Impact of developmental trauma on brain function and connectivity.

Presented by Carl A. Armes, BS. & Robert Coben, Ph.D.

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OUTLINE

- Ace Study
- Previous Findings
- Methods
- EEG Measures
- Results
- Discussion

WHAT IS DEVELOPMENTAL TRAUMA?

- The Complex Trauma Taskforce of the National Child Traumatic Stress Network [Van der Kolk, B. A. (2005) Developmental Trauma Disorder, Psychiatric Annals, 35(5): 401-40] coined the term "Developmental Trauma Disorder" because most of the maltreated children did not meet the criteria for PTSD.
- PTSD also cannot capture the multiplicity of physical, emotional, and sexual abuse.
- PTSD diagnosis does not also encompass the developmental effects, such as self endangering behaviors, self-hatred, self-blame, chronic feelings of ineffectiveness, and loss of body regulation in areas of sleep, food and self-care.

ADVERSE CHILDHOOD EXPERIENCES STUDY (ACE)

[Anda, Robert F., et al. "The enduring effects of abuse and related adverse experiences in childhood." *European archives of psychiatry and clinical neuroscience* 256.3 (2006): 174-186.]

- Study of linkage between epidemiologic and neurobiological evidence of the effects of childhood trauma.
- Questions pertained to respondent's first 18 years of life.
- Assessed 8 adverse childhood experiences: abuse (emotional, physical, or sexual); witnessing domestic violence; parental marital discord; growing up with- mentally ill; substance abusing; or criminal household members.

3 TYPES OF ABUSES

Eur Arch Psychiatry Clin Neurosci. 2006 Apr; 256(3): 174–186.
Published online 2005 Nov 29. doi: 10.1007/s00406-005-0624-4

The enduring effects of abuse and related adverse experiences in childhood

A convergence of evidence from neurobiology and epidemiology

Robert F. Anda, MD, MS, Vincent J. Felitti, MD, FACP, J. Douglas Bremner, MD, John D. Walker, MD, Charles Whitfield, MD, Bruce D. Perry, MD, PhD, Shanta R. Dube, MPH, and Wayne H. Giles, MD, MS

Definition and prevalence of each category of adverse childhood experience and the ACE score

Childhood abuse	Total N = 17,337
Emotional abuse	10.6
(Did a parent or other adult in the household…)	
1 Often or very often swear at you, insult you, or put you down?	
2 Sometimes, often, or very often act in a way that made you fear that you might be physically hurt?	
Physical	28.3
(Did a parent or other adult in the household…)	
1 Often or very often push, grab, slap, or throw something at you?	
2 Often or very often hit you so hard that you had marks or were injured?	
Sexual	20.7
(Did an adult or person at least 5 years older ever…)	
1 Touch or fondle you in a sexual way?	
2 Have you touch their body in a sexual way?	
3 Attempt oral, anal, or vaginal intercourse with you?	
4 Actually have oral, anal, or vaginal intercourse with you?	

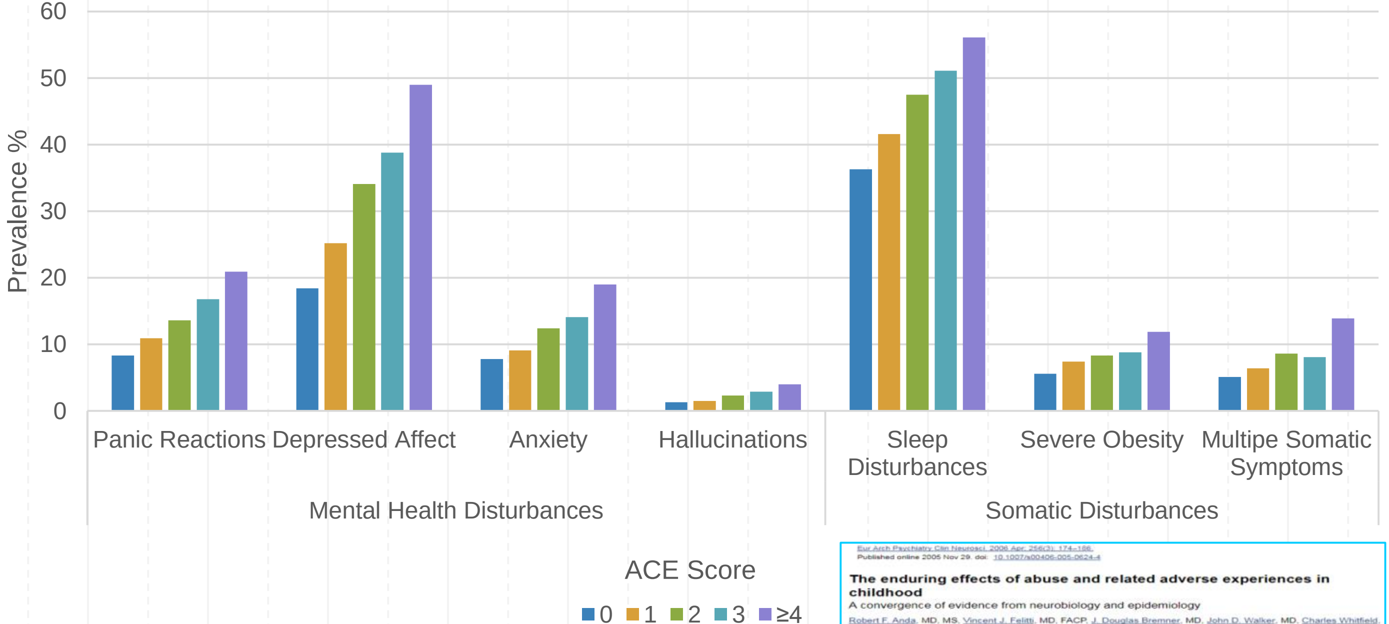
ADVERSE CHILDHOOD EXPERIENCES STUDY (ACE)

- Information from medical review of systems (ROS), the physical examination (PE), and the ACE Study questionnaire (ACEQ) used to define the health-related behaviors or problem sources.
- Behaviors: mental health disturbances; somatic disturbances; substance abuse; impaired childhood memory; sexuality; and perceived stress, anger control, and risk of intimate partner violence.

ACE SCORING

- The number of ACEs (range: 0–8) was summed to create the ACE scores, with scores of 4 or more included as one category (≥ 4).
- Analyses were conducted treating the ACE score as 4 dichotomous variables (yes or no for scores of ≥ 4, 3, 2, and 1) with a score of 0 (no ACEs) as the referent.
- At least 1 ACE reported by 64% of respondents.
- As ACE score increased, mean number of comorbid outcomes increased.

Relationship of ACE Score to the Prevalence of Mental Health Disturbances and Somatic Health Disturbances



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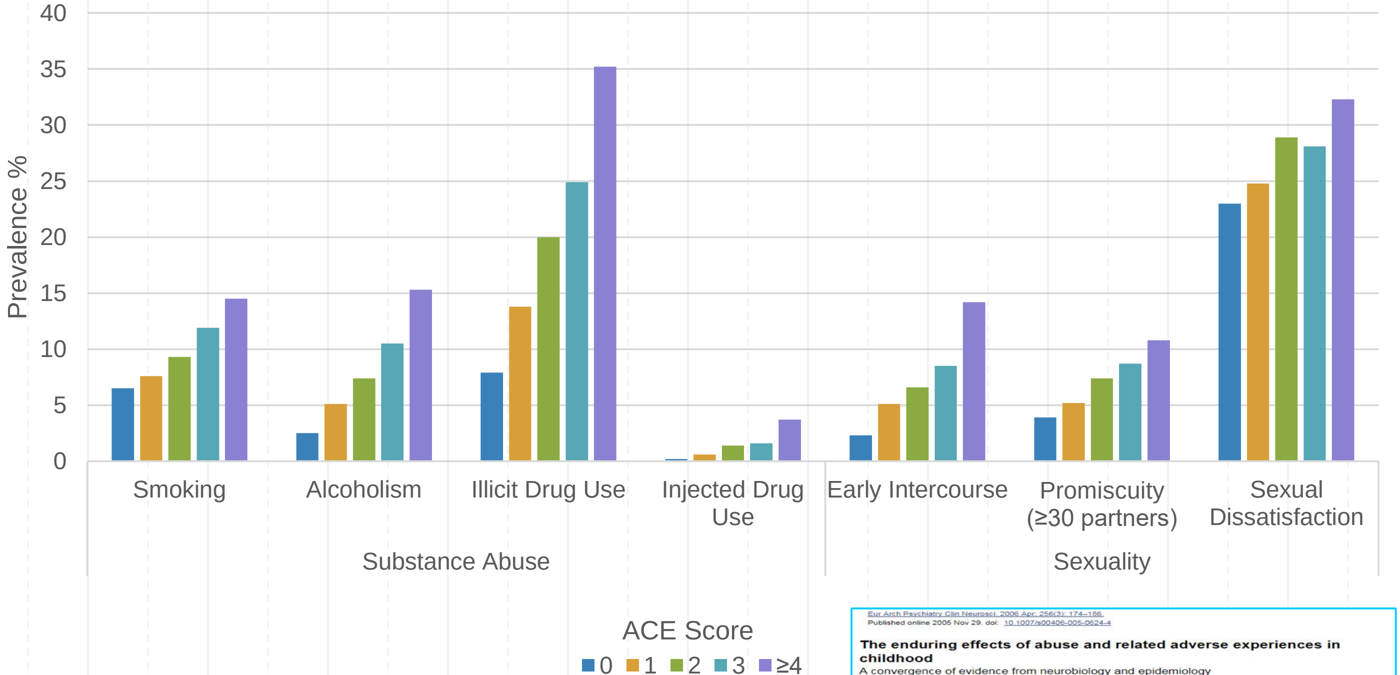
Relationship of ACE Score to the Prevalence of Substance Abuse and Sexuality



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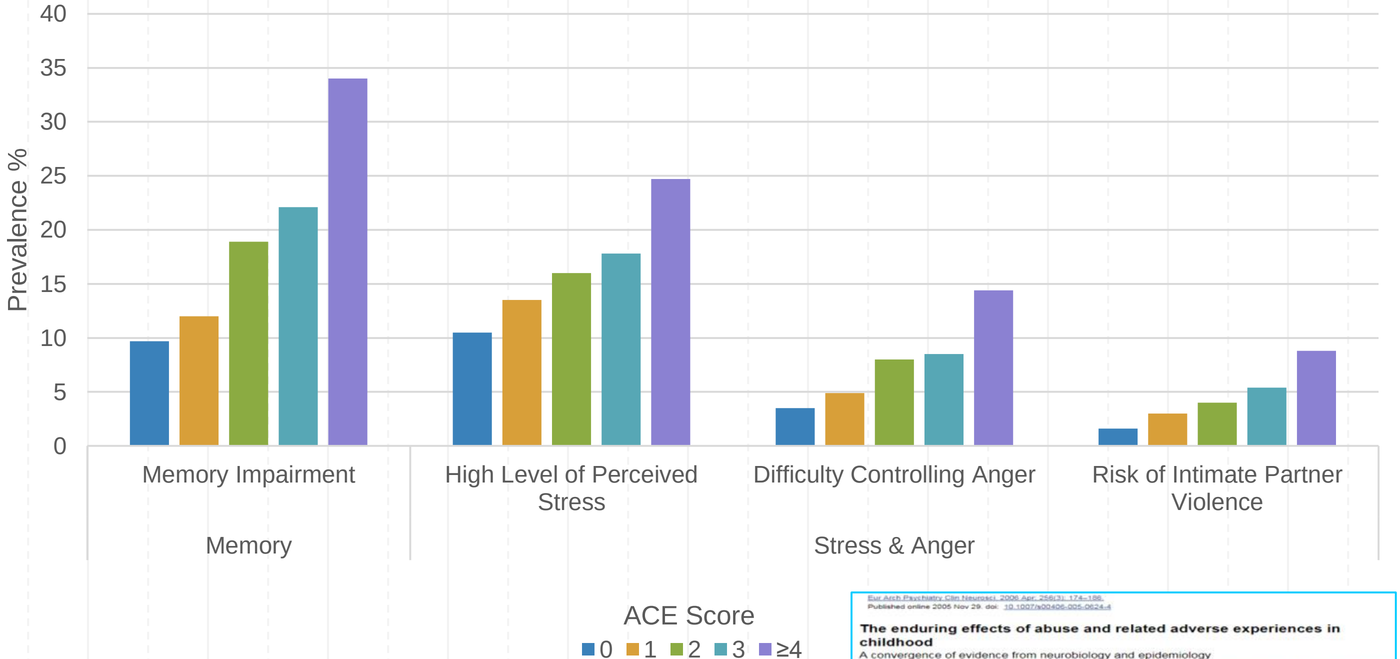
Relationship of ACE Score to the Prevalence of Memory and Stress & Anger



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nature REVIEWS NEUROSCIENCE

The effects of childhood maltreatment on brain structure, function and connectivity

Martin H. Teicher, Jacqueline A. Samson, Carl M. Anderson & Kyoko Ohashi

Nature Reviews Neuroscience **17**, 652–666 (2016) | doi:10.1038/nrn.2016.111
Published online 19 September 2016

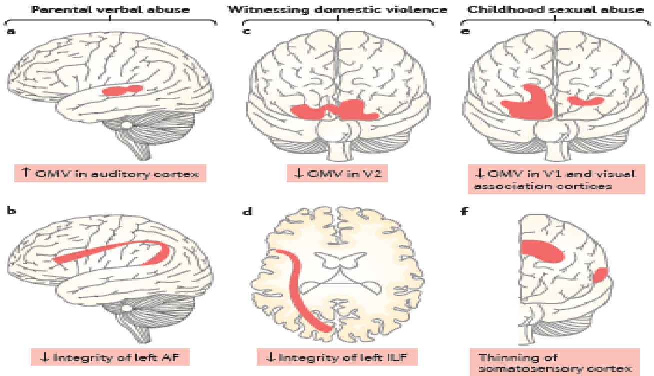

Figure 1 | **Abuse type-specific effects on the developing brain.** Images depicting the potential effects of exposure to specific types of childhood maltreatment on grey-matter volume (GMV) or thickness and fibre-tract integrity. Exposure to parental verbal abuse was associated with increased GMV in the auditory cortex portion of the left superior temporal gyrus[25] (part a) and decreased integrity of the left arcuate fasciculus (AF) interconnecting Wernicke's area and Broca's area[26] (part b). Visually witnessing multiple episodes of domestic violence was associated with reduced GMV in right lingual gyrus, left occipital pole and bilateral secondary visual cortex (V2)[27] (part c) and decreased integrity of the left inferior longitudinal fasciculus (ILF), which serves as a visual–limbic pathway[28] (part d). Adults reporting exposure to multiple episodes of childhood forced-contact sexual abuse were found to have reduced GMV in right and left primary visual cortex (V1) and visual association cortices, as well as reduced thickness in right lingual, left fusiform and left middle occipital gyri[29] (part e) and portions of the somatosensory cortex representing the clitoris and surrounding genital area[30] (part f). Part a is adapted with permission from REF. 25, Elsevier. Part b is adapted with permission from REF. 26, Elsevier. Part c is adapted from REF. 27. Part d is adapted with permission from REF. 28, Elsevier. Part e is adapted with permission from REF. 29, Elsevier. Part f is adapted from an image courtesy of C. Heim, Charité Universitätsmedizin Berlin, Germany, and J. Pruessner, McGill University, Canada.

- Verbal abuse: higher grey matter volume (GMV) in auditory cortex and lower integrity of left arcuate fasciculus. Diminished arcuate fasciculus integrity associated with lower verbal IQ and comprehension.

- Witness domestic abuse: Lower grey matter density in right lingual gyrus and reduced thickness in portions of visual cortex. Witnessing domestic violence between 11-13 years of age had considerable effect on thickness and volume.

- Sexual abuse: Lower GMV in primary visual cortex and visual association cortices directly correlate with duration of exposure before age of 12 and associated with deficit in visual memory.

nature REVIEWS NEUROSCIENCE

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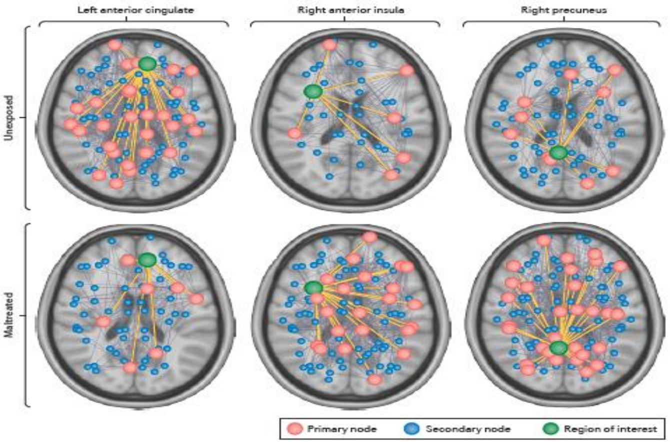


Figure 6 | **Network changes associated with childhood maltreatment.** Maltreatment during childhood has been found to be associated with changes in structural connectivity at the network level. Here, the entire cerebral cortex of young adults with ($n = 142$) or without ($n = 123$) histories of childhood maltreatment was divided into 112 regional nodes. Within each group, between-subject correlations in the cortical thicknesses of each nodal pairing were used to infer connectivity, as brain regions that co-vary reliably in size between subjects are either structurally or functionally interconnected[90]. Network architecture and the centrality of each node were then determined by applying graph theory to the 112×112-node maltreated and non-maltreated cross-correlation matrices. Three key differences in structural nodal centrality between maltreated and non-maltreated groups are shown here. Green circles indicate nodal centres (the regions of interest) in each case for the left anterior cingulate cortex (left), the right anterior insula (middle) and the right precuneus (right). Red circles indicate primary nodes, which are regions with direct connections to the nodal centre. Blue circles delineate secondary nodes, which have direct connections with the primary nodes but do not have direct connections with the nodal centre. Childhood maltreatment was associated with a marked decrease in the centrality of the left anterior cingulate, as indicated by a substantial decrease in primary and secondary connections. Conversely, maltreatment was associated with a significant increase in the centrality of the right anterior insula and the right precuneus, as indicated by the greater number of primary and secondary nodal connections in these regions in the maltreated group. Adapted with permission from REF. 90, Elsevier.

- Plasticity of the limbic system was found to be altered.
- Structural connectivity was lower for maltreated subjects in the left anterior cingulate (emotions), as well as the temporal pole, and medial frontal gyrus (social cognition and theory of mind).
- In contrast structural connectivity was higher for maltreated subjects in areas such as precuneus and anterior insula, which are linked to self-awareness.

Journal of TRAUMATIC STRESS
PUBLISHED BY THE INTERNATIONAL SOCIETY FOR TRAUMATIC STRESS STUDIES

Neural correlates of reexperiencing, avoidance, and dissociation in PTSD: Symptom dimensions and emotion dysregulation in responses to script-driven trauma imagery

James W. Hopper, Paul A. Frewen, Bessel A. van der Kolk, Ruth A. Lanius

First published: 22 October 2007 Full publication history
DOI: 10.1002/jts.20284 View/save citation

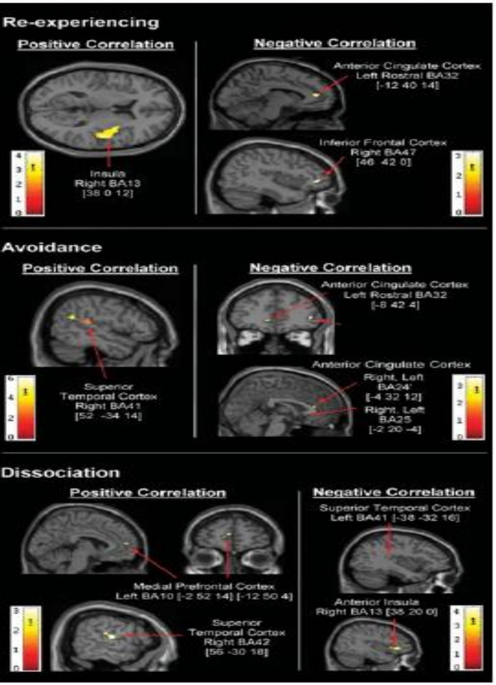


Figure 1. Correlations between state symptoms and neural responses to script-driven trauma imagery (*N* =27). Activations from baseline associated with trauma and neutral imagery were calculated from average activation patterns during the 30-s postscript imagery periods. Significant differences in blood-oxygenation-level-dependent (BOLD) response location and intensity in the trauma relative to the neutral condition were determined via subtraction analyses using SPM99. The statistical parametric maps of the *t* statistic (contrast images) yielded by these linear contrasts were then correlated with Responses to Script-Driven Imagery Scale (RSDI) reexperiencing, avoidance, and dissociation scores, using simple pairwise correlations in a whole-brain random-effects model with two-tailed α <.05, corresponding to a minimum $|r| \geq .30$ (i.e., medium-sized or greater correlation magnitude). Sample RSDI reexperiencing items: "Did you feel as though the event was reoccurring, like you were reliving it?" "Were you distressed?" Sample RSDI avoidance items: "Did you avoid experiencing images, sounds, or smells connected to the event?" "Did you avoid feelings about the event?" Sample RSDI dissociation items: "Did what you were experiencing seem unreal to you, like you were in a dream or watching a movie or play?" "Did you feel disconnected from your body?"

- Re-experiencing severity correlated positively with right anterior insula activity (involved in aspects of emotional states) and negatively with rostral anterior cingulate cortex activity (which can inhibit the amygdala.
- Re-experiencing correlated negatively with activation of right inferior frontal cortex (IFC), a region implicated in inhibition of movement and of emotional experience.
- Avoidance was negatively correlated with activation in three separate anterior cingulate cortex (ACC) clusters: left rostal ACC and SC, and bilateral dorsal ACC.
- Dissociation was negatively correlated with activity in left superior temporal cortex, as well as right anterior insula and right IFC.

The Journal of Neuropsychiatry and Clinical Neurosciences

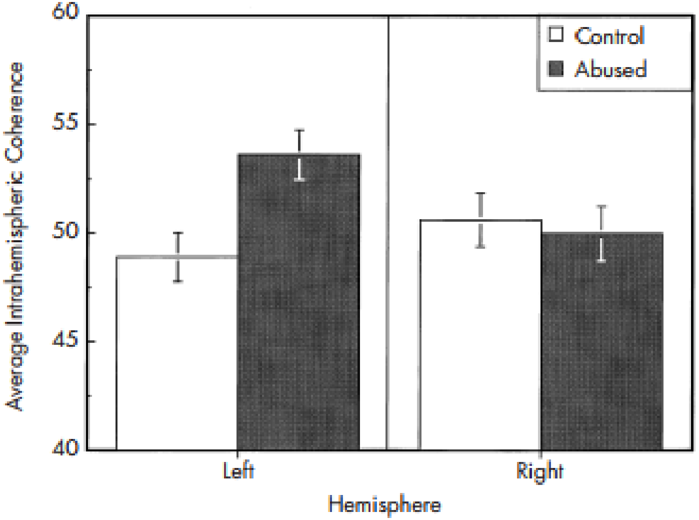
Preliminary Evidence for Aberrant Cortical Development in Abused Children

A Quantitative EEG Study

Yutaka Ito, M.D., Ph.D., Martin H. Teicher, M.D., Ph.D., Carol A. Glod, R.N., Ph.D., and Erika Ackerman, B.S.

View Author and Article Information
Published online: August 01, 1998 | https://doi.org/10.1176/jnp.10.3.298

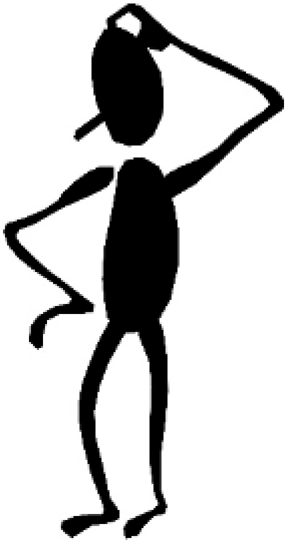
FIGURE 2. Differences between children with a history of abuse and normal control subjects in magnitude of average intrahemisphere alpha EEG coherence based on common reference (linked-ear) montage.



- 15 adolescent inpatients age (mean age 10.7 years, male:female=7:8, 10 medicated) with a history of intense physical or sexual abuse. The control subjects were 15 healthy volunteers (mean age 10.1 years, M:F=6:9).
- Abused children had greater average left hemisphere coherence than normal children, but also significantly greater left vs right coherence.

HYPOTHESIS

- Adults that experienced developmental trauma will show significantly different findings than those that did not have such a history. Regions may include those near the anterior cingulate, left frontal temporal and limbic regions and right posterior regions involved in social engagement and anxiety/fear. We theorize that connectivity anomalies will be found as well.



METHODS

- Study 1: 50 subjects underwent 19 channel EEG EC and EO. 34 experimental (hx of abuse) vs. 16 normal controls. For post-hoc analyses the exp group was divided in abuse groups with 19 suffering emotional abuse/neglect and 15 physical/sexual abuses.
- Study 2: 19 subjects underwent 64 channel EEG EC and EO. 12 experimental (hx of abuse) vs. 7 normal controls.
- Dependent measures included log power, source localized activations, graph theory connectivity metrics.

ICA/EEGLAB Scientists and Journals

- Journal of Neuroscience Methods
- Plos One
- Computational Intelligence and Neuroscience
- NeuroImage
- Computational Intelligence and Neuroscience
- Frontiers in Neuroscience
- Frontiers in Neural Circuits

- 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

Makeig, Scott, et al. "Independent Component Analysis of Electroencephalographic Data." *in Advances in Neural Information Processing Systems*. 1996.

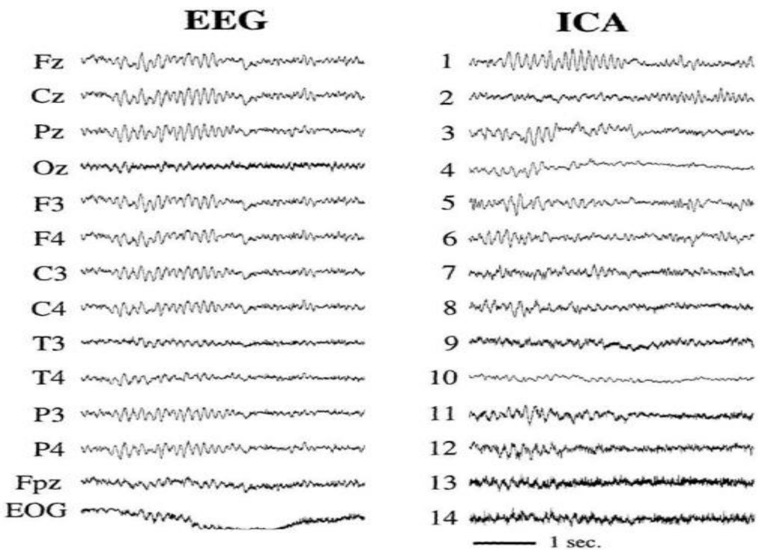


Figure 1: Left: 4.5 seconds of 14-channel EEG data. Right: an ICA transform of the same data, using weights trained on 6.5 minutes of similar data from the same session.

Journal of Neuroscience Methods 134 (2004) 9–21

JOURNAL OF NEUROSCIENCE METHODS

www.elsevier.com/locate/jneumeth

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

Arnaud Delorme*, Scott Makeig

Swartz Center for Computational Neuroscience, Institute for Neural Computation, University of California San Diego, La Jolla, CA 92093-0961, USA

Received 17 June 2003; received in revised form 22 September 2003; accepted 16 October 2003

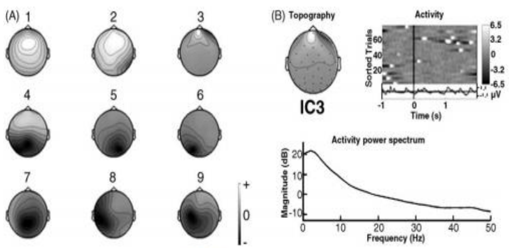


Fig. 4. Visualizing independent components. (A) Topographical 2-D scalp maps of the nine independent components (ICs) accounting for the most EEG variance of the 32 components returned by the ICA algorithm for the sample dataset. The component scalp map values returned by ICA are proportional to µV (scaling is distributed between the component maps and activity time courses). From its far-frontal scalp map, IC3 appears to account for eye movement artifacts. (B) The 'Component Properties' display for IC3 verifies that it accounts for eye artifacts since its activity spectrum is smoothly decreasing (bottom panel), and prominent eye movement artifacts appear in its activity ERP image (top right panel). By removing this and other eye movement components (not shown) from the dataset, the user can remove most evidence of eye movements from the data without removing other activity of interest (Jung et al., 2000).

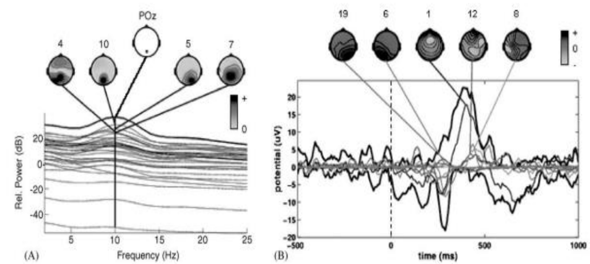
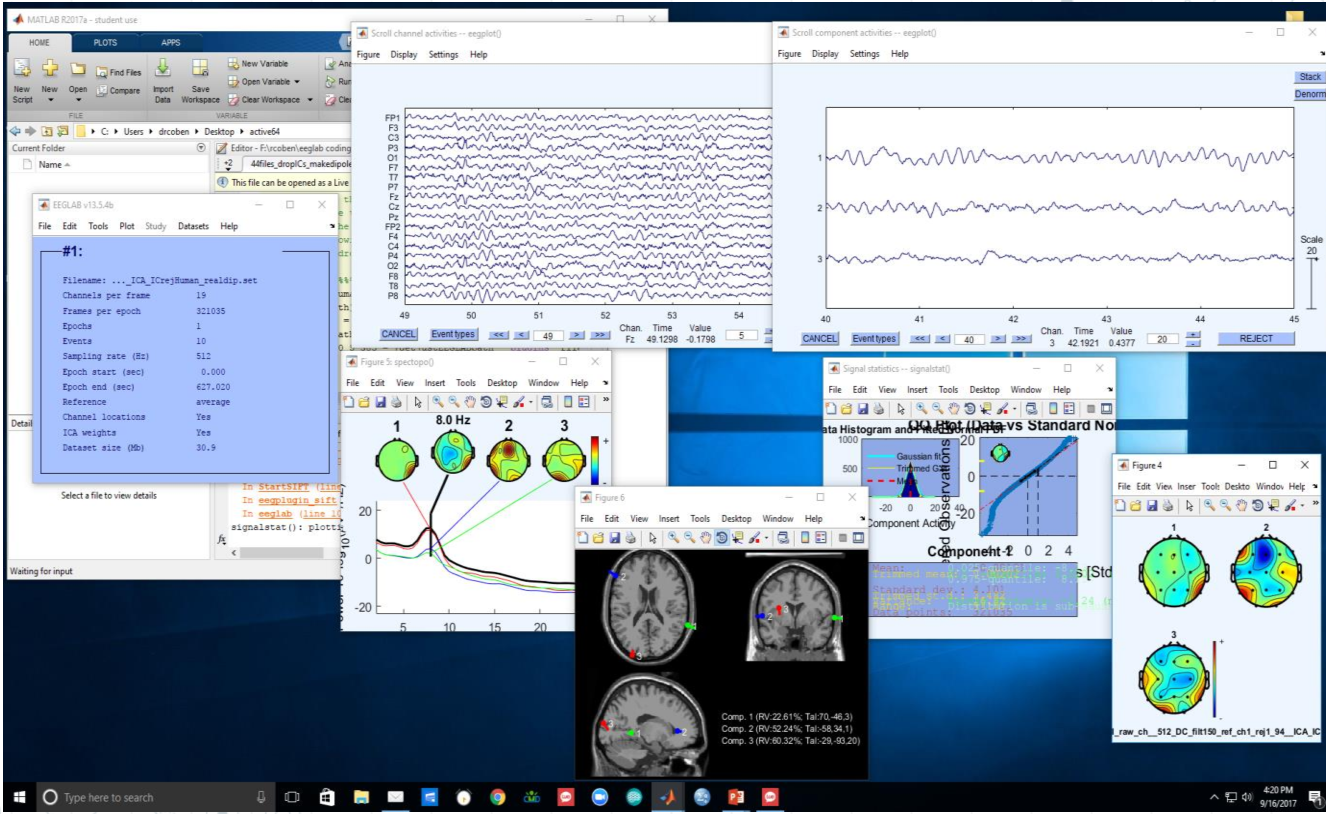


Fig. 5. Evaluating independent component contributions. (A) An EEGLAB *spectopo()* plot showing the components accounting for the largest portions of 10 Hz activity at electrode POz (middle scalp map). The figure shows the power spectrum of the selected channel (top black trace), the activity spectra of the projection to that channel of each of the 32 components (lower traces), and the scalp power maps of the four largest-contributing components (4, 5, 7, 10). (B) An *envtopo()* plot showing the envelopes (i.e., the min and max values, over all channels, at each time point) of the five independent components making the largest potential contributions to the ERP. The black thick traces show the envelope (all channels) of the ERP data and the thin traces, the envelopes of the depicted component contributions to the ERP.


MATLAB R2017a - student use
HOME
PLOTS
APPS
Scroll channel activities -- eegplot()
Scroll component activities -- eegplot()
EEGLAB v13.5.4b
File Edit Tools Plot Study Datasets Help
#1:
Filename: ..._ICA_ICrejHuman_realdip.set
Channels per frame 19
Frames per epoch 321035
Epochs 1
Events 10
Sampling rate (Hz) 512
Epoch start (sec) 0.000
Epoch end (sec) 627.020
Reference average
Channel locations Yes
ICA weights Yes
Dataset size (Mb) 30.9
Select a file to view details
Waiting for input
Figure 5: spectopo()
8.0 Hz
Signal statistics -- signalstat()
Figure 6
Comp. 1 (RV:22.61%; Tal:70,-46,3)
Comp. 2 (RV:52.24%; Tal:-58,34,1)
Comp. 3 (RV:60.32%; Tal:-29,-93,20)
Figure 4
CANCEL
Event types
REJECT
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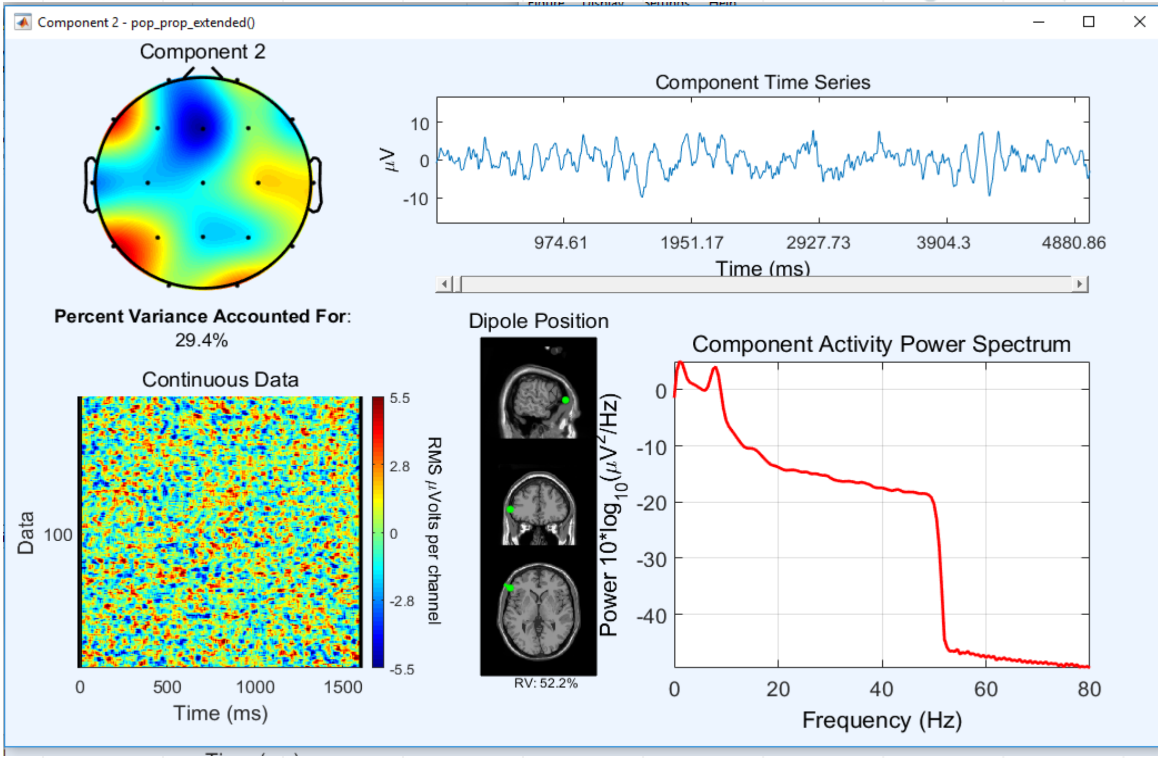
9/16/2017


Component 2 - pop_prop_extended()
Component 2
Percent Variance Accounted For:
29.4%
Continuous Data
Data
100
0
500
1000
1500
Time (ms)
5.5
2.8
0
-2.8
-5.5
RMS μVolts per channel
Component Time Series
10
0
-10
μV
974.61
1951.17
2927.73
3904.3
4880.86
Time (ms)
Dipole Position
RV: 52.2%
Component Activity Power Spectrum
Power 10*log10(μV²/Hz)
0
-10
-20
-30
-40
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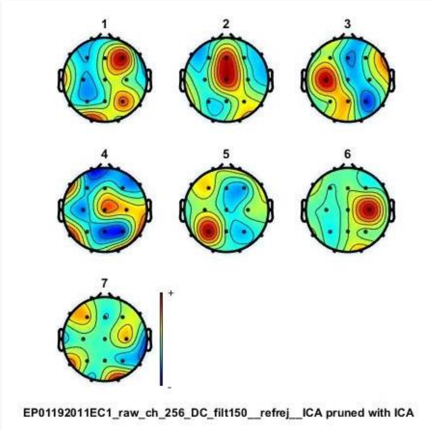
Frequency (Hz)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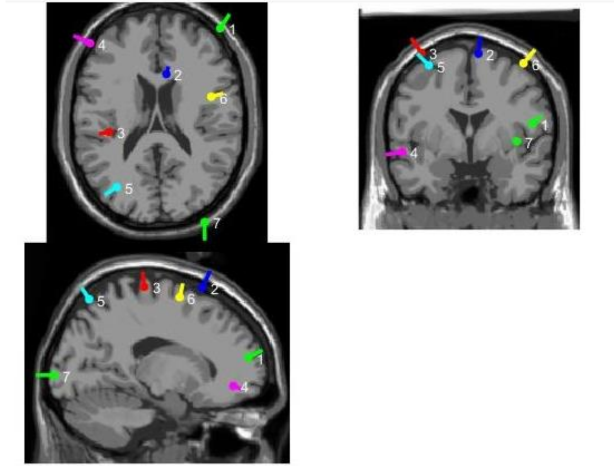

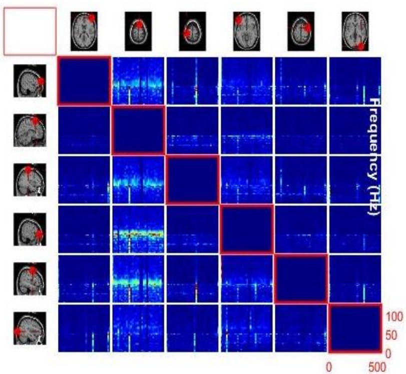
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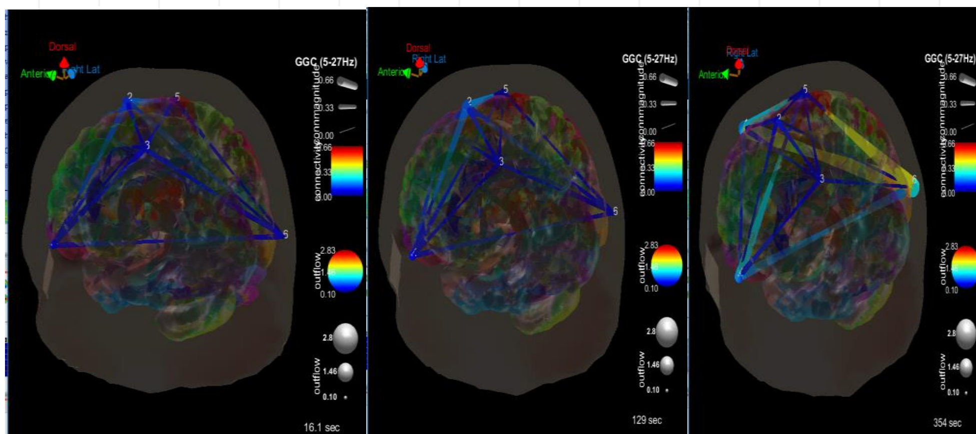
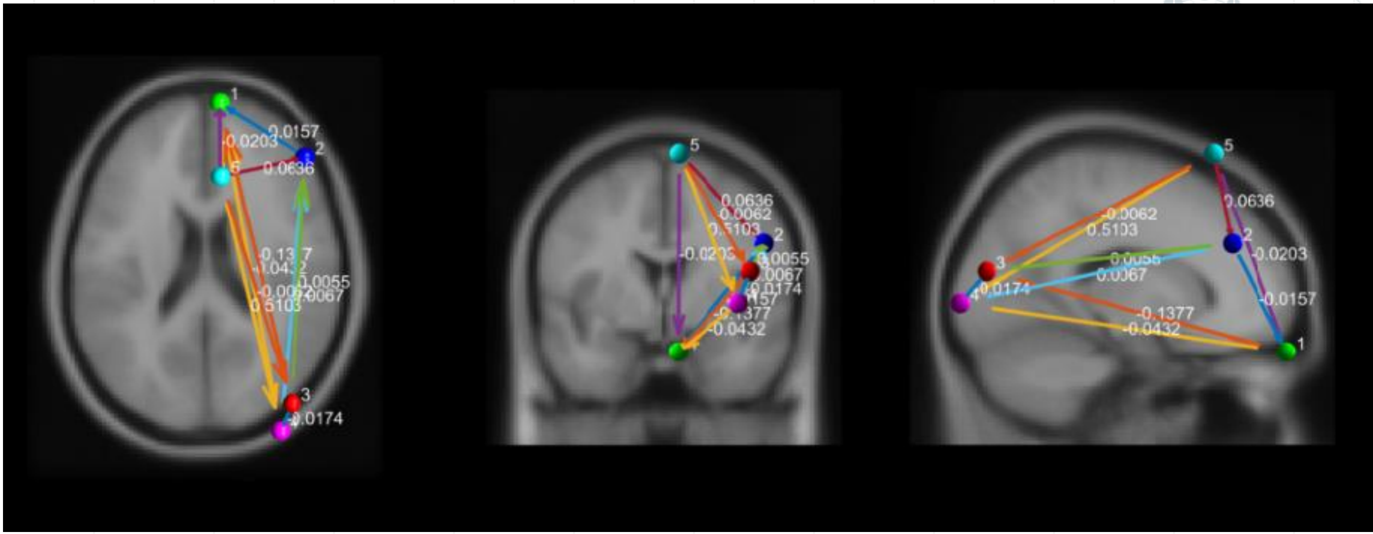

Dorsal
GGC (5-27Hz)
outflow
16.1 sec
Dorsal
GGC (5-27Hz)
outflow
129 sec
GGC (5-27Hz)
outflow
354 sec



5
0.0636
-0.0062
0.5103
2
-0.0203
3
4
-0.0157
-0.1377
-0.0432
1


3.0T 3
Ex: 1166124539
AXIAL FLAIR
Se: 8/17
Im: 16 (POS)
Ax: S 28.64
Mag: 2.5
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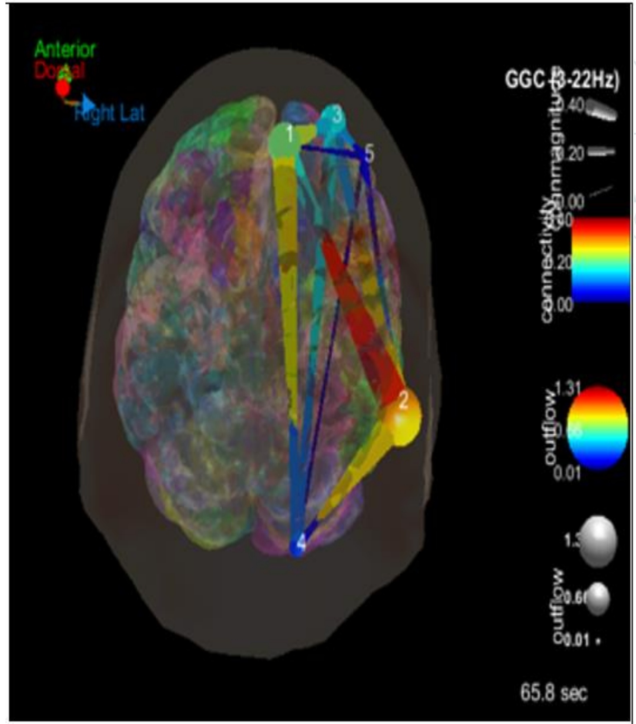
TE: 84.0
5.0thk


Anterior
GGC (3-22Hz)
connectivity
outflow
65.8 sec

GRAPH THEORY

Nodes
Edges
Paths
Clustering
Hubs

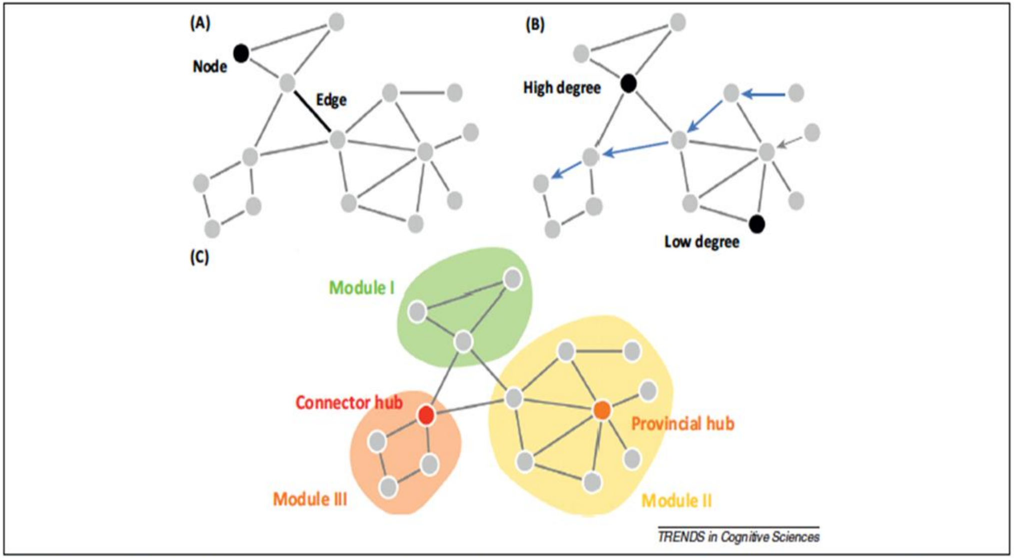
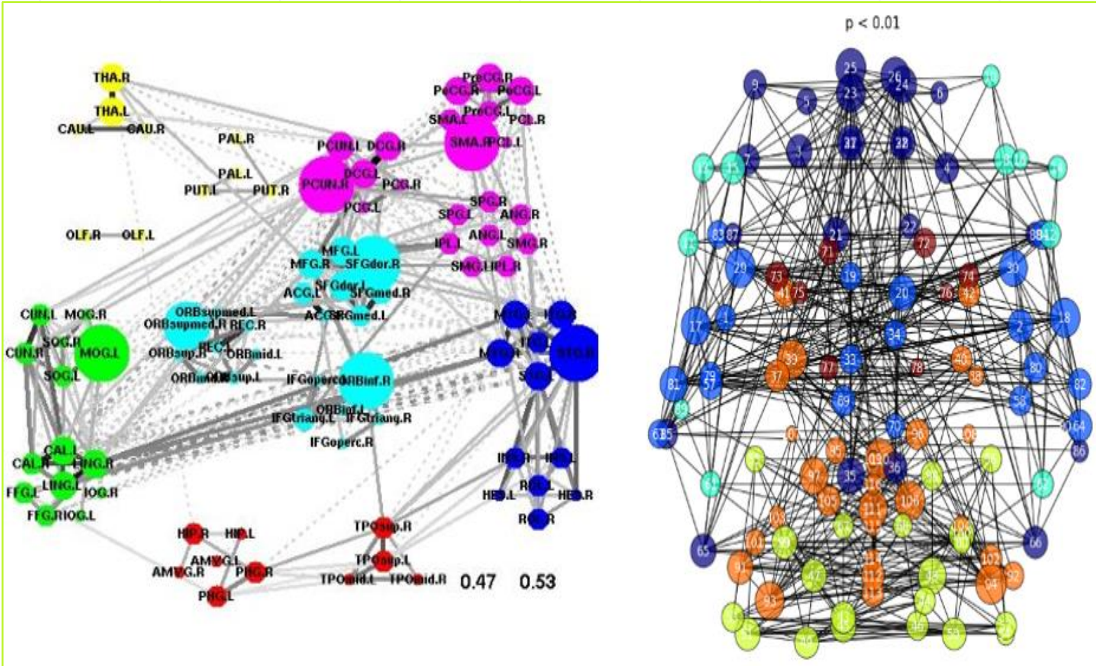


Figure 1. Basic network attributes. **(A)** Brain networks can be described and analyzed as graphs comprising a collection of nodes (describing neurons/brain regions) and a collection of edges (describing structural connections or functional relationships). The arrangement of nodes and edges defines 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.

Path
Length
Radius
Diameter



GRAPH THEORY METRICS

- Clustering coefficient is a measure of the degree to which nodes in a graph tend to cluster together. Cluster coefficient of a node is always between 0 and 1

- Average path length- average number of steps along the shortest paths for all possible pairs of network nodes

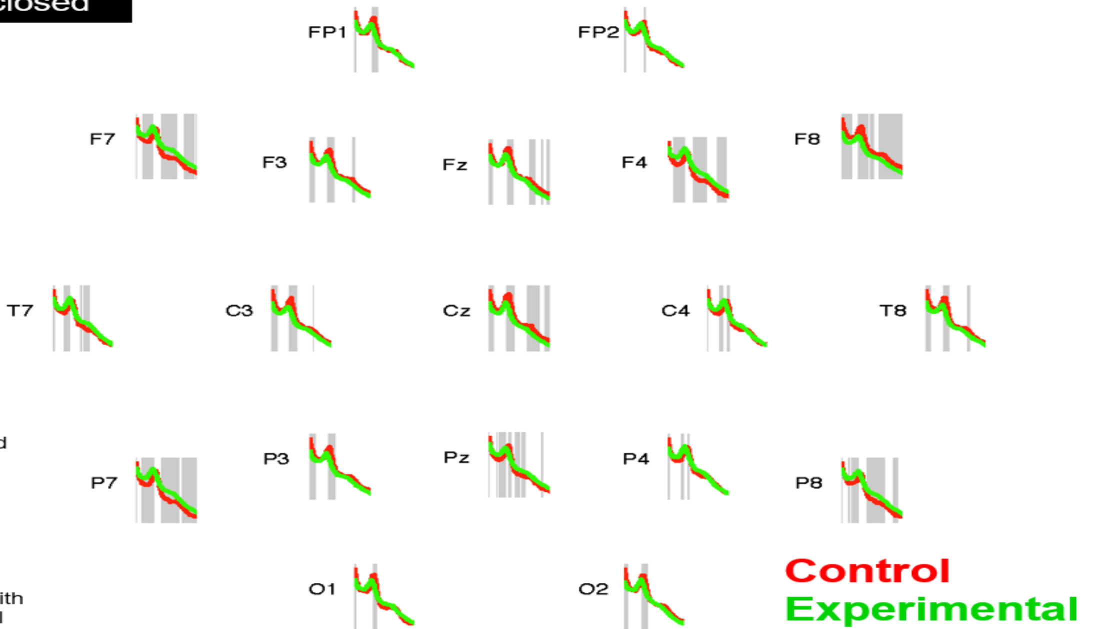
- Global efficiency- measure of how efficiently a network exchanges information

- Radius- minimum eccentricity (distance from one node to another) of any vertex.

- Diameter- maximum eccentricity of any vertex

STUDY 1: POWER AND SOURCE FINDINGS

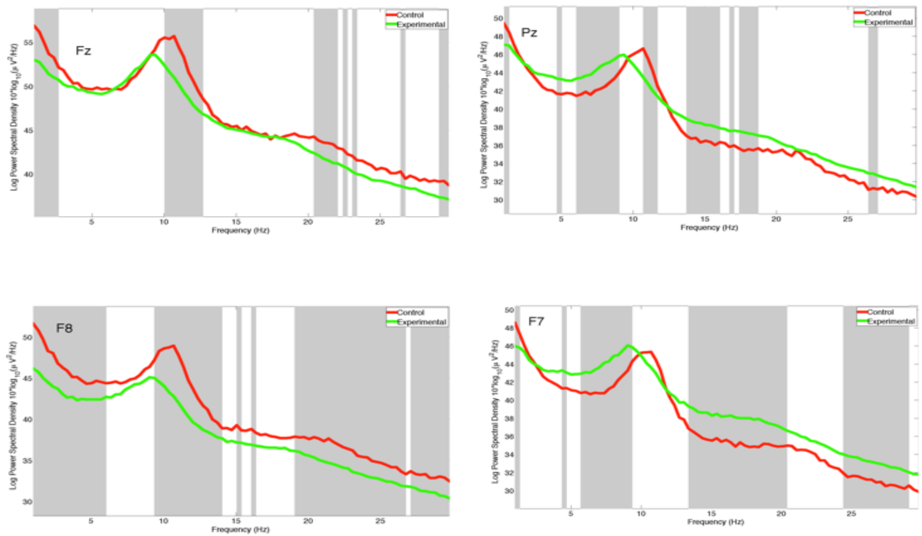
Channel level
19-chan eyes closed



19-chan data
Eyes-closed, ICs dropped
All channel plot
Channel-level data
1-30 Hz
Grey lines indicate significant differences
At p < .0000000001
And with fdr correction
P made small because with normal settings almost all bands at all channels were significantly different

Channel level
19-chan eyes closed

This slide exemplifies two general patterns of differences between the groups, which can be seen at multiple channels, depending on which channel you look at.

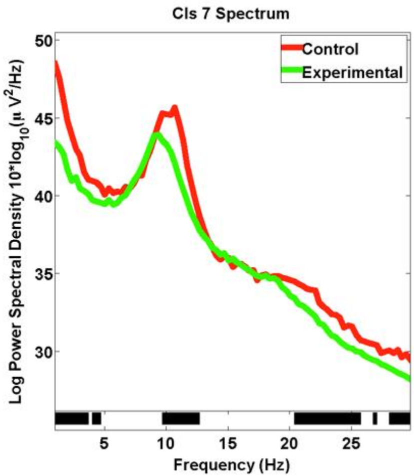


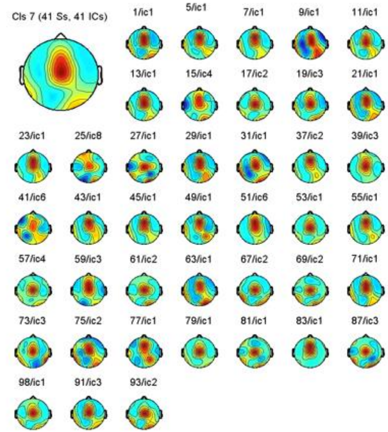
19-chan data
Eyes-closed, ICs dropped
Channel-level data
1-30 Hz
Grey lines indicate significant differences
At $p < .0000000001$
And with fdr correction

Control
Experimental

IC level
19-chan
eyes closed

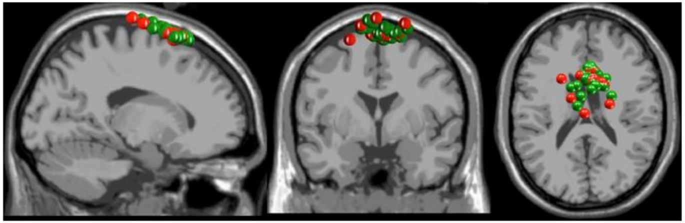
19-chan data,
Eyes-closed,
ICs dropped
IC-level data,
1-30 Hz with fdr Note

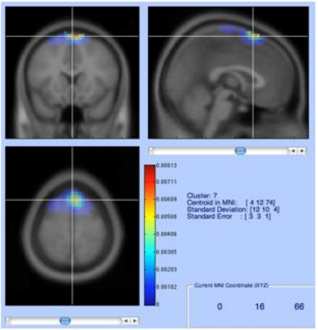




- Left Superior Frontal Gyrus, BA6
- Right SFG, BA6

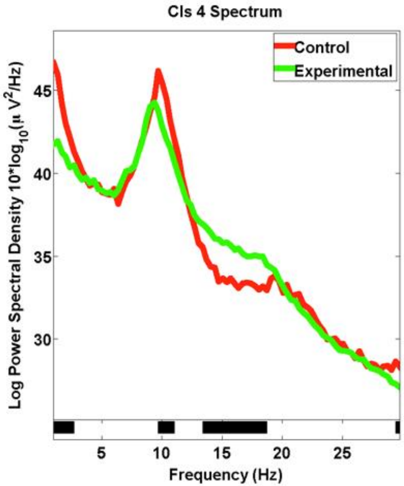
Control
Experimental

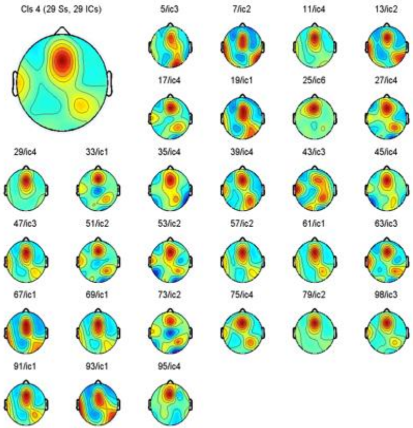




IC level
19-chan
eyes closed

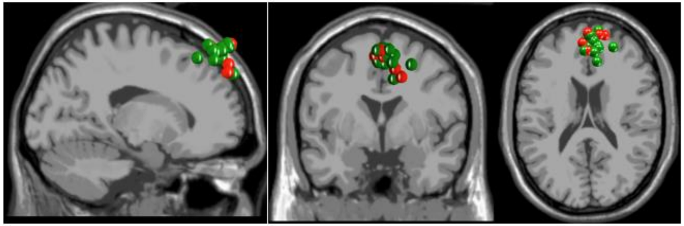
19-chan data,
Eyes-closed,
ICs dropped
IC-level data,
1-30 Hz with fdr Note

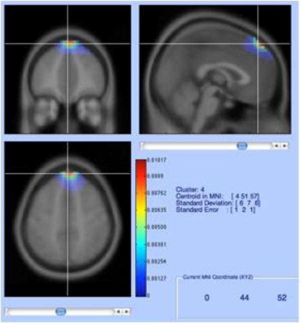


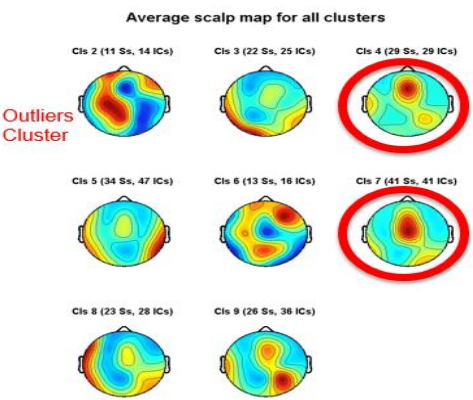


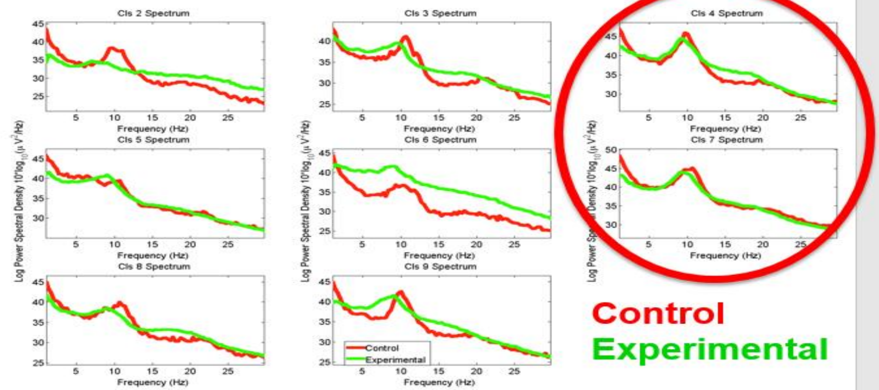
- Left Superior Frontal Gyrus, BA8
- Right SFG, BA8

Control
Experimental







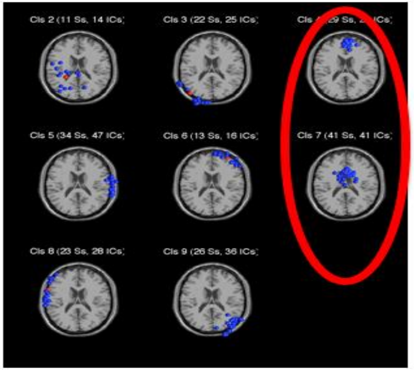


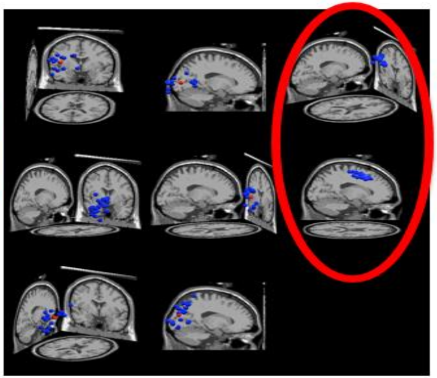
Control
Experimental

Summary of IC clusters
7 clusters, one 1 outlier cluster
Clusters 4 and 7 focused on

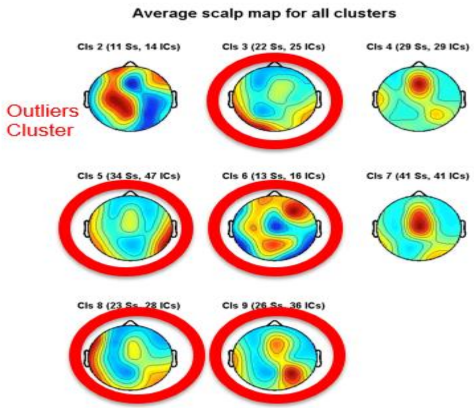
19-chan data,
Eyes-closed,
ICs dropped
IC-level data,

IC level
19-chan
eyes closed

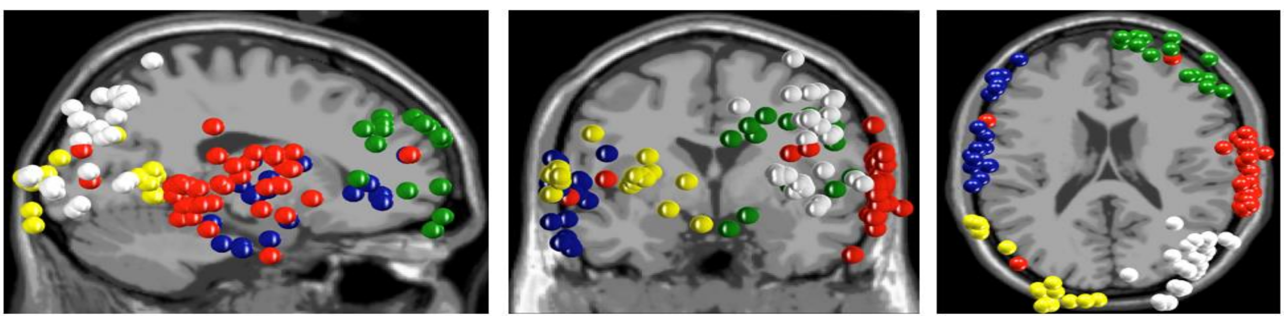




LIMITATIONS OF 19 CH DATA FOR SOURCE LOCALIZATION



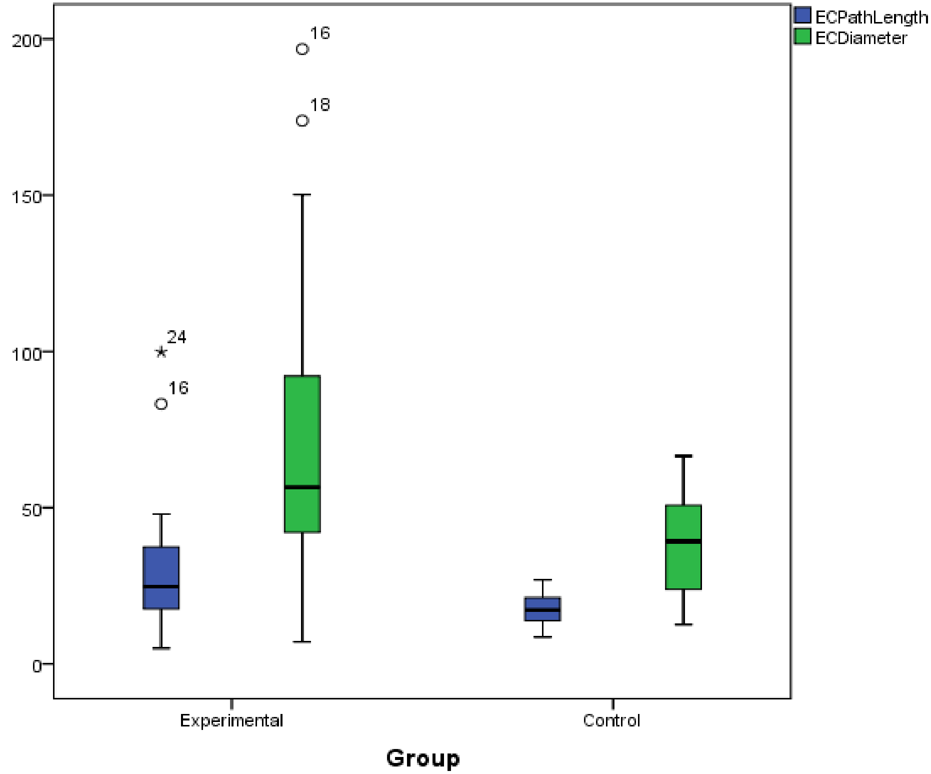
Example remaining
IC dipoles from
eyes-closed 19-chan IC analysis



STUDY1: CONNECTIVITY FINDINGS

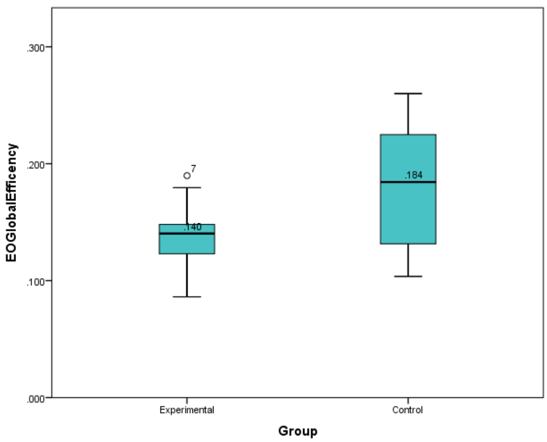
- Experimental v control group demographics
- No significant difference for gender and handedness
- Age was significantly different (p .014). Mean age of groups was 31.7 years (sd 19.21) for exp and 19.38 (sd 1.36) for controls

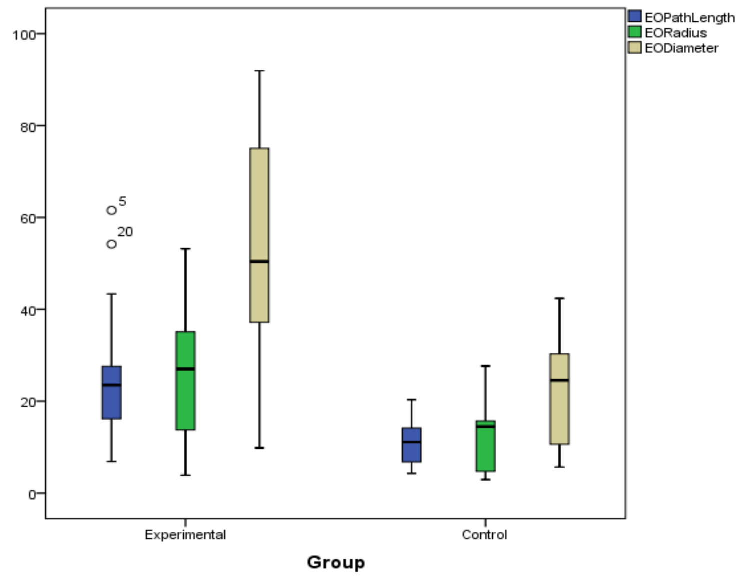
- Eyes closed graph theory metrics
- No significant differences for clustering coefficient, global efficiency and radius
- Significant differences seen for path length (p .038) and diameter (p .011)
- Mean path length for exp 29.89 (sd 20.5) and controls 17.877 (sd 5.23)
- Mean diameter for exp 74.62 (sd 48.34) and controls 38.97 (sd 15.51)



ECPathLength
ECDiameter
200
150
100
50
0
16
18
24
16
Experimental
Control
Group

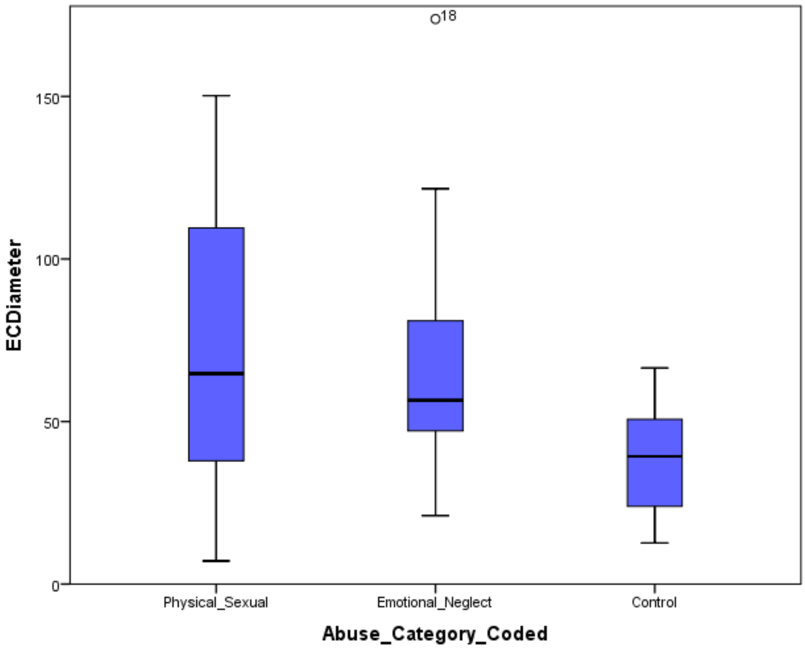
- Eyes open graph theory metrics
- No significant difference for clustering coefficient
- Significant difference for path length (p .002), global efficiency (p .01), radius (p .009) and diameter (p .002)





- Comparing abuse groups to control group. Physical/sexual, emotional/neglect, and controls.
- No significant difference for age, gender or medication usage
- Significant difference for age between the groups (p .009)
- No significant difference for age between the abuse groups

- Eyes closed graph theory metrics
- No significant difference for clustering coefficient, path length, global efficiency or radius
- Significant difference for diameter (p .04)
- Diameter means physical/sexual abuse 74.58 (sd 46.98), emotional abuse/neglect 74.66 (sd 51.23) and controls 38.97 (sd 15.51)
- No difference in diameter comparing abuse groups


ECDiameter
150
100
50
0
18
Physical_Sexual
Emotional_Neglect
Control
Abuse_Category_Coded

- Eyes open graph theory metrics
- No significant difference between the three groups for clustering coefficient
- Significant differences for path length (p .004), global efficiency (p .038), radius (p .009) and diameter (p .006)

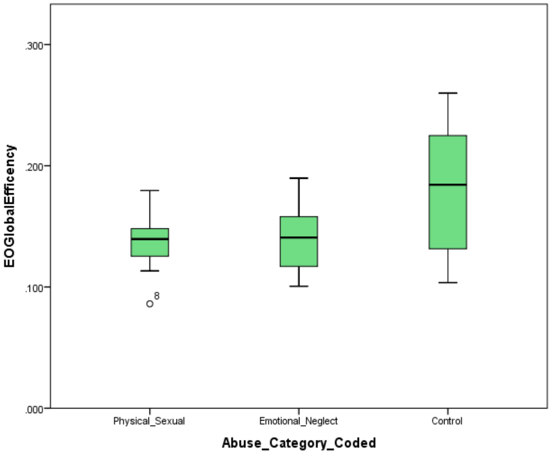
- Post hoc tests of significance across the three groups show that the abuse groups are different than the control group but no different from each other.

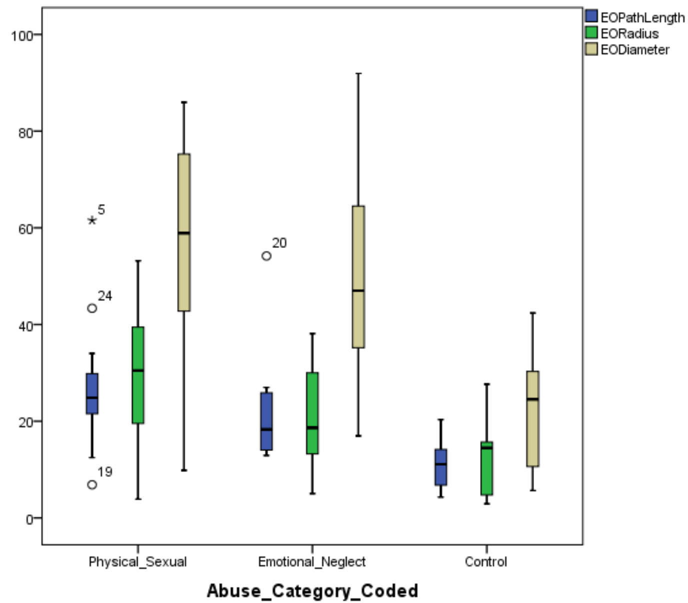
Multiple Comparisons

Scheffe

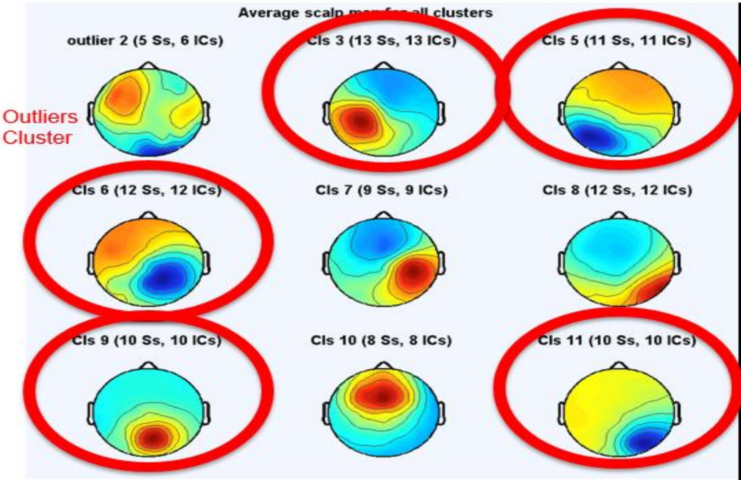
Dependent Variable	(I) Abuse_Category_Coded	(J) Abuse_Category_Coded	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
EOPathLength	Physical_Sexual	Emotional_Neglect	5.234	4.177	.464	-5.43	15.90
		Control	15.385*	4.266	.004	4.49	26.28
	Emotional_Neglect	Physical_Sexual	-5.234	4.177	.464	-15.90	5.43
		Control	10.151	4.341	.078	-.93	21.23
	Control	Physical_Sexual	-15.385*	4.266	.004	-26.28	-4.49
		Emotional_Neglect	-10.151	4.341	.078	-21.23	.93
EOGlobalEfficency	Physical_Sexual	Emotional_Neglect	-.004	.021	.985	-.06	.05
		Control	-.048	.019	.069	-.10	.00
	Emotional_Neglect	Physical_Sexual	.004	.021	.985	-.05	.06
		Control	-.044	.020	.115	-.10	.01
	Control	Physical_Sexual	.048	.019	.069	.00	.10
		Emotional_Neglect	.044	.020	.115	-.01	.10
EORadius	Physical_Sexual	Emotional_Neglect	7.715	4.528	.248	-3.85	19.27
		Control	15.227*	4.625	.009	3.42	27.03
	Emotional_Neglect	Physical_Sexual	-7.715	4.528	.248	-19.27	3.85
		Control	7.512	4.706	.292	-4.50	19.53
	Control	Physical_Sexual	-15.227*	4.625	.009	-27.03	-3.42
		Emotional_Neglect	-7.512	4.706	.292	-19.53	4.50
EODiameter	Physical_Sexual	Emotional_Neglect	7.588	13.019	.844	-25.74	40.91
		Control	42.342*	13.019	.010	9.02	75.67
	Emotional_Neglect	Physical_Sexual	-7.588	13.019	.844	-40.91	25.74
		Control	34.754*	13.276	.044	.77	68.74
	Control	Physical_Sexual	-42.342*	13.019	.010	-75.67	-9.02
		Emotional_Neglect	-34.754*	13.276	.044	-68.74	-.77

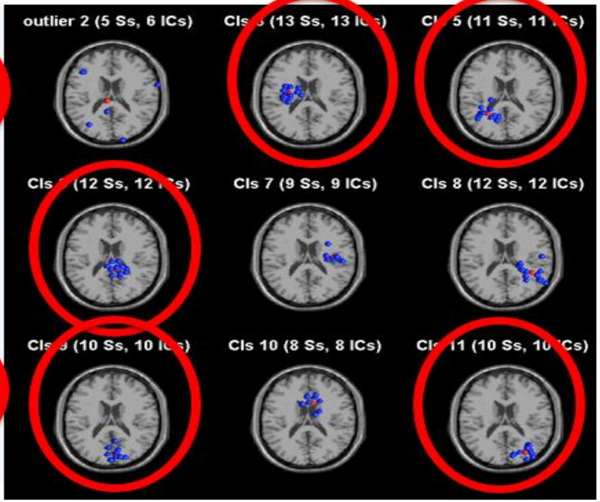
*. The mean difference is significant at the 0.05 level.


.300
.200
.100
.000
EOGlobalEfficency
8
Physical_Sexual
Emotional_Neglect
Control
Abuse_Category_Coded


EOPathLength
EORadius
EODiameter
100
80
60
40
20
0
5
24
19
20
Physical_Sexual
Emotional_Neglect
Control
Abuse_Category_Coded

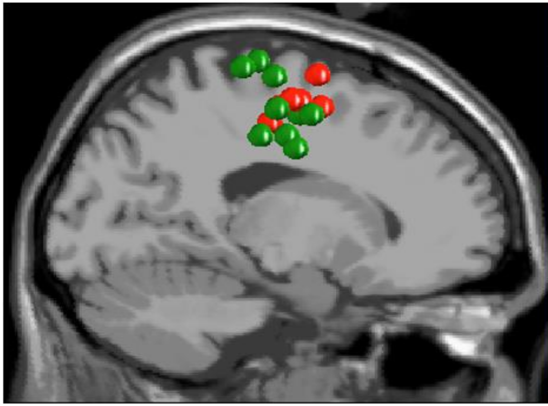
STUDY2: POWER AND SOURCE FINDINGS

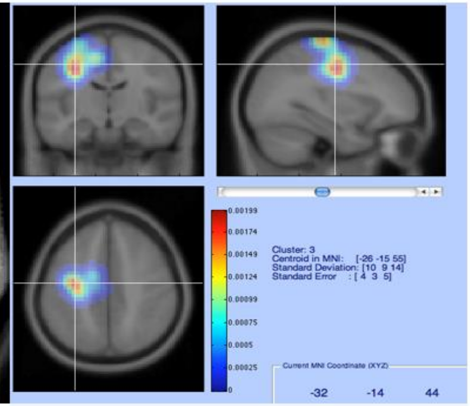


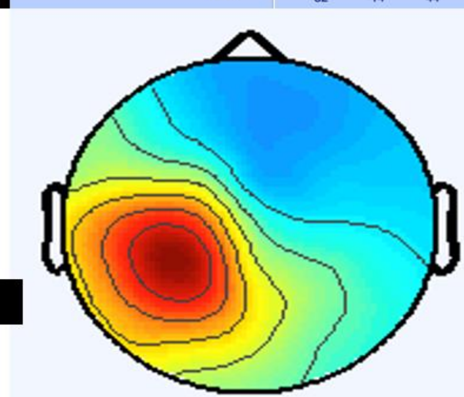


IC level
64-chan
eyes closed

Summary of IC clusters
64-chan data,
Eyes-closed,
ICs dropped
IC-level data,





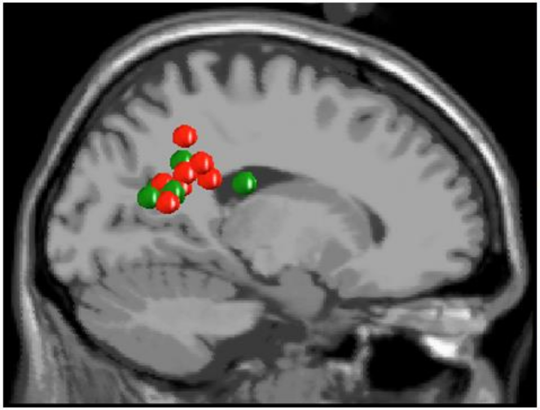


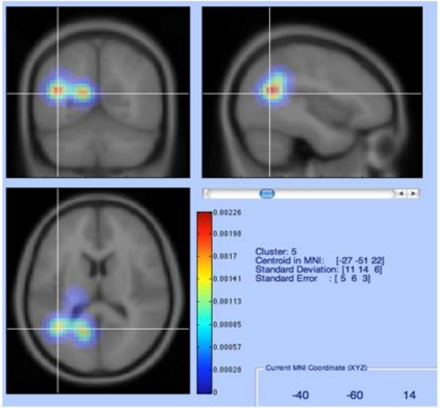
- Left Frontal Syb-Gral White Matter
- Left Frontal Precentral Gyrus White Matter
- Left Parietal Postcentral Gyrus White Matter

Control
Experimental

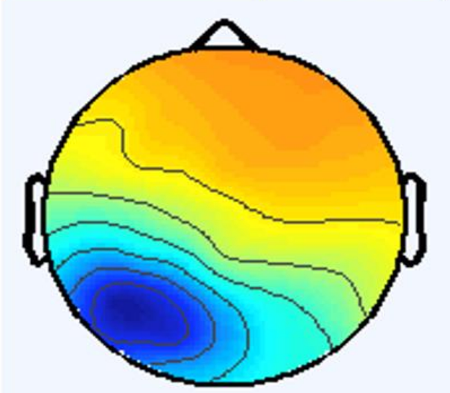
IC level
64-chan eyes
closed

IC 3





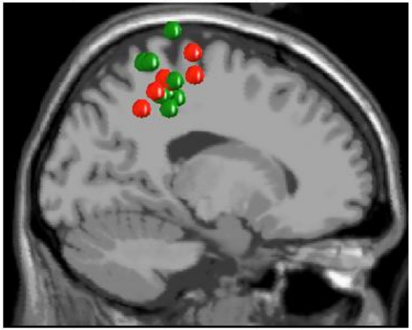
- Left Middle Temporal Gyrus White Matter
- Left Temporal Lobe Sub Gyral White Matter

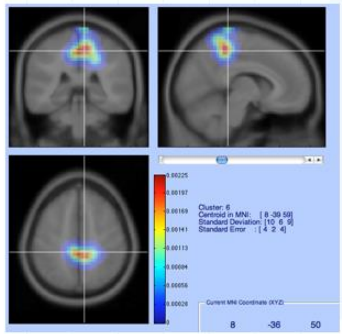


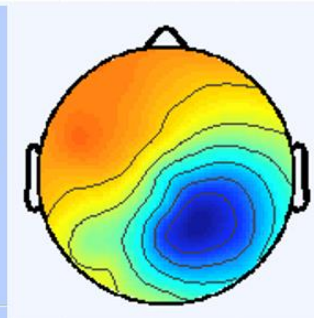
Control
Experimental

IC level
64-chan eyes closed

IC 5





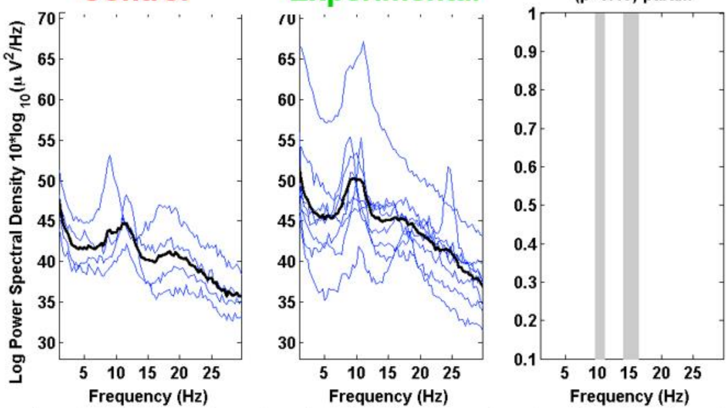


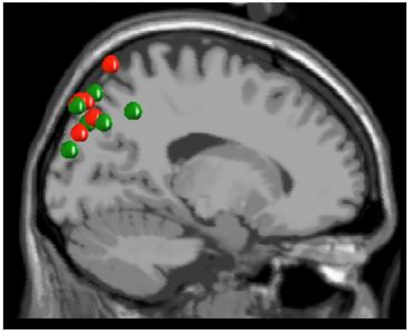
- Right Frontal Paracentral Lobule White Matter
- Right Parietal Precuneus White Matter
- Right Parietal Precuneus

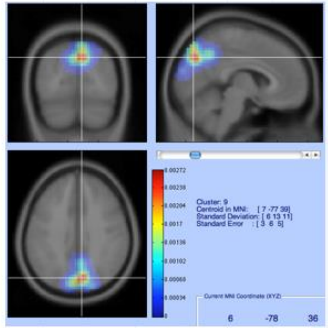
Control
Experimental

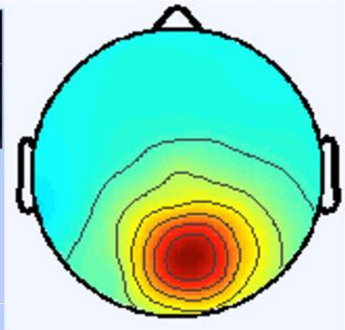
IC 6

IC level
64-chan eyes closed







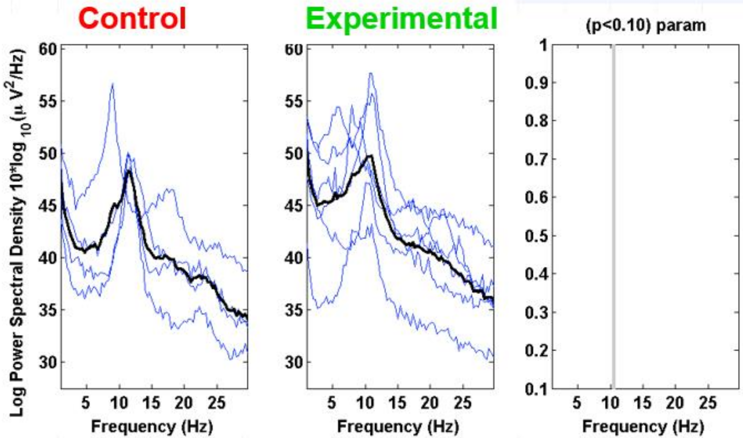


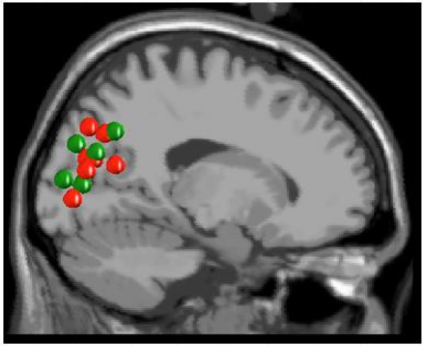
- Right Parietal Precuneus, BA 7
- Right Occipital Cuneus White Matter

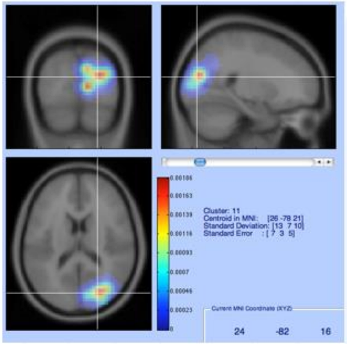
Control
Experimental

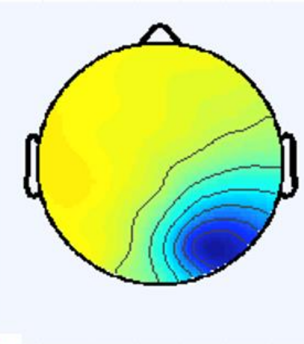
IC 9

IC level
64-chan eyes closed







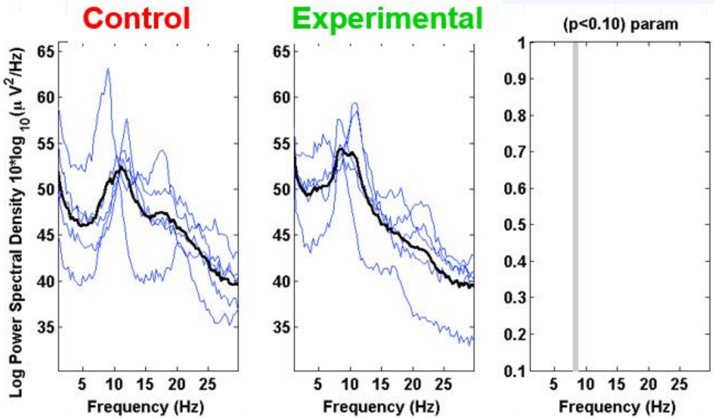


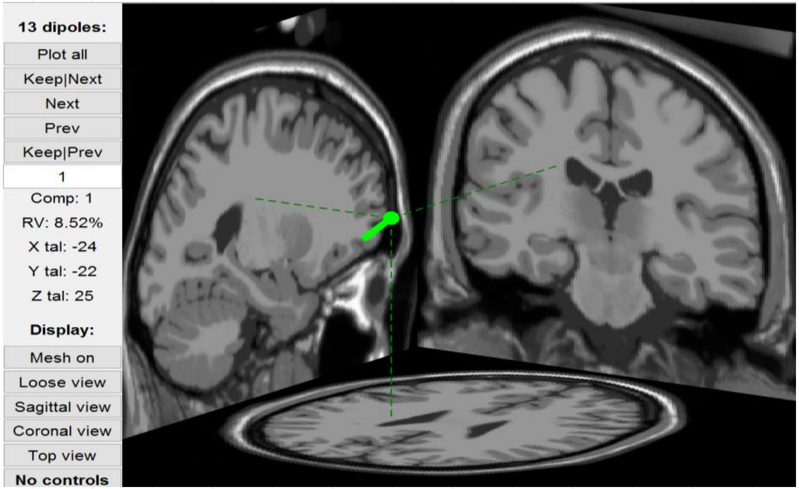
- Right Middle Occipital Gyrus White Matter
- Right Cuneus White Matter
- Right Middle Occipital Gyrus, BA 18

Control
Experimental

IC 11

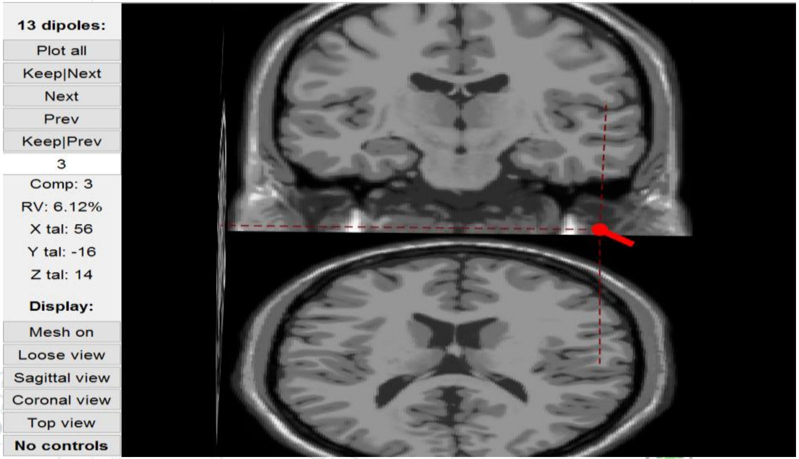
IC level
64-chan eyes
closed





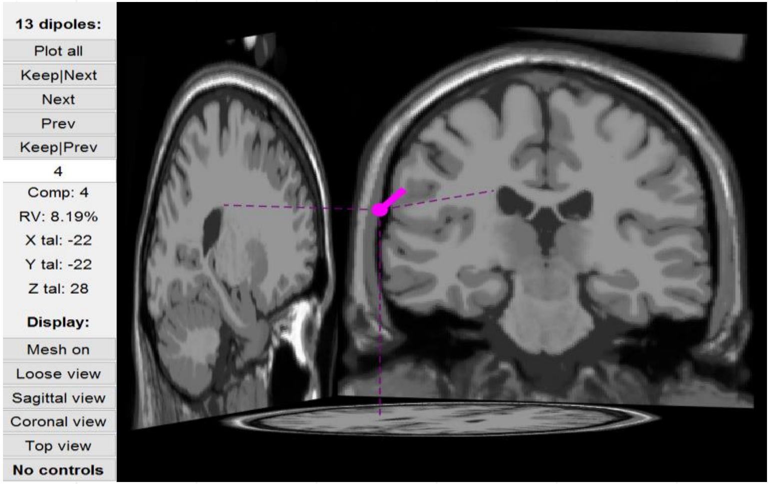
Left Cerebrum, Frontal Lobe, Sub-Gyral, White Matter

Left Cerebrum, Sub-lobar, Insula, White Matter



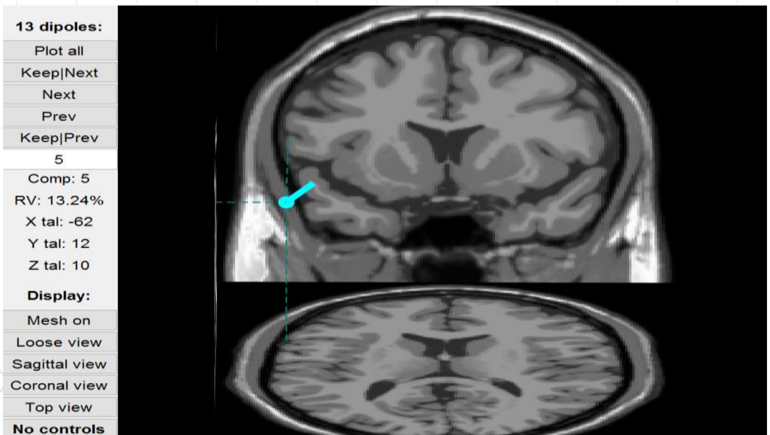
Right Cerebrum, Parietal Lobe, Postcentral Gyrus, White Matter

Right Cerebrum, Temporal Lobe, Transverse Temporal Gyrus, Gray Matter



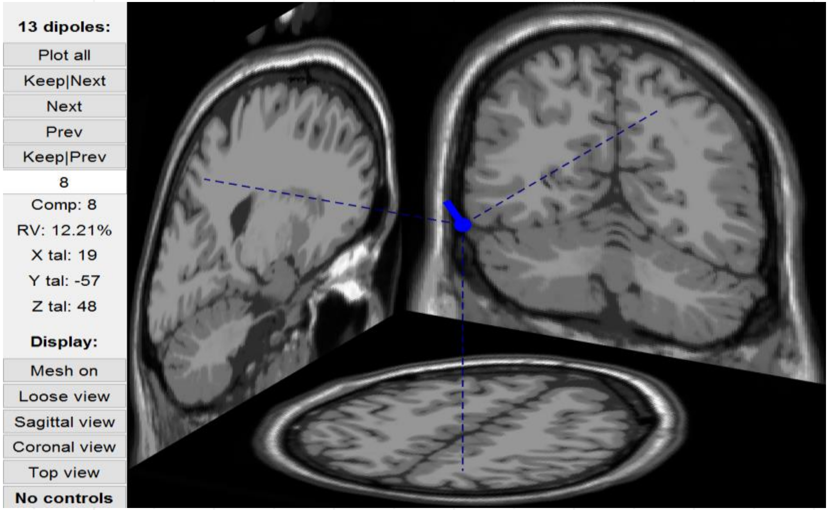
Left Cerebrum, Frontal Lobe, Sub-Gyral, White Matter

Left Cerebrum, Limbic Lobe, Cingulate Gyrus, White Matter



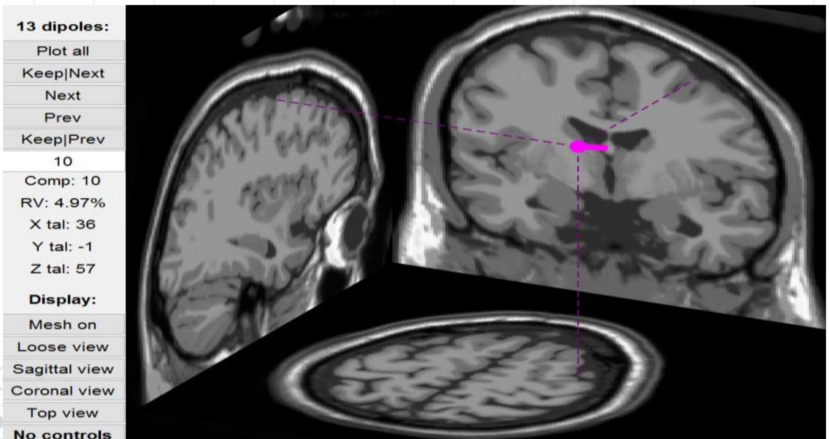
Left Cerebrum, Frontal Lobe, Inferior Frontal Gyrus, Gray Matter, Brodmann area 44

Left Cerebrum, Frontal Lobe, Inferior Frontal Gyrus, White Matter



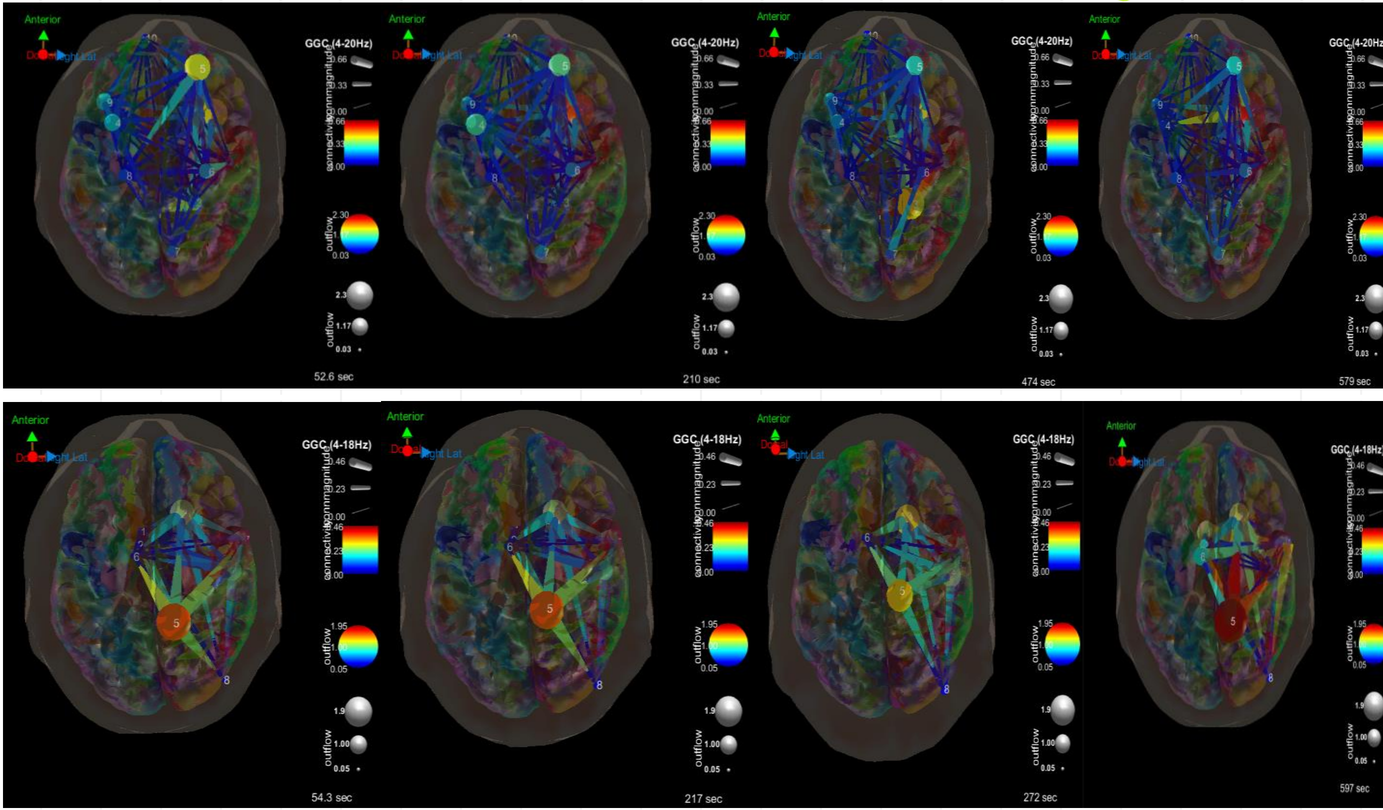
Right Cerebrum, Parietal Lobe, Precuneus, White Matter

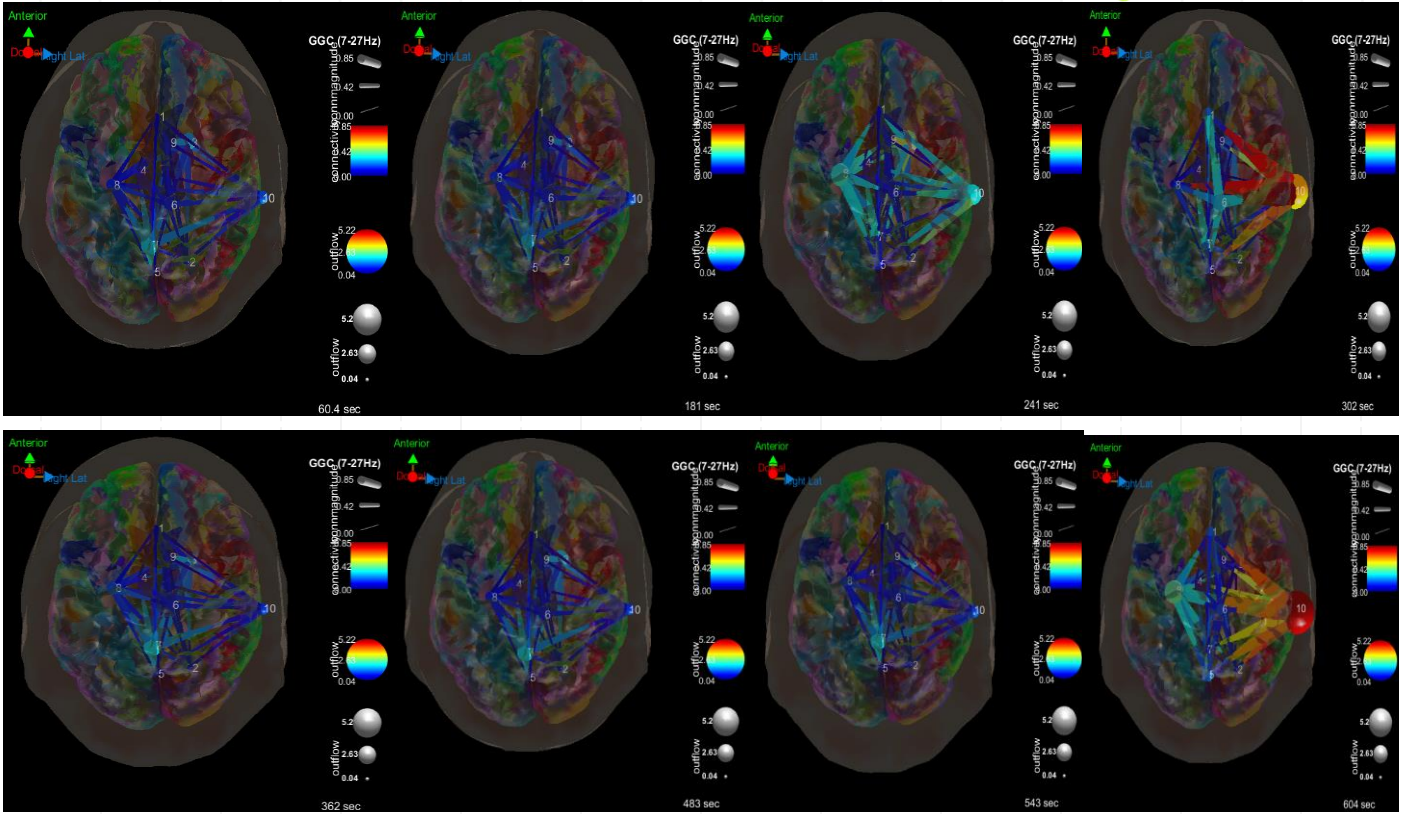
Right Cerebrum, Parietal Lobe, Sub-Gyral, White Matter

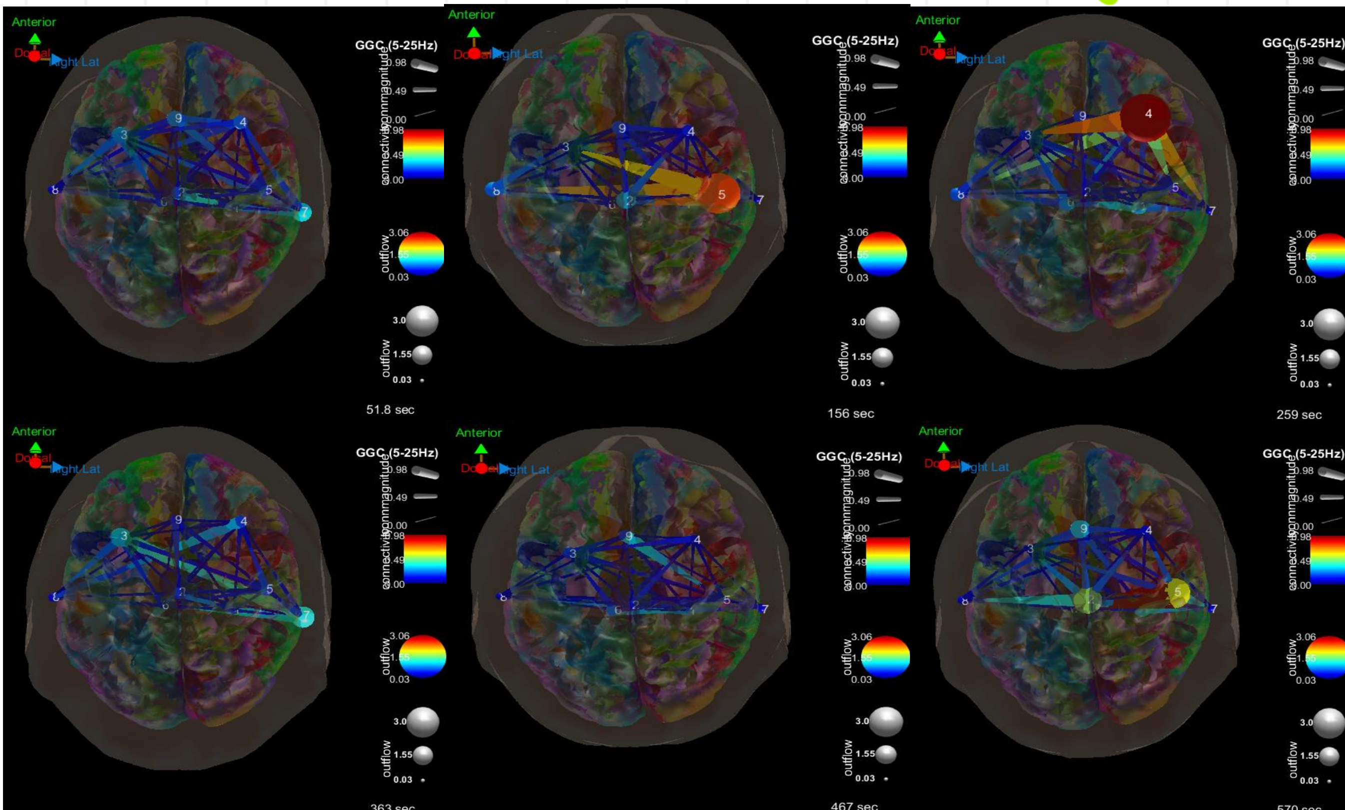


Right Cerebrum, Frontal Lobe, Middle Frontal Gyrus, Gray Matter, Brodmann area 6

Right Cerebrum, Frontal Lobe, Middle Frontal Gyrus, White Matter


Anterior
GGC (4-20Hz)
connectivity magnitude
outflow
52.6 sec
210 sec
474 sec
579 sec
GGC (4-18Hz)
54.3 sec
217 sec
272 sec
597 sec


Anterior
GGC (7-27Hz)
connectivity magnitude
outflow
60.4 sec
181 sec
241 sec
302 sec
362 sec
483 sec
543 sec
604 sec


Anterior
Right Lat
GGC (5-25Hz)
connectivity magnitude
outflow
0.98
0.49
0.00
3.06
1.55
0.03
3.0
51.8 sec
156 sec
259 sec
363 sec
467 sec
570 sec

CONCLUSIONS/DISCUSSION

- EEG/ICA capable of demonstrating differences and regions of interest
- Individuals that experienced abuse as children show wide spread power anomalies as adults that include multiple frequencies (theta, alpha and beta 1)
- Dipole localization suggests regions of interest that are likely critical to their challenges and consistent with other forms of neuroimaging
- These include midline frontal, medial - posterior left frontal/temporal (insula), precuneus, and right occipital/parietal/temporal regions of the brain.
- The majority of these include localizations to white matter tracts that connect cortical to limbic regions of the brain.
- Extensive anomalies of connectivity suggesting that communication between nodes, especially long range connectivity is problematic.
- At least in term of connectivity difficulties, abuse groups do not differ. This is, whether you experience physical, sexual or emotional abuse your brain pathways and their functioning are altered similarly.

CONCLUSIONS/DISCUSSION

- 19 channel data is severely limited in it's ability to source localize activity to deeper structures and white matter pathways
- Study 2's low sample size may limit some of it's findings and generalization
- More data and types of analyses may help us find even more interesting relationships

- Implications for intervention:
- Regions of interest may be points of feedback
- Alpha and Beta 1 inhibition
- Connectivity training may offer further access to systems that seem critical to functioning

REFERENCES

1. Anda, R. F., et al. (2006) The enduring effects of abuse and related adverse experiences in childhood: A convergence of evidence from neurobiology and epidemiology. *Eur Arch Psychiatry Clin Neurosci*. 256(3): 174–186. doi:10.1007/s00406-005-0624-4.
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THANKS!

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Resources:

EEGLAB
Multivariate Granger Causality Toolbox
Causality Toolbox