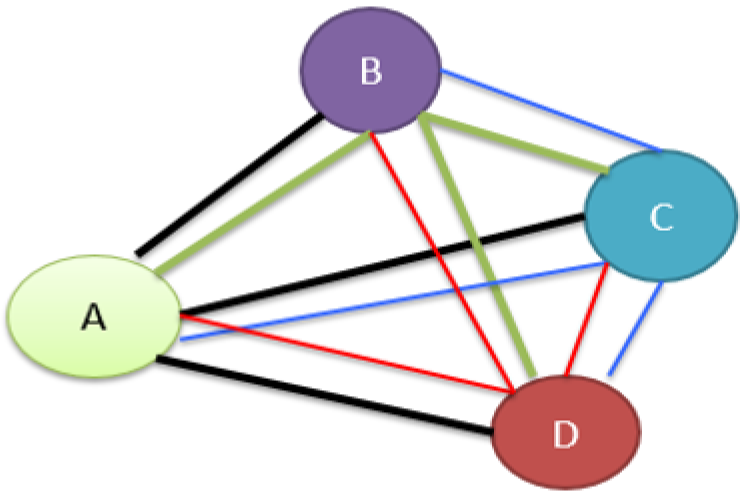
[1]Integrated Neuroscience Services, Fayetteville, AR, United States
[2]EEG Software, LLC, Gainesville, FL, United States
[3]Department of Psychological Science, University of Arkansas, Fayetteville, AR, United States





QPS: Averaging coherences

- A method of combining averaged psync values.
  - 4 channels of EEG
  - Each pair has a running psync calculation
  - For each channel, the 3 pairs of psync values are computed, averaged and this is used as the output reward value
  - If a raw channel is in artifact condition, the channel is not used in the averaging calculation



A = (AB + AC + AD)/3
B = (BA + BC + BD)/3
C = (CA + CB + CD)/3
D = (DA + DB + DC)/3

QPS Ave = (A + B + C + D)/4

QPS Average

- 3 modes:
  - Avg: average value (sum/samples)/number of samples
  - Dev: difference in the range of values
  - Mod: simultaneous combination of avg and dev

n=number of values NOT in artifact
v=Psync value
Avg=average value result

$$Avg = \left(\sum_1^n (v_i)\right) / n$$

compute Avg like submode AVG

$$answer = \sqrt{\left(\sum_1^n (v_i - Avg)^2\right)}$$

Anecdotal evidence

- Obsessive-Compulsive Disorder
- Seizures
- Autism
- TBI
- Dyslexia
- Speech/Language
- Emotional regulation
- Depression
- Developmental trauma/PTSD

Efficacy Studies in Support of 4 channel MVCNF (N = 591)

Population	Sample	Design	Findings 1	Findings 2
General Population	N = 174	MVCNF v 2 Ch CNF	MVCNF > 2 Ch CNF	Enhanced coherence and reduced power
Traumatic Brain Injury	N = 20	Compared time since injury in 3 groups	Improvements in symptoms and NP testing	Changes associated with increases in coherence
Epilepsy	N = 52	MVCNF v 2 Ch CNF	MVCNF > 2 Ch CNF	81% reduction in seizures
Learning Disabilities	N = 63	MVCNF v 2 ch CNF v resource room	MVCNF > 2 ChCNF > RR	1.6 year increase in reading
Autism	N = 110	MVCNF v 2 Ch CNF	MVCNF > 2 Ch CNF	98% success rate
Autism MND	N = 78	MVCNF v 2 Ch CNF v Bipolar	MVCNF > 2 ChCNF > Bipolar	Mu suppression with coherence changes
Depression	N = 54	MVCNF Psychotherapy v WLC	MVCNF > both groups	94% success rate, crossover and 2 yr f/u
Developmental Trauma	N = 40	MVCNF v. Psychotherapy	Exp > controls on clinical ratings	Δ in power, sources and connectivity

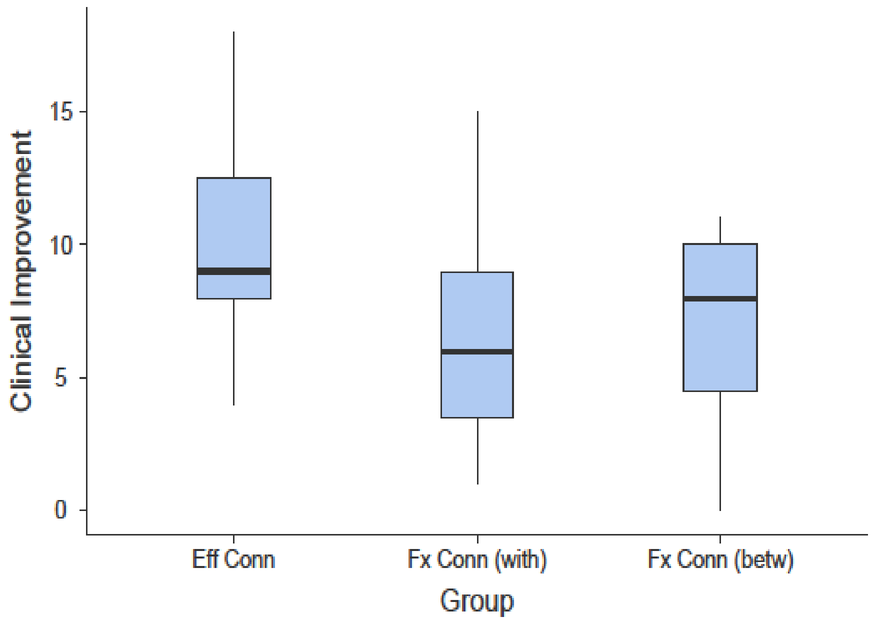
Study Methodology

- Subjects were assigned to one of three groups (N = 45).
- These included an effective connectivity (15), functional connectivity within group (15) and a functional connectivity between group (15) comparison. Group 1 and 2 were the same subjects (within groups) that received different interventions at different time points (FC always first).
- All subjects received four channel multivariate coherence training over 12-15 sessions.
- Clinical ratings and therapist ratings (0-20) were derived at the completion of their treatment regimen.
- Client ratings were largely subjective and based on self-ratings only or parental ratings at the completion of training and during the process.
- Therapist ratings were performed at the completion of training and were based on objective test findings including neuropsychological, behavioral and qeeg findings that reflected change over time.
- QEEG analysis of change included measures of power at the component level, dipole sources, spectral properties, and multiple measures of graph theory connectivity.

ANOVA

ANOVA

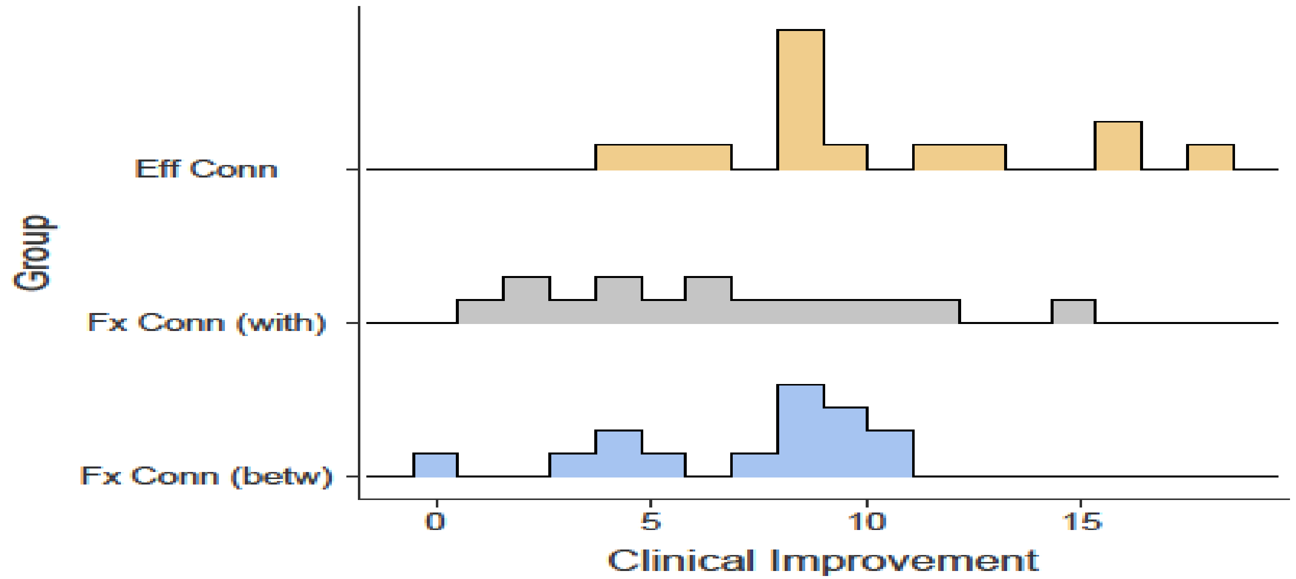
	Sum of Squares	df	Mean Square	F	p
Group	110	2	55.1	3.66	0.034
Residuals	631	42	15.0		



Contrasts

Contrasts - Group

	Estimate	SE	t	p
Fx Conn (with) - Eff Conn	-3.67	1.42	-2.59	0.013
Fx Conn (betw) - Eff Conn	-2.80	1.42	-1.98	0.055



ANOVA

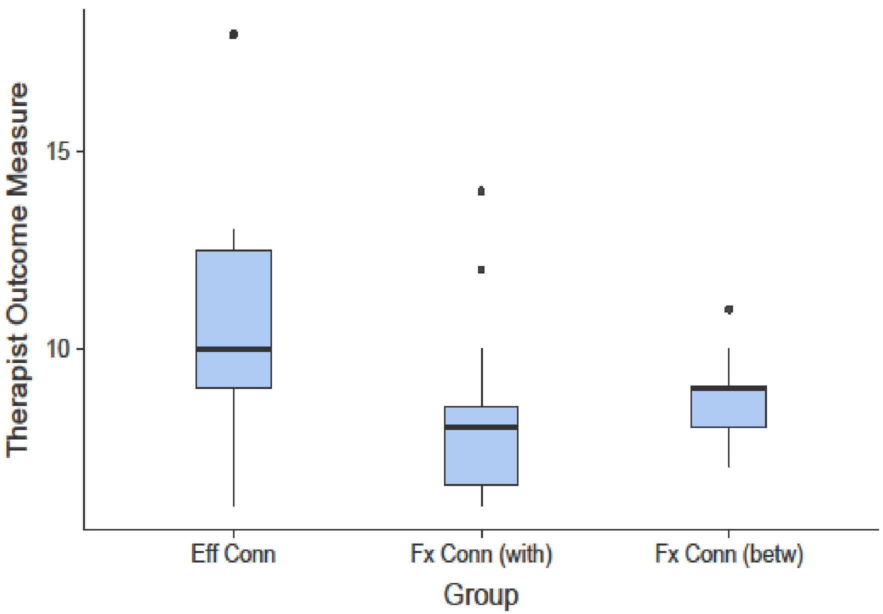
ANOVA

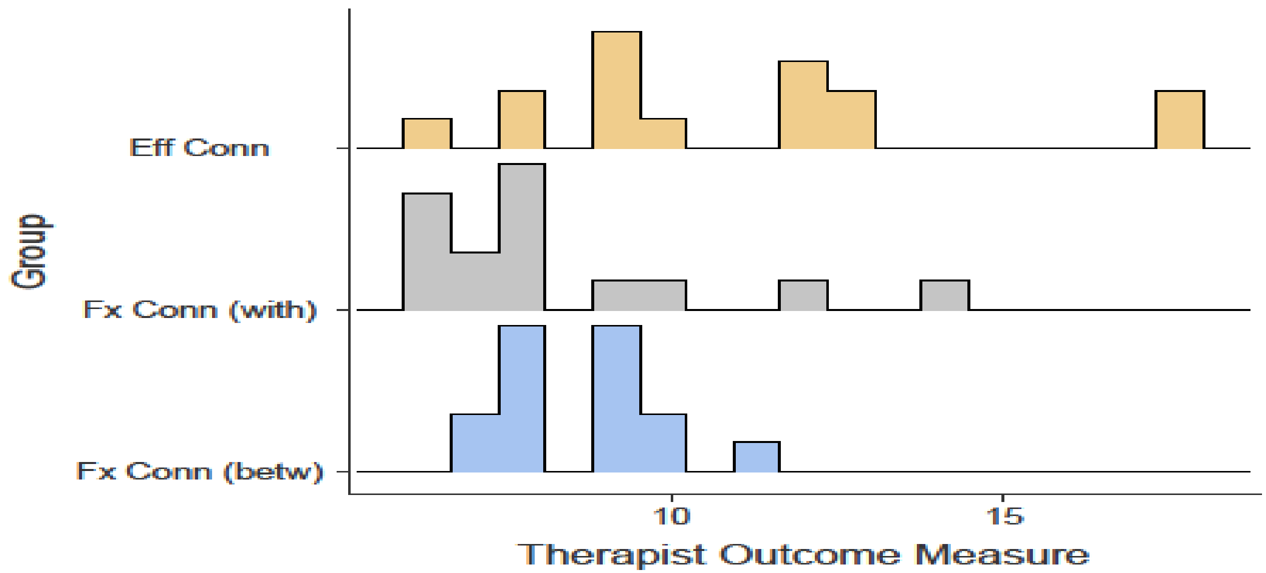
	Sum of Squares	df	Mean Square	F	p
Group	71.0	2	35.49	5.72	0.006
Residuals	260.7	42	6.21		

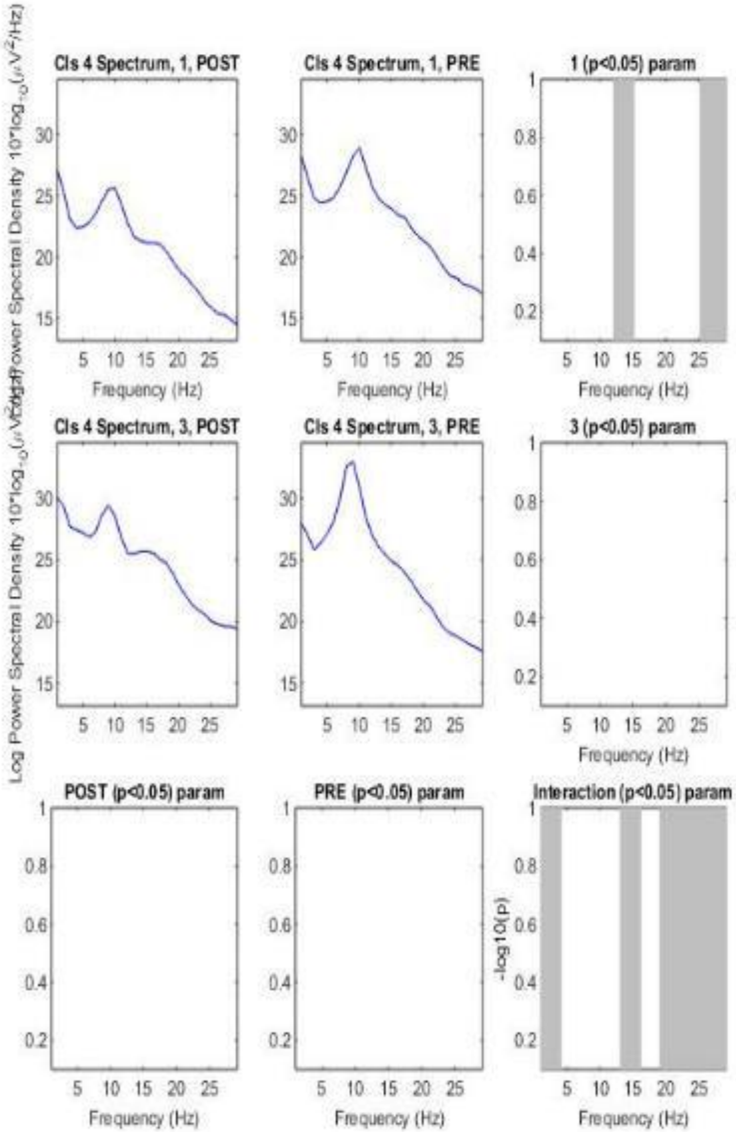
Contrasts

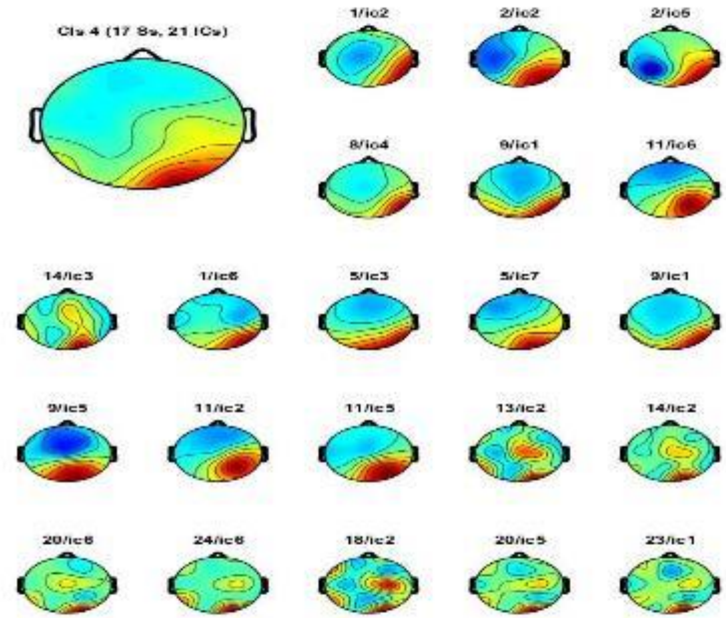
Contrasts - Group

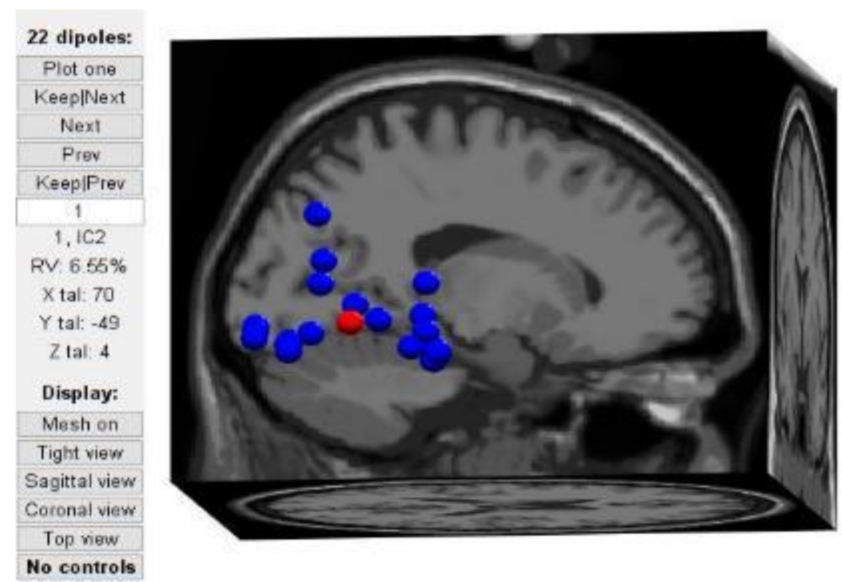
	Estimate	SE	t	p
Fx Conn (with) - Eff Conn	-2.87	0.910	-3.15	0.003
Fx Conn (betw) - Eff Conn	-2.40	0.910	-2.64	0.012

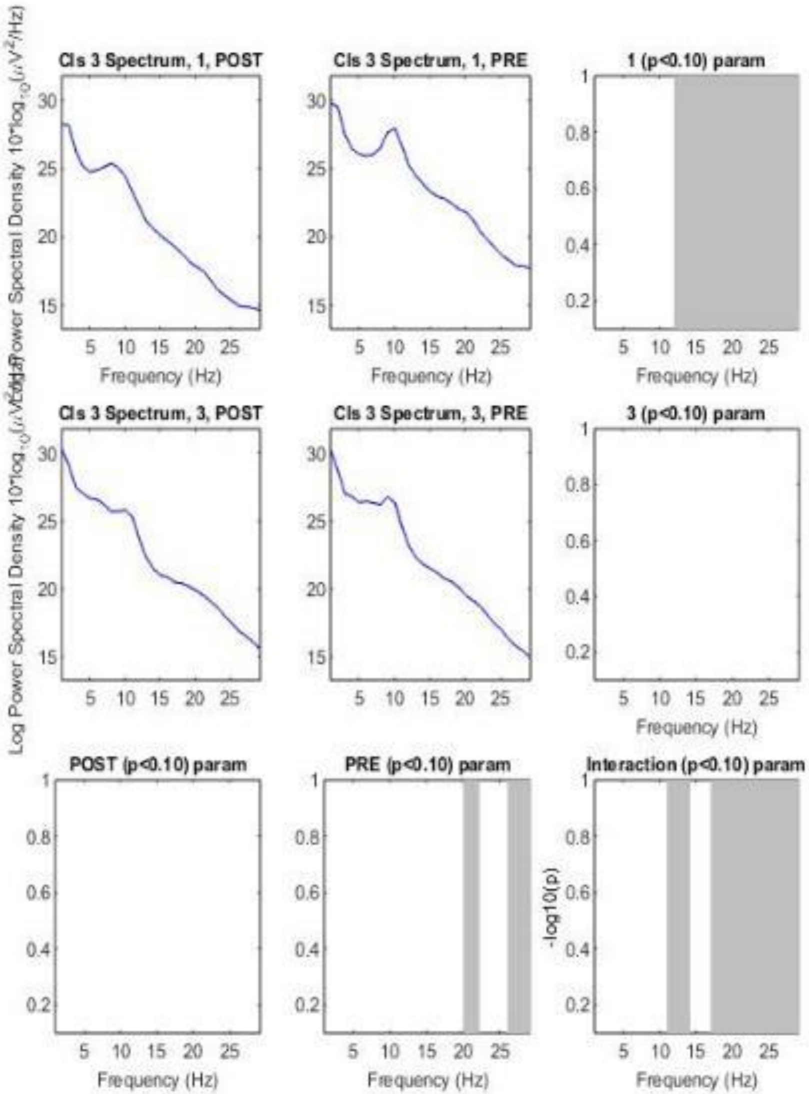




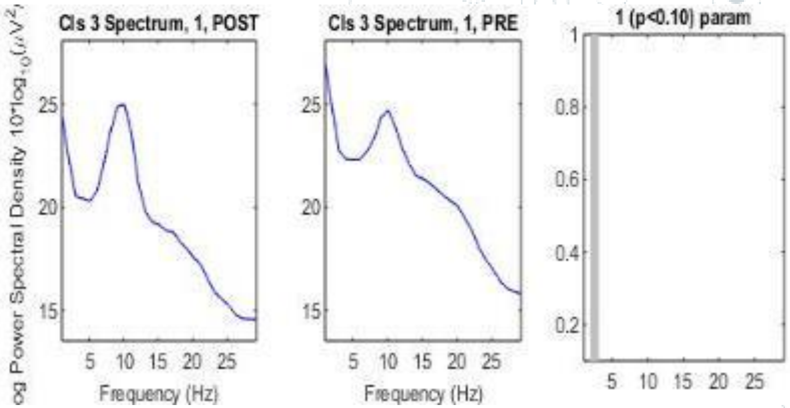

Cls 4 Spectrum, 1, POST
Cls 4 Spectrum, 1, PRE
1 (p<0.05) param
Cls 4 Spectrum, 3, POST
Cls 4 Spectrum, 3, PRE
3 (p<0.05) param
POST (p<0.05) param
PRE (p<0.05) param
Interaction (p<0.05) param
Log Power Spectral Density $10*log_{10}(\mu V^2/Hz)$
Frequency (Hz)
-log10(p)


Cls 4 (17 Ss, 21 ICs)
1/ic2
2/ic2
2/ic5
8/ic4
9/ic1
11/ic6
14/ic3
1/ic6
5/ic3
5/ic7
9/ic1
9/ic5
11/ic2
11/ic5
13/ic2
14/ic2
20/ic6
24/ic6
18/ic2
20/ic5
23/ic1

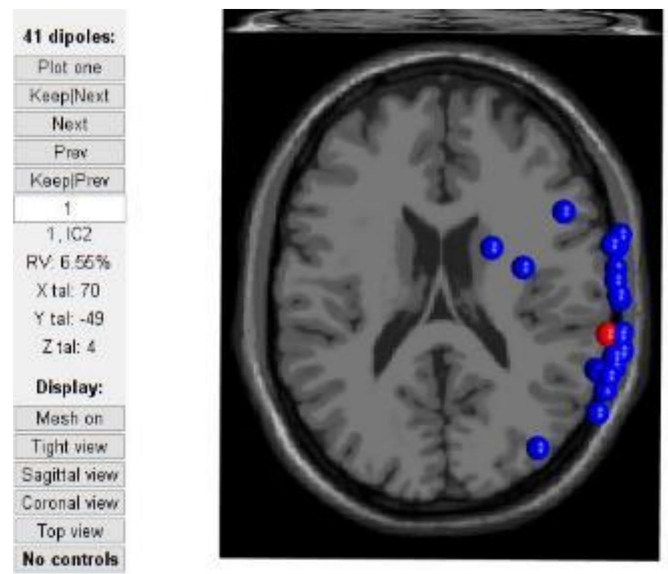

22 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
1, IC2
RV: 6.55%
X tal: 70
Y tal: -49
Z tal: 4
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls



Cls 3 Spectrum, 1, POST
Cls 3 Spectrum, 1, PRE
1 (p<0.10) param
Cls 3 Spectrum, 3, POST
Cls 3 Spectrum, 3, PRE
3 (p<0.10) param
POST (p<0.10) param
PRE (p<0.10) param
Interaction (p<0.10) param
Log Power Spectral Density 10*log10(μV²/Hz)
-log10(p)
Frequency (Hz)



Cls 3 Spectrum, 1, POST
Cls 3 Spectrum, 1, PRE
1 (p<0.10) param
Log Power Spectral Density 10*log10(μV²/Hz)
Frequency (Hz)

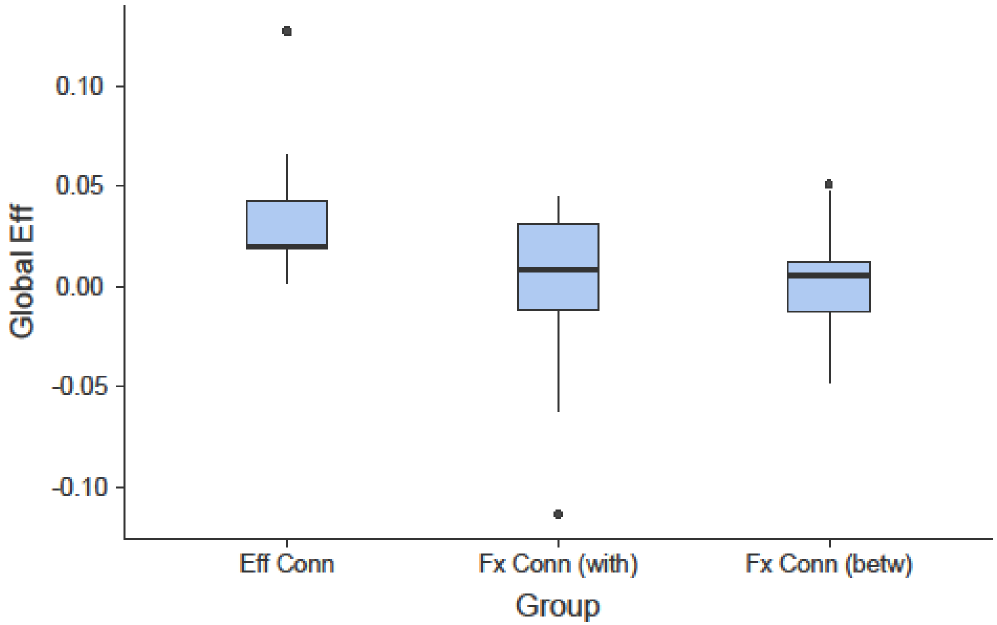


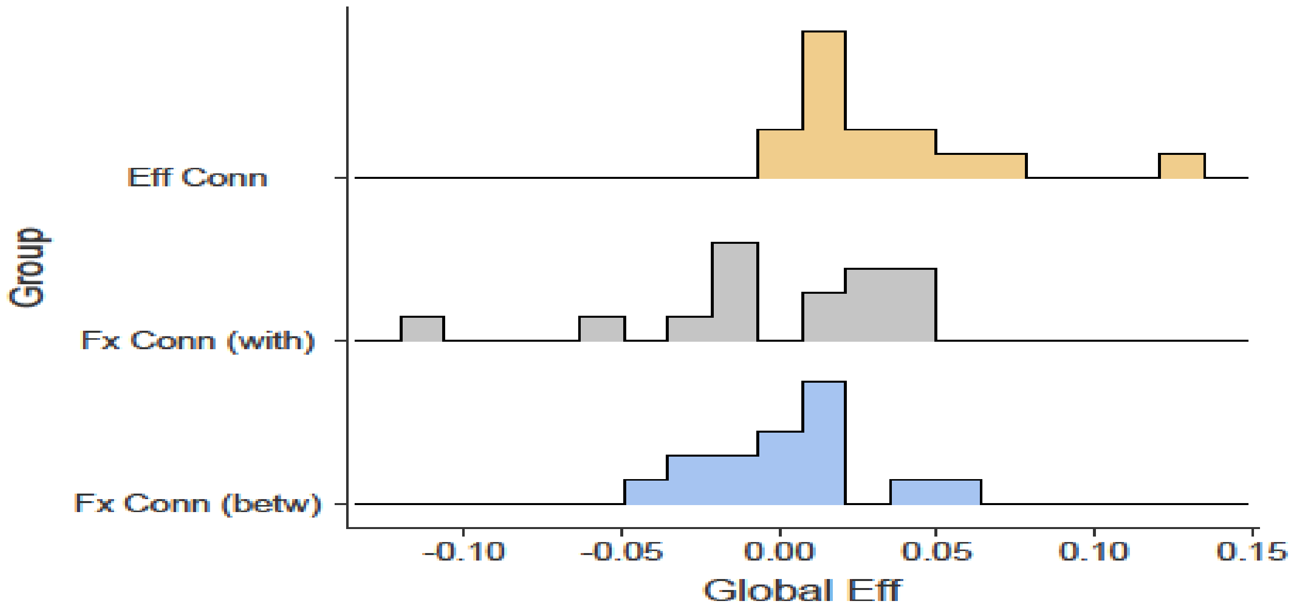
41 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
1, IC2
RV: 6.55%
X tal: 70
Y tal: -49
Z tal: 4
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls

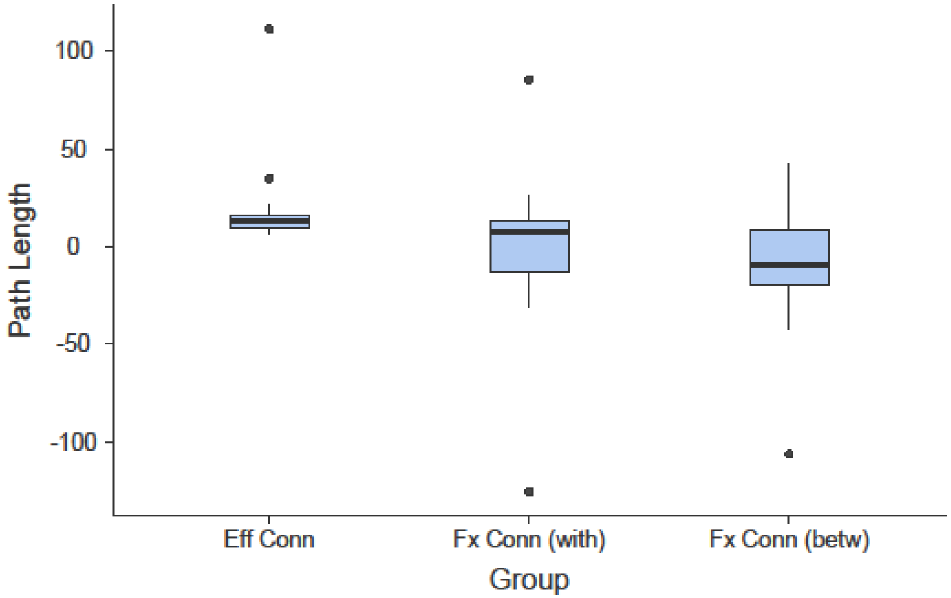
Statistical Analyses of Graph Theory Metrics (Connectivity)

Analysis of Variance

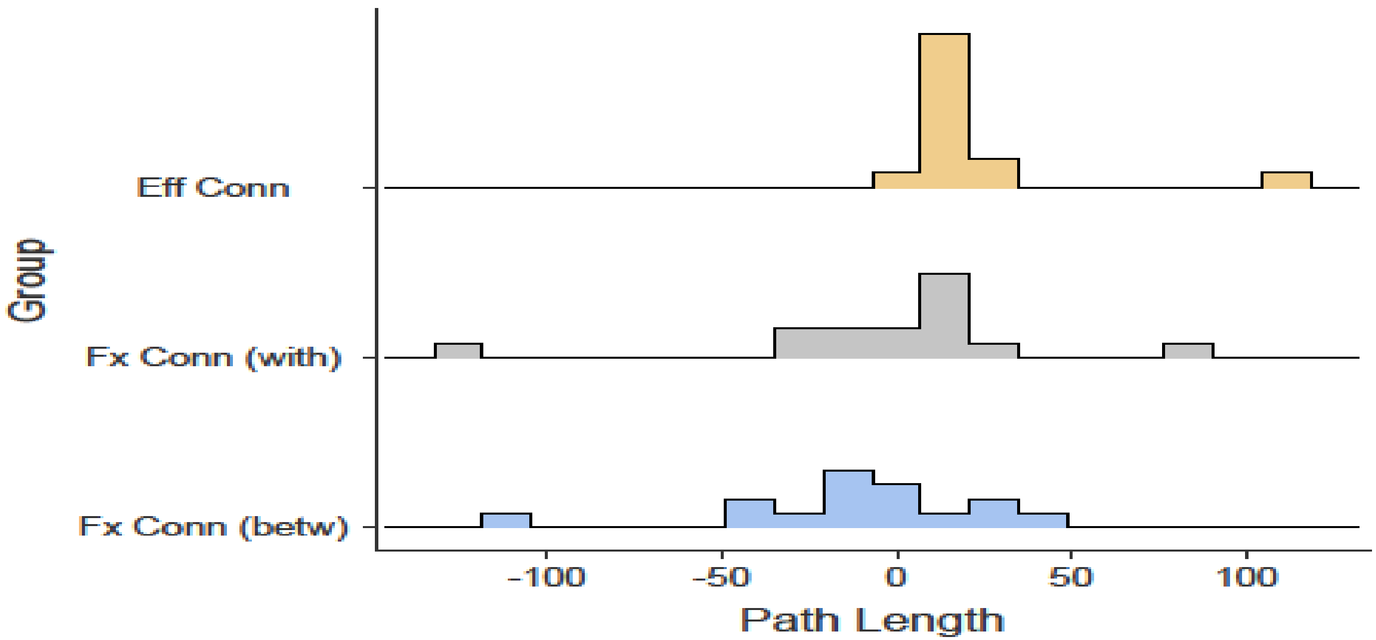
Cluster Coefficient	Global Efficiency	Path Length	Radius	Diameter
$F = 0.429$	$F = 4.60$	$F = 2.93$	$F = 3.35$	$F = 3.70$
$p = 0.654$	$p = 0.016$	$p = 0.064$	$p = 0.045$	$p = 0.033$


0.10
0.05
0.00
-0.05
-0.10
Global Eff
Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group

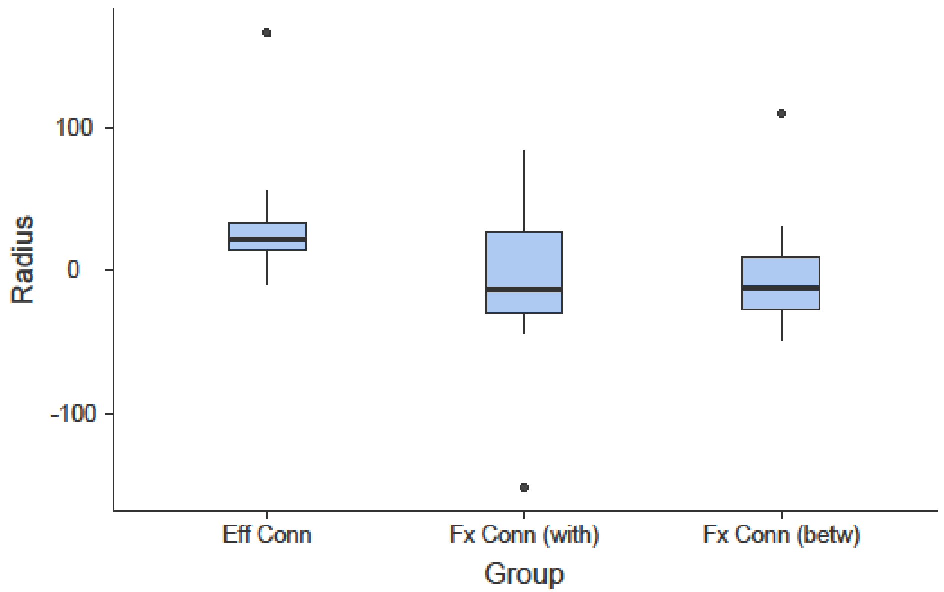

Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group
-0.10
-0.05
0.00
0.05
0.10
0.15
Global Eff

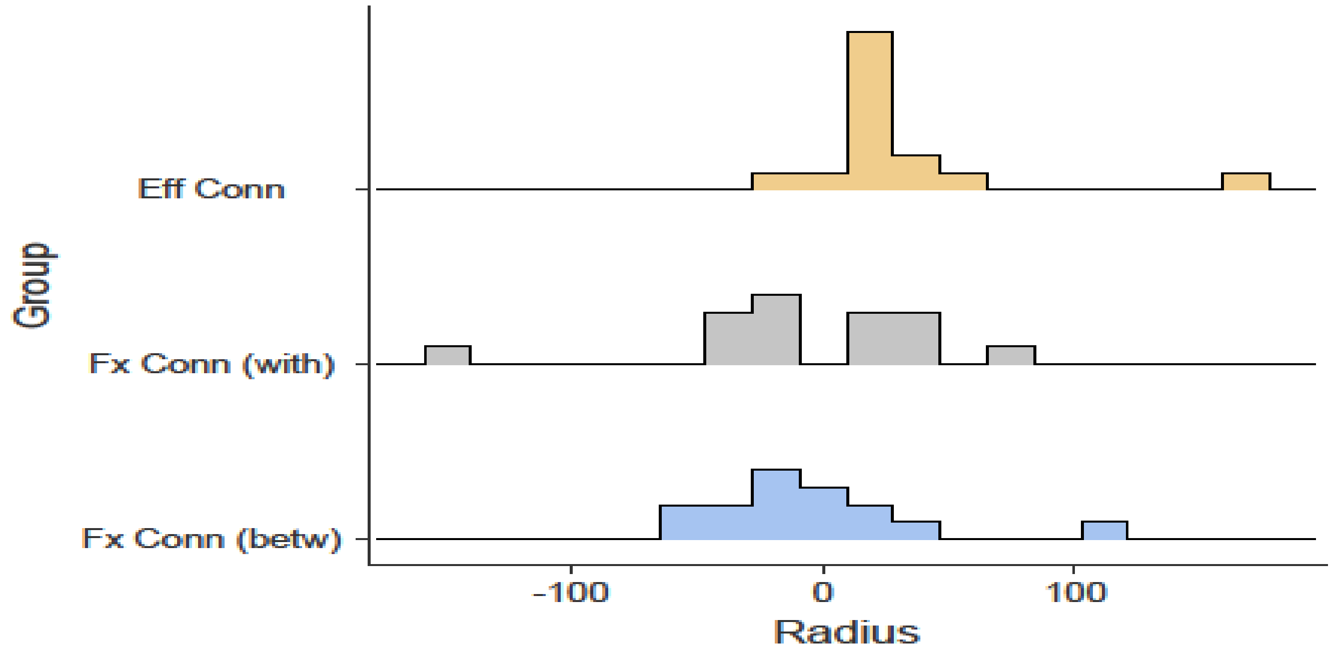


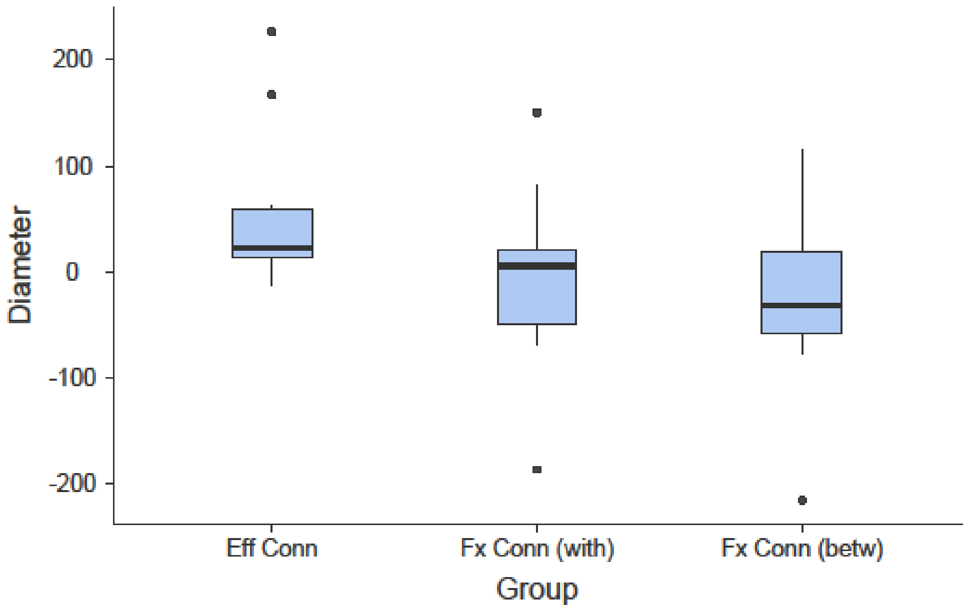
100
50
0
-50
-100
Path Length
Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group



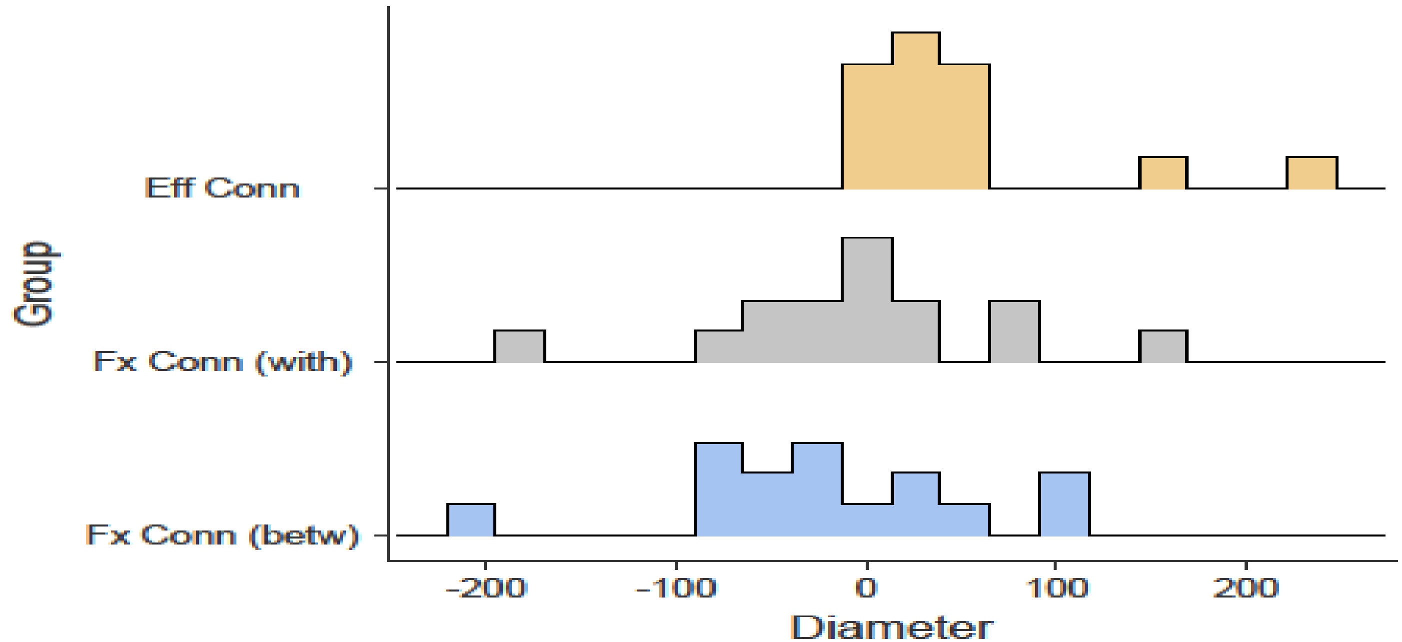
Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group
-100
-50
0
50
100
Path Length


Radius
100
0
-100
Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group


Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group
-100
0
100
Radius



200
100
0
-100
-200
Diameter
Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group



Eff Conn
Fx Conn (with)
Fx Conn (betw)
Group
-200
-100
0
100
200
Diameter

Correlation Matrix

		Medications	Clinical Improvement	Therapist Outcome Measure	Diameter
Medications	Pearson's r	—	-0.142	-0.142	-0.027
	p-value	—	0.353	0.351	0.862
Clinical Improvement	Pearson's r		—	0.563	0.319
	p-value		—	< .001	0.033
Therapist Outcome Measure	Pearson's r			—	0.242
	p-value			—	0.109
Diameter	Pearson's r				—
	p-value				—

Conclusions

- Measures of effective connectivity can be gleaned from QEEG data.
- Effective connectivity guided multivariate coherence training led to enhanced client and therapist ratings of outcome.
- Therapist ratings are consistently higher than clients and show more significant differences.
- Both ratings show an increased likelihood of greater outcomes (> 10) in the effective connectivity group.
- Positive NF outcomes in this group showed greater reductions of delta/theta, alpha and beta frequencies. These were commonly seen over bilateral posterior brain regions including temporal locations and midline frontal locations as well.
- Positive NF outcomes were associated with greater changes in multivariate connectivity. This is especially true for long range connectivity (diameter).
- Use of effective connectivity leads to changes in connectivity and is more likely to prevent negative connectivity changes.

Case Review 3

The patient is a 54-year-old male who suffered a TBI 3 months prior in a motorcycle accident. He was in a coma for 19 days with axonal shearing injuries. He was in a hospital for a month and then transferred to inpatient rehabilitation for another month before going home. There was evidence of an acute intracranial bleed.

Reported symptoms have included visual problems, visual hallucinations, confusion. He has night terrors and nighttime confusion as he sees things in the dark like fires. He has trouble sleeping due to nightmares, frequent urination and hallucinations when awake.

He is taking Neurontin and Ativan and receives ST, OT and PT.

WAIS®-IV

Wechsler Adult Intelligence Scale®-Fourth Edition

Composite Score Summary

Scale	Sum of Scaled Scores	Composite Score		Percentile Rank	95% Conf. Interval	Qualitative Description
Verbal Comprehension	25	VCI	91	27	86-97	Average
Perceptual Reasoning	17	PRI	75	5	70-82	Borderline
Working Memory	24	WMI	111	77	104-117	High Average
General Ability	42	GAI	80	9	76-86	Low Average

TACTILE:

							Error Totals
Right Hand-Left Hand	RH	LH	Both:	RH	LH		RH 0 LH 0
Right Hand-Left Face	RH	LF	Both:	RH	LF		RH 0 LF 0
Left Hand-Right Face	LH	RF	Both:	LH	RF		RF 0 LH 0

AUDITORY:

Right Ear-Left Ear	RE	LE	Both:	RE	LE	RE 0 LE 2

VISUAL:

Above eye level Eye level Below eye level	RV	LV	Both:	RV	LV	R: 3 L: 8

Finger Tapping–Worst hand (taps) *[TAP WH]*	23.8	2	***16***	Severe Impairment
Hand Dynamometer–Worst hand (kgs) *[GRIP WH]*	14.5	4	***11***	Severe Impairment

Benton Judgment Of Line Orientation – Form V

3–10 HL

5–8 HM

Correct 18

moderately defective

Composites:

RBANS Update Form A

View by: Default Order

	Index score
RBANS Update Form A Immediate Memory	78
RBANS Update Form A Visuospatial/ Constructional	64
RBANS Update Form A Language	84
RBANS Update Form A Attention	82
RBANS Update Form A Delayed Memory	-
List Recall	<=2
List Recognition	<=2
Story Recall	3
Figure Recall	1
RBANS Update Form A Total Scale	-

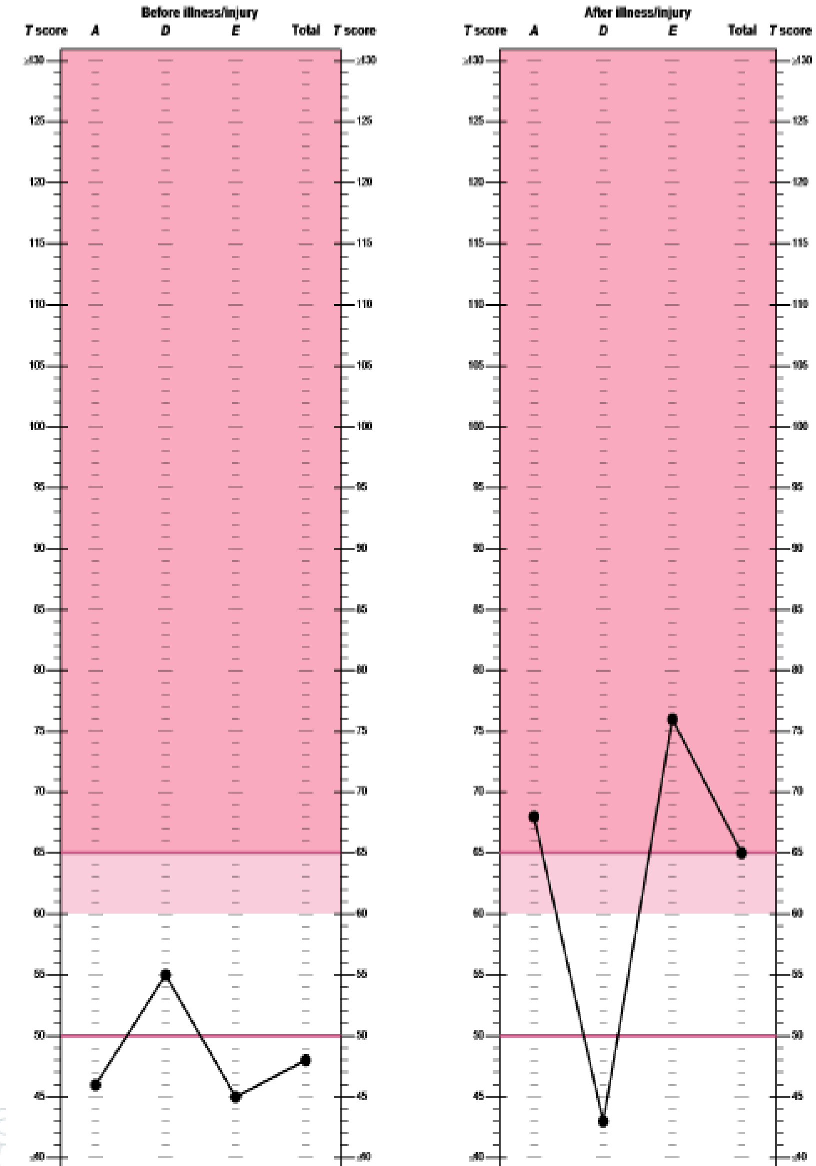
Subtests:

RBANS Update Form A

	Scaled Score
List Learning	4
Story Memory	8
Figure Copy	1
Semantic Fluency	5
Digit Span	13
Coding (1)	1
Story Recall	3
Figure Recall	1

	Percentile Rank
Line Orientation	17-25
Picture Naming	17-25
List Recall	<=2
List Recognition	<=2

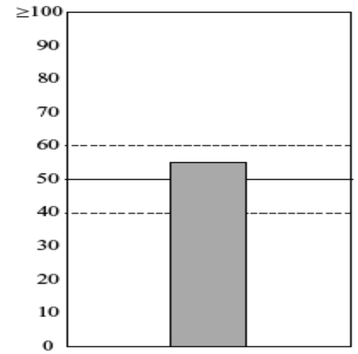
FrSBe Profile



Scale	A	D	E	Total
aw score	25	29	29	83
T score	46	55	45	48

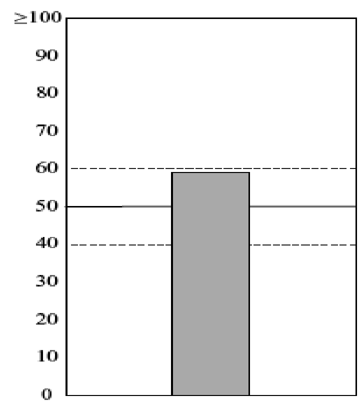
Scale	A	D	E	Total
Raw score	38	22	50	110
T score	68	43	76	65

BAI®
Beck Anxiety Inventory®



Raw Score:	8
T Score (Plotted):	55
Percentile Rank:	83.6
Diagnostic Range:	Mild

BDI®-II
Beck Depression Inventory®-II

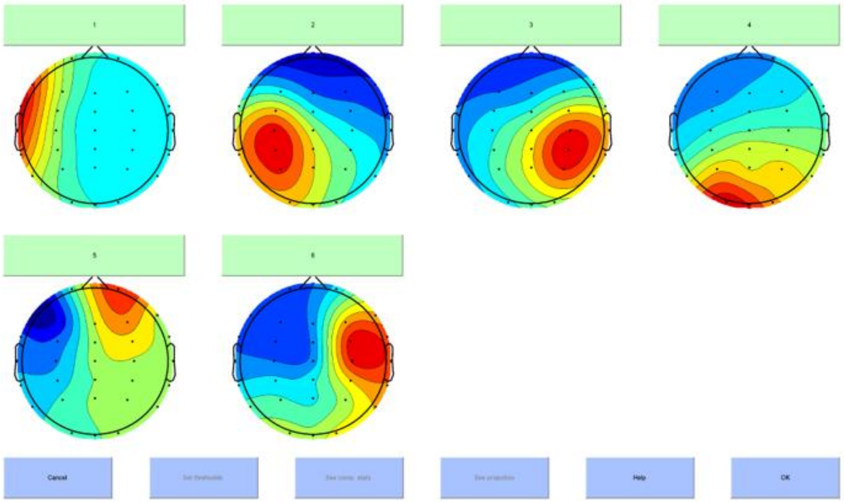


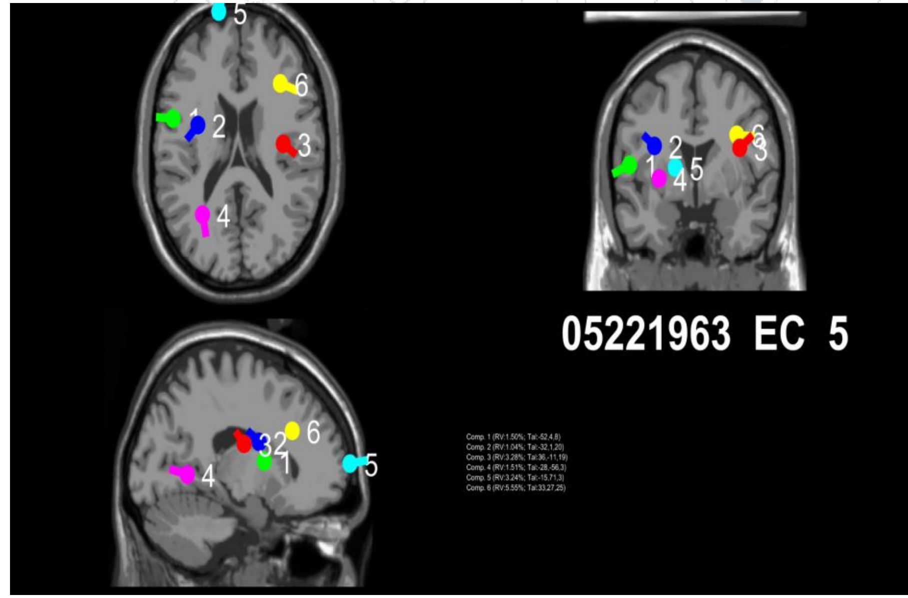
Raw Score:	12
T Score (Plotted):	59
Percentile Rank:	86.8
Diagnostic Range:	Minimal

Eyes Closed

ICA Component Maps

(after ICA rejection)

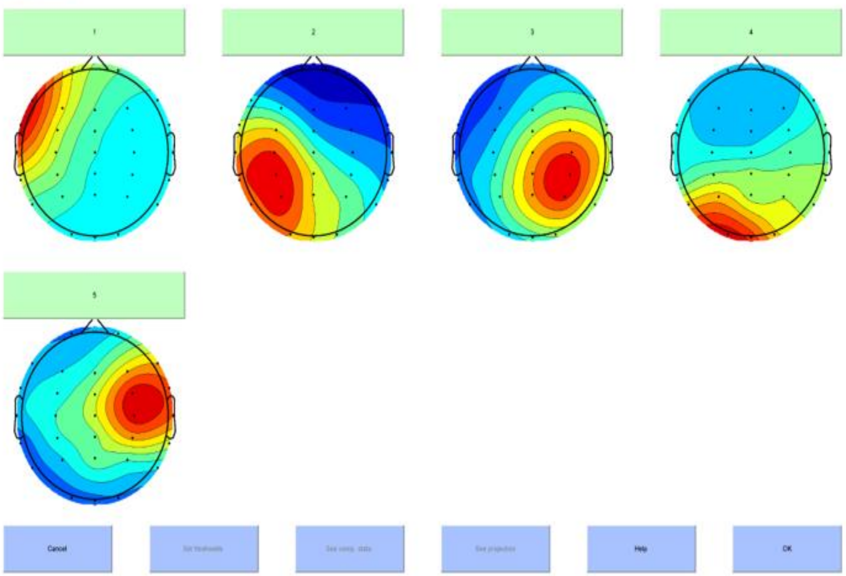


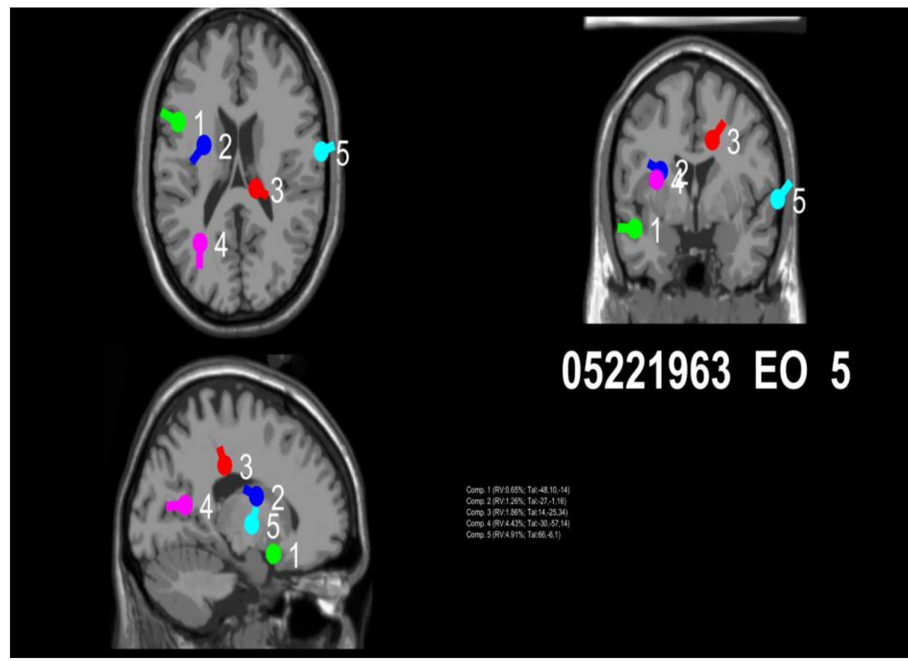


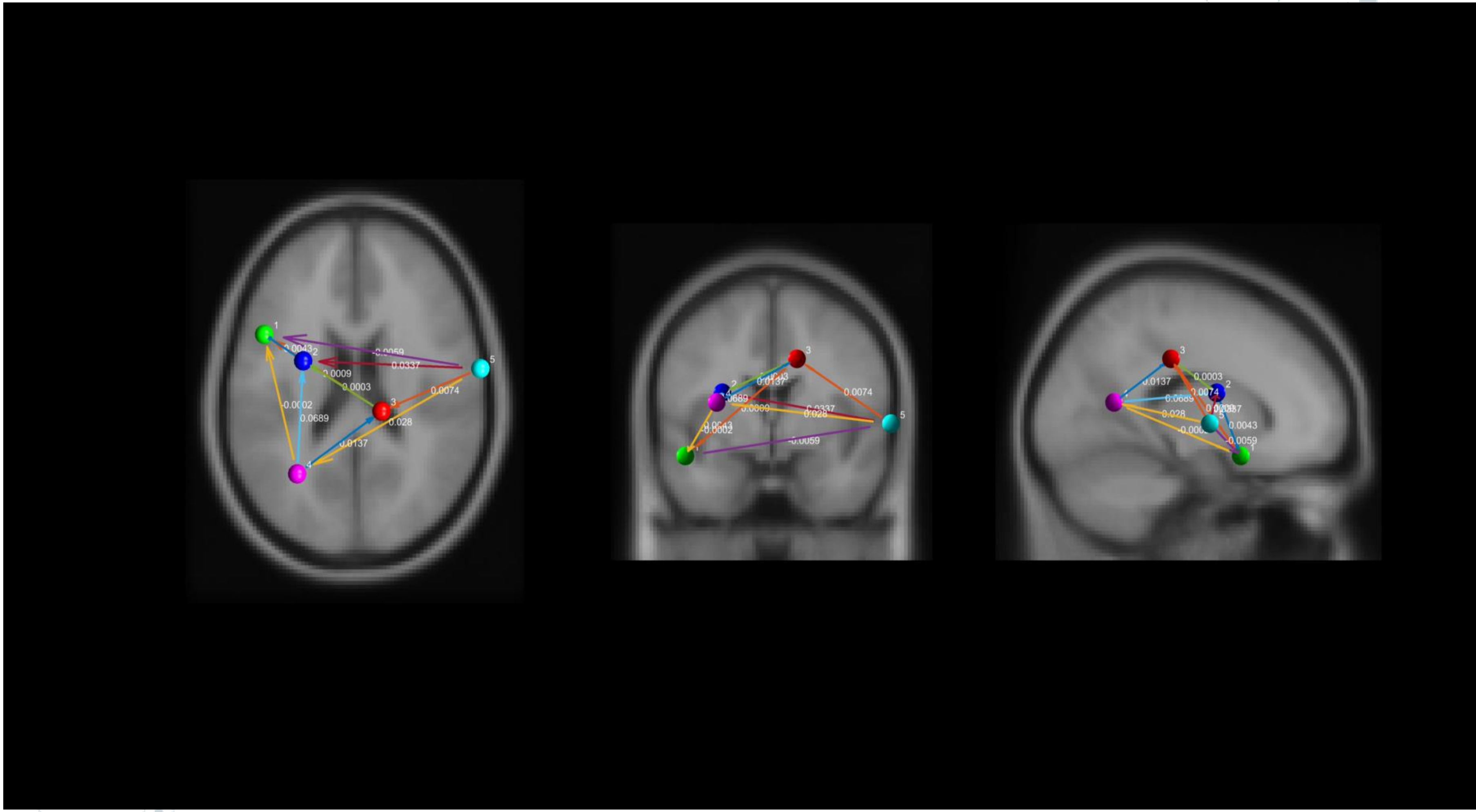
Eyes Open

ICA Component Maps

(after ICA rejection)

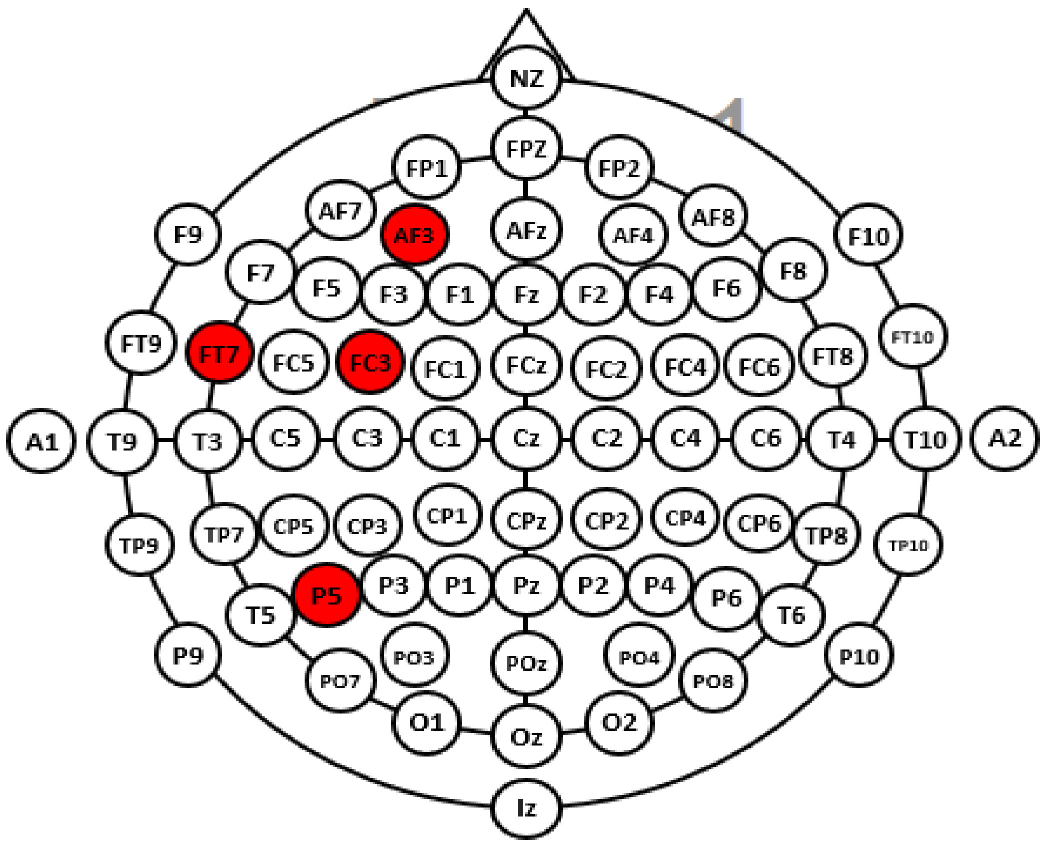





1
2
3
4
5
0.0043
-0.0059
0.0337
0.0009
0.0003
0.0074
-0.0002
0.0689
0.028
0.0137

		[x] Four Channel →→→		[x] Avg	[x] U	[ ] D
[ ] Initial	[ ] Single Channel		[ ] 1.5	[ ] Lag	[ ] U	[ ] D
[x] New	[ ] Coherence			[ ] Dev	[ ] U	[ ] D

Inhibit	7-11
Inhibit	20-26
Inhibit	40-50
Reward	3-15



Informant: Self

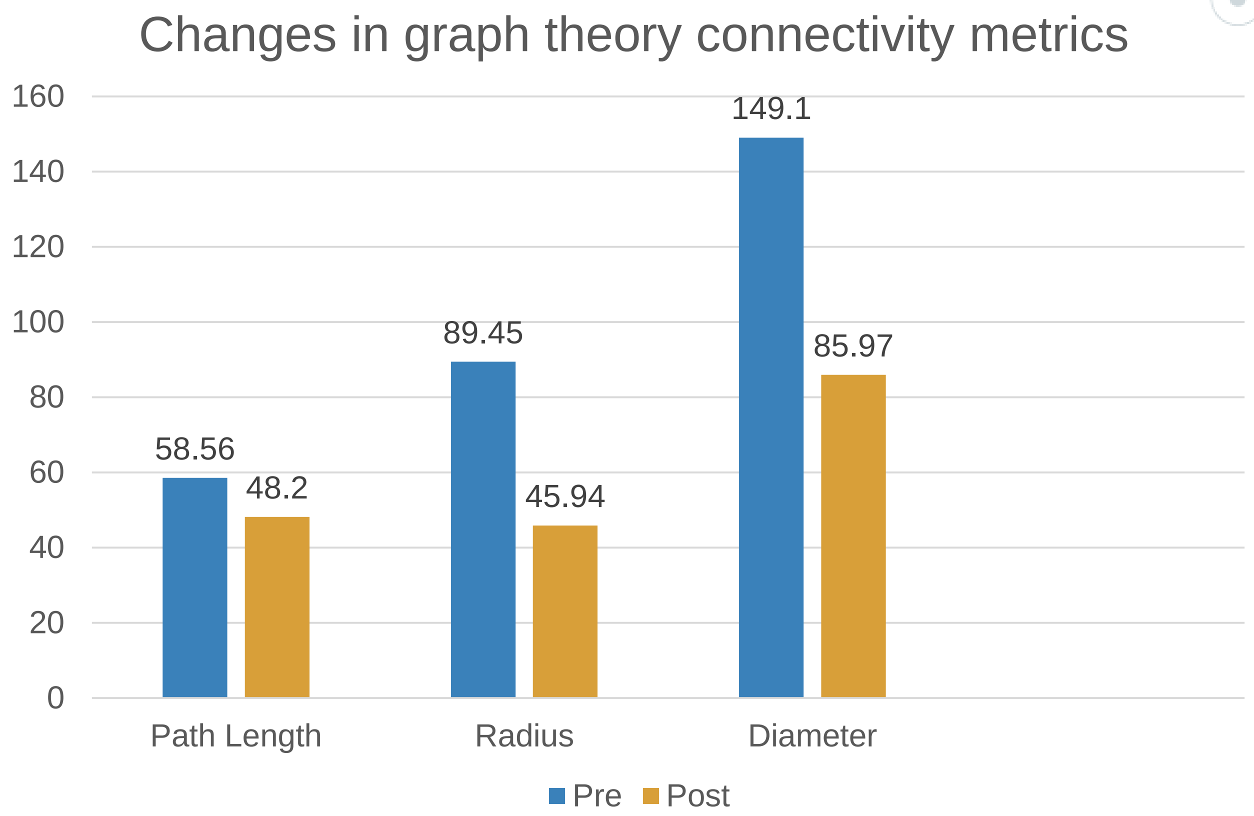
Previous Protocol/# of sessions: 12

Initial Treatment Goal:				
Memory	no change	**slightly improved**	improved	much improved
Speech	**no change**	slightly improved	improved	much improved
Sleep	**no change**	slightly improved	improved	much improved
Vision	no change	slightly improved	**improved**	much improved

Positive Changes Noted:

Continued Areas of Concern:

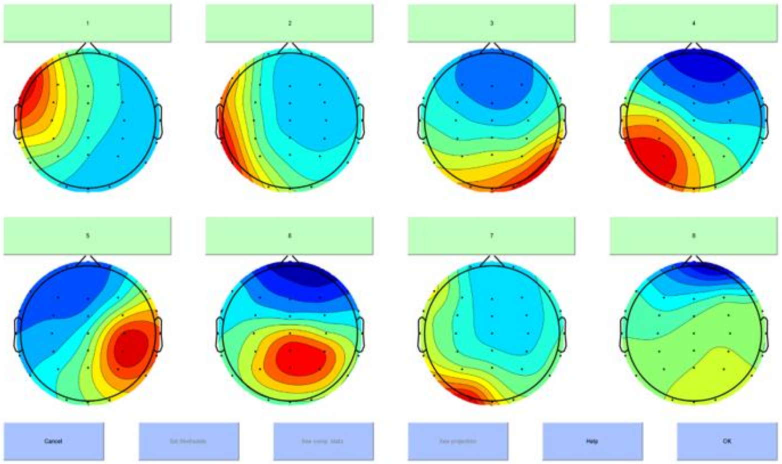
Vision.

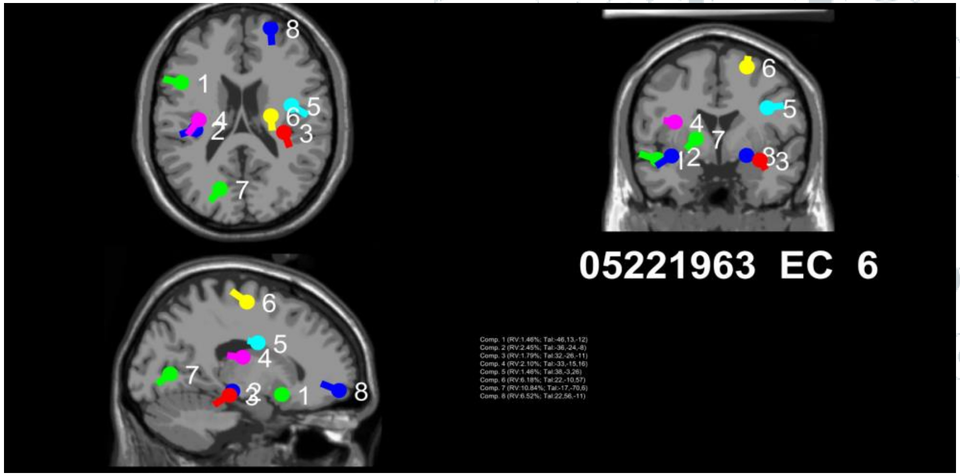

Changes in graph theory connectivity metrics
160
140
120
100
80
60
40
20
0
58.56
48.2
89.45
45.94
149.1
85.97
Path Length
Radius
Diameter
Pre
Post

Eyes Closed

ICA Component Maps

(after ICA rejection)

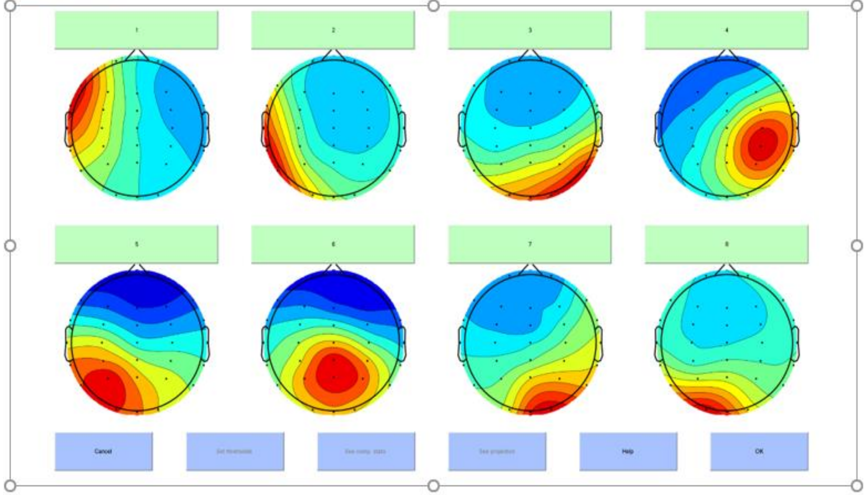


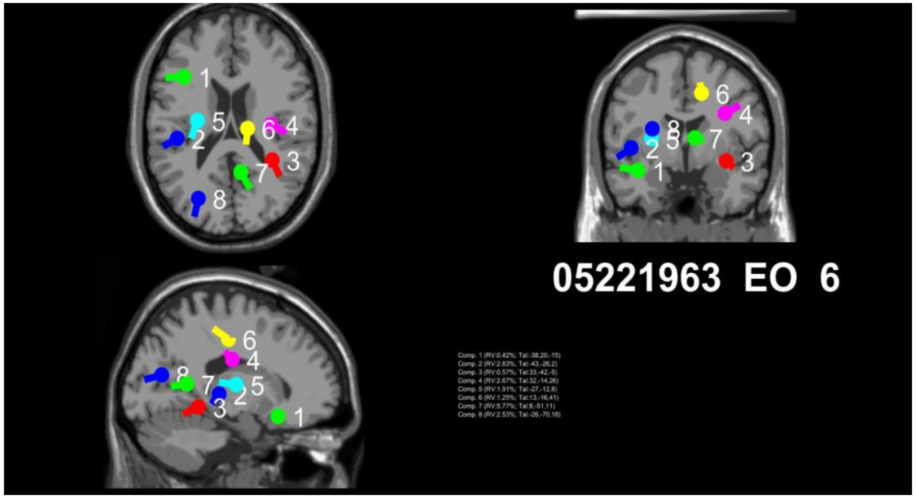


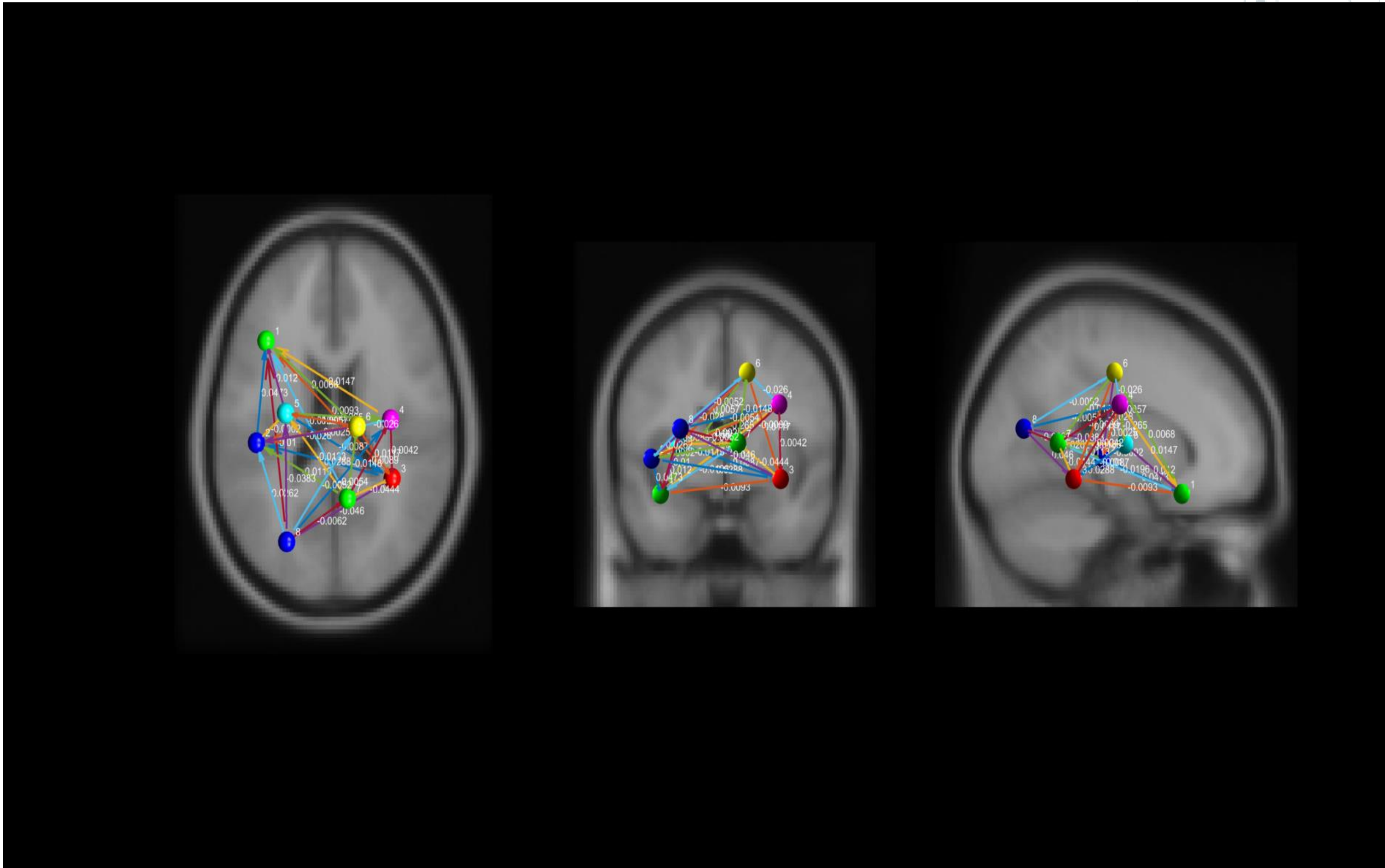
Eyes Open

ICA Component Maps

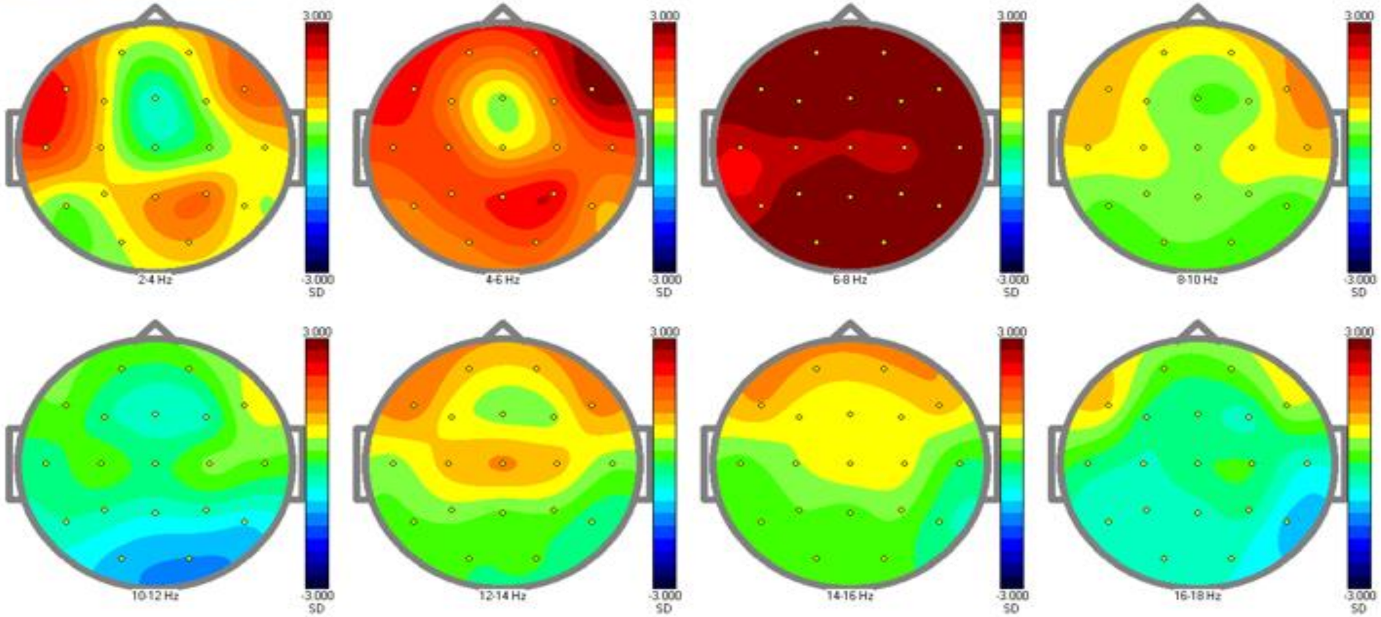
(after ICA rejection)

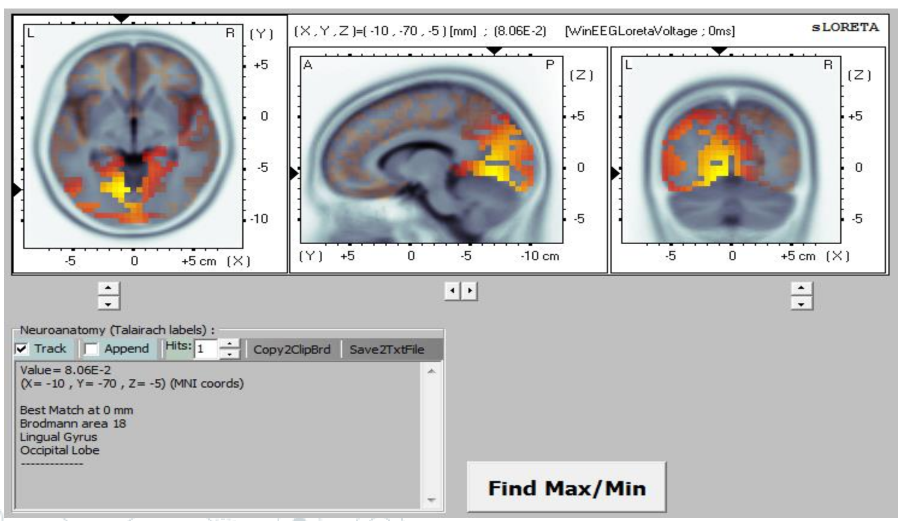


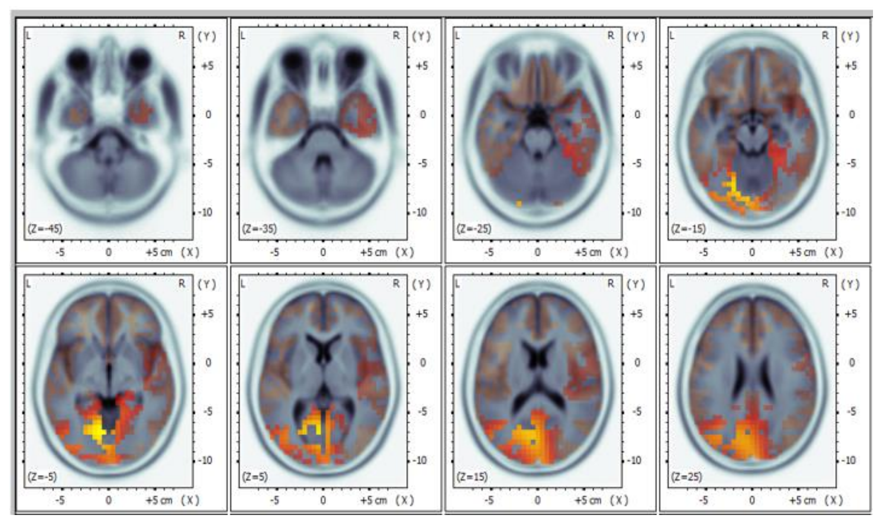




Z-Score Relative Power

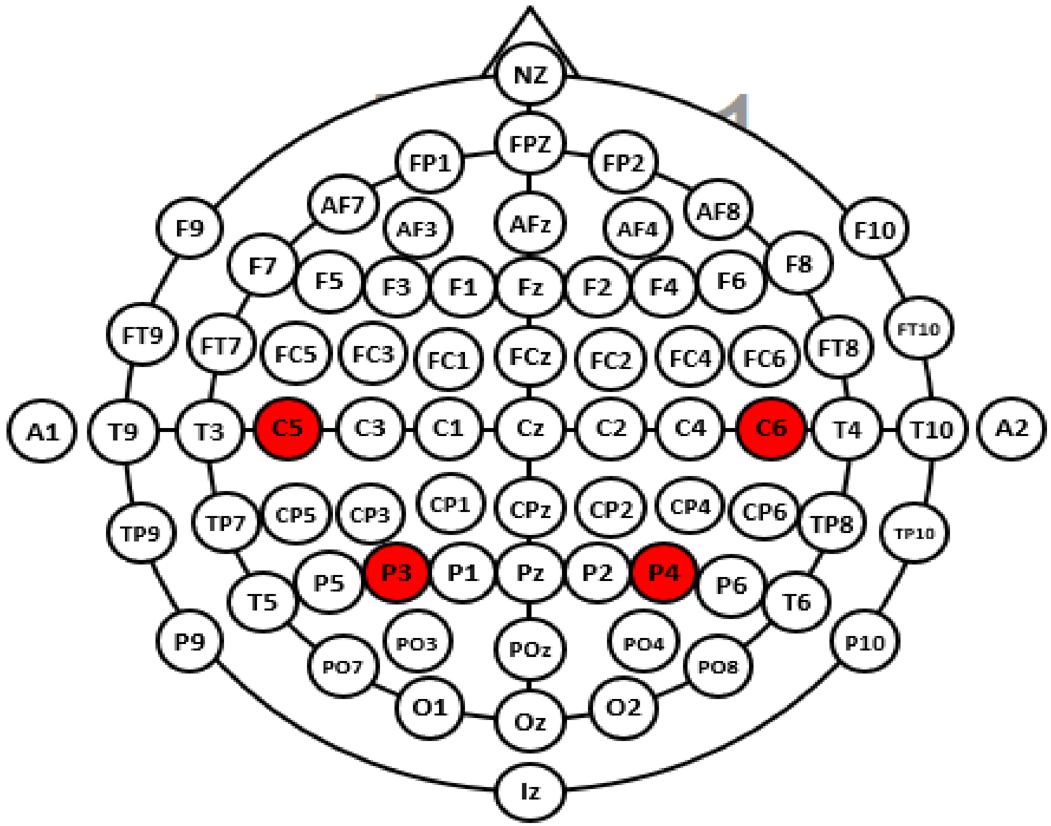






			[x] Four Channel →→→	[x] Avg	[x] U	[ ] D
	[ ] Initial	[ ] Single Channel	[ ] 1.5	[ ] Lag	[ ] U	[ ] D
	[x] New	[ ] Coherence		[ ] Dev	[ ] U	[ ] D

Inhibit	1-5
Inhibit	6-12
Inhibit	15-20
Reward	1-17



Informant: Self

Previous Protocol/# of sessions: P3+P4+C5+C6 x 11 sessions
QPS Aug up.

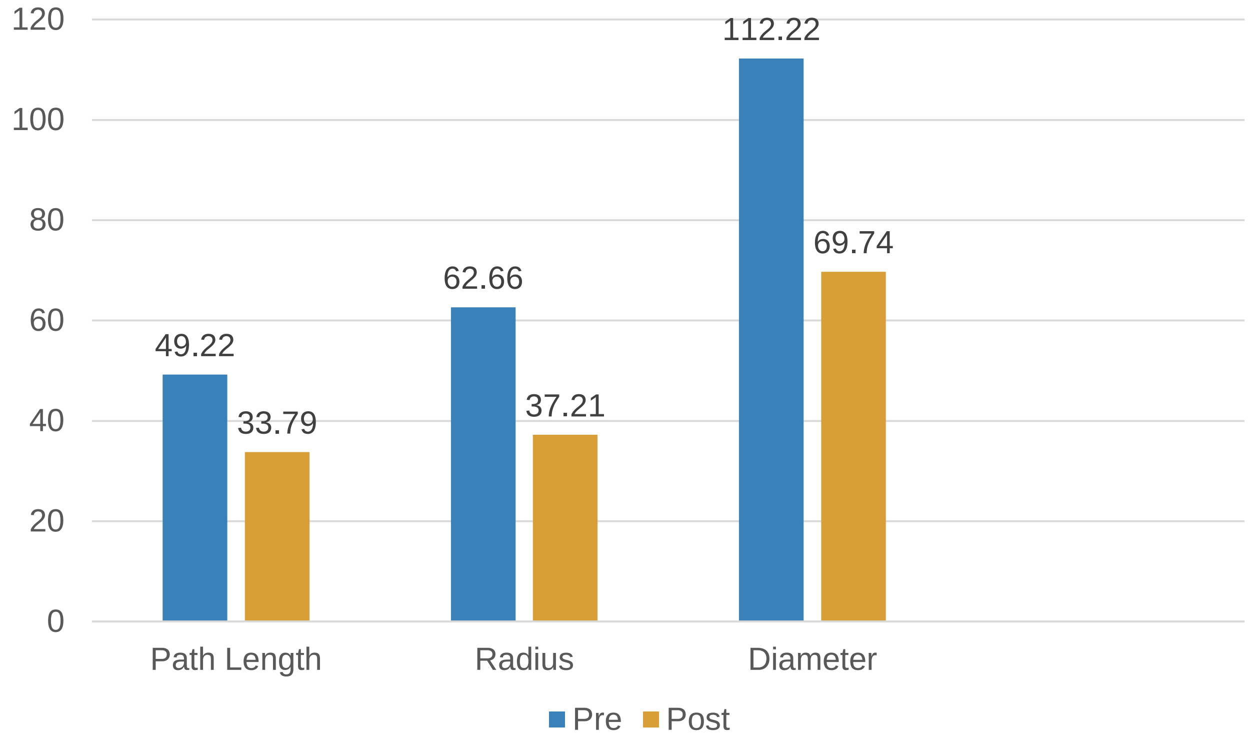
Initial Treatment Goal:				
Vision	no change	slightly improved	improved	(much improved)
Memory	no change	slightly improved	(improved)	much improved
Sleep	no change	slightly improved	(improved)	much improved
Speech	no change	slightly improved	(improved)	much improved

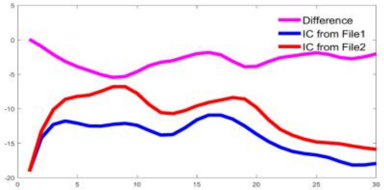
Positive Changes Noted:

Continued Areas of Concern:

Keep improving coordination, balance, & vision

Changes in graph theory connectivity metrics

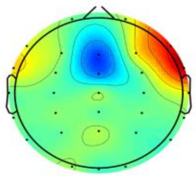




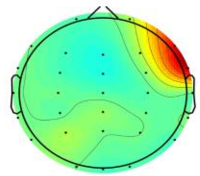
Topomap Corr:0.84771 Currthresh 0.75 GOOD
Mean PSD diff:-2.9505 Currthresh 10 GOOD
Mean IC dipole diff:13.1156 Currthresh 25 GOOD
Mean IC rv diff:0.020077 Currthresh 15 GOOD

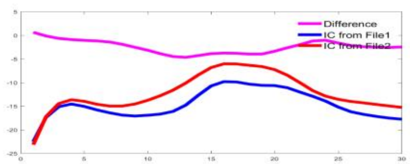
Recommendation is: Matches Up

File1 IC:2



File2 IC:3

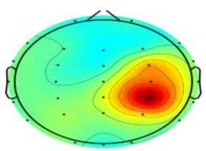




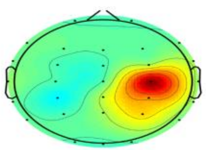
Topomap Corr:0.7815 Currthresh 0.75 GOOD
Mean PSD diff:-2.441 Currthresh 10 GOOD
Mean IC dipole diff:11.6032 Currthresh 25 GOOD
Mean IC rv diff:0.020077 Currthresh 15 GOOD

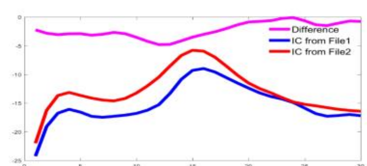
Recommendation is: Matches Up

File1 IC:3



File2 IC:4

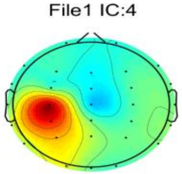




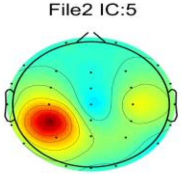
Topomap Corr:0.83033 Currthresh 0.75 GOOD
Mean PSD diff:-2.2812 Currthresh 10 GOOD
Mean IC dipole diff:18.5043 Currthresh 25 GOOD
Mean IC rv diff:0.020077 Currthresh 15 GOOD

Recommendation is: Matches Up

File1 IC:4

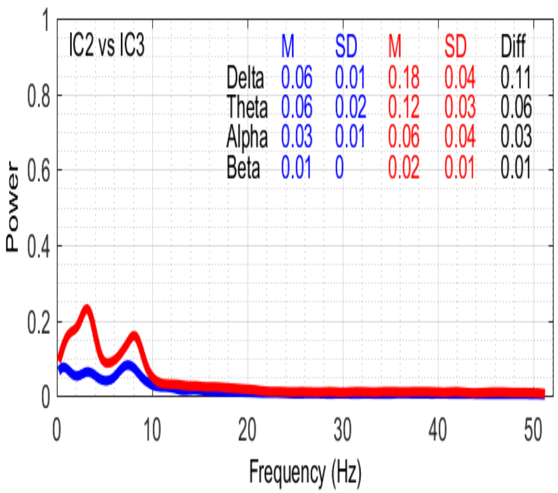


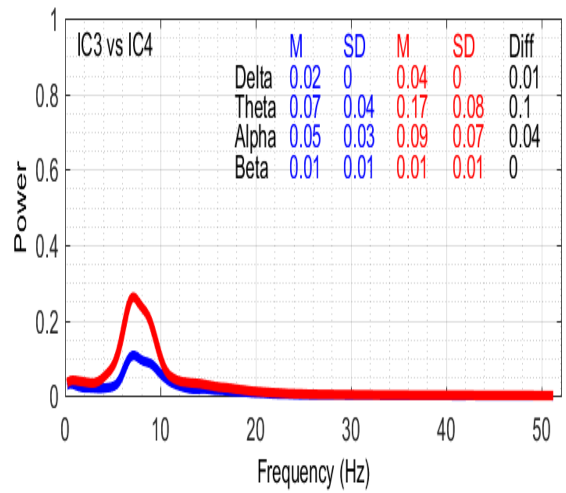
File2 IC:5

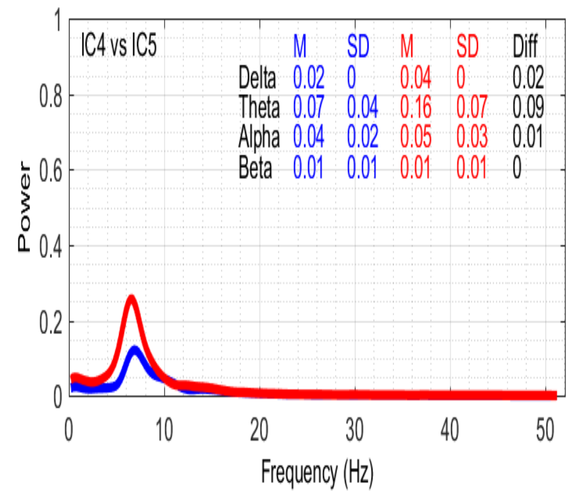


File1:05221963 EO 11

File2:05221963 EO 10







Thank you and to our team!

https://www.integratebrainhealth.com/

INS INPS HEADON!

INTEGRATED HEALTH COACHING IBN

INTEGRATE BRAIN HEALTH

Phone: 479-225-3223

Phone: 866-936-1882

email: admin@integrated-neuro.com

Mail to: 92 W. Sunbridge Drive Fayetteville AR