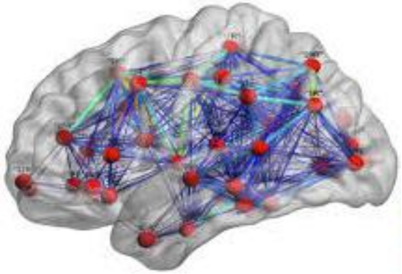
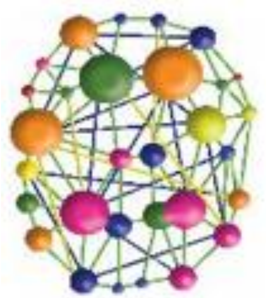


Multivariate Coherence Training for Developmental Trauma

Robert Coben, PhD., Neuropsychologist, Co-Director, Integrated Neuroscience Services

Clark Thompson, MA., Post Doctoral Fellow, Integrated Neuropsychological Services

Anne Stevens, PhD., Neuropsychologist, Co-Director, Integrated Neuropsychological Services

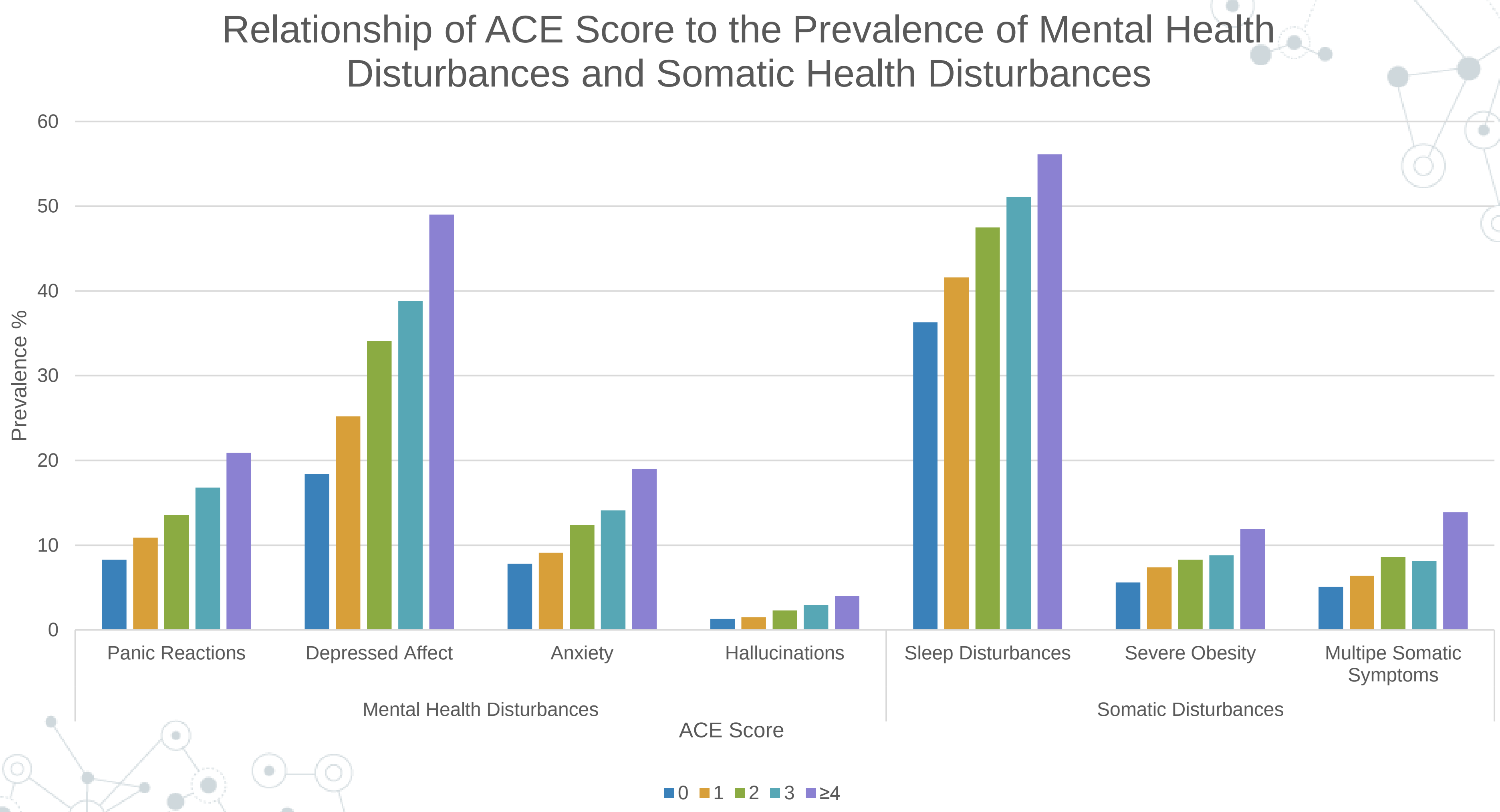


WHAT IS DEVELOPMENTAL TRAUMA?

- 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.

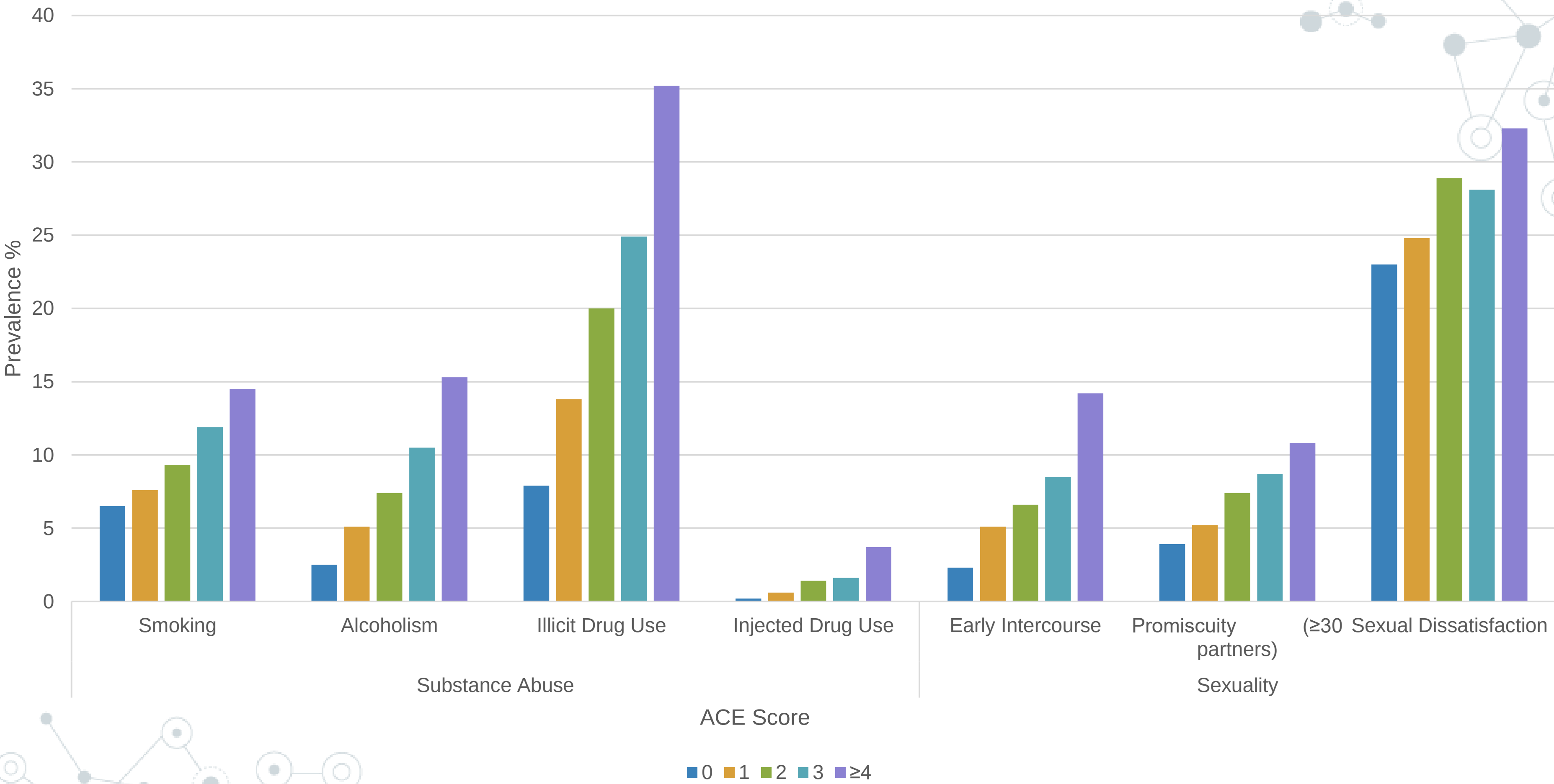
ADVERSE CHILDHOOD EXPERIENCES STUDY (ACE) [Anda, Robert F., et al. "The enduring effects of abuse and related adverse experiences in childhood." *European archives of psychiatry and clinical neuroscience* 256.3 (2006): 174-186.]

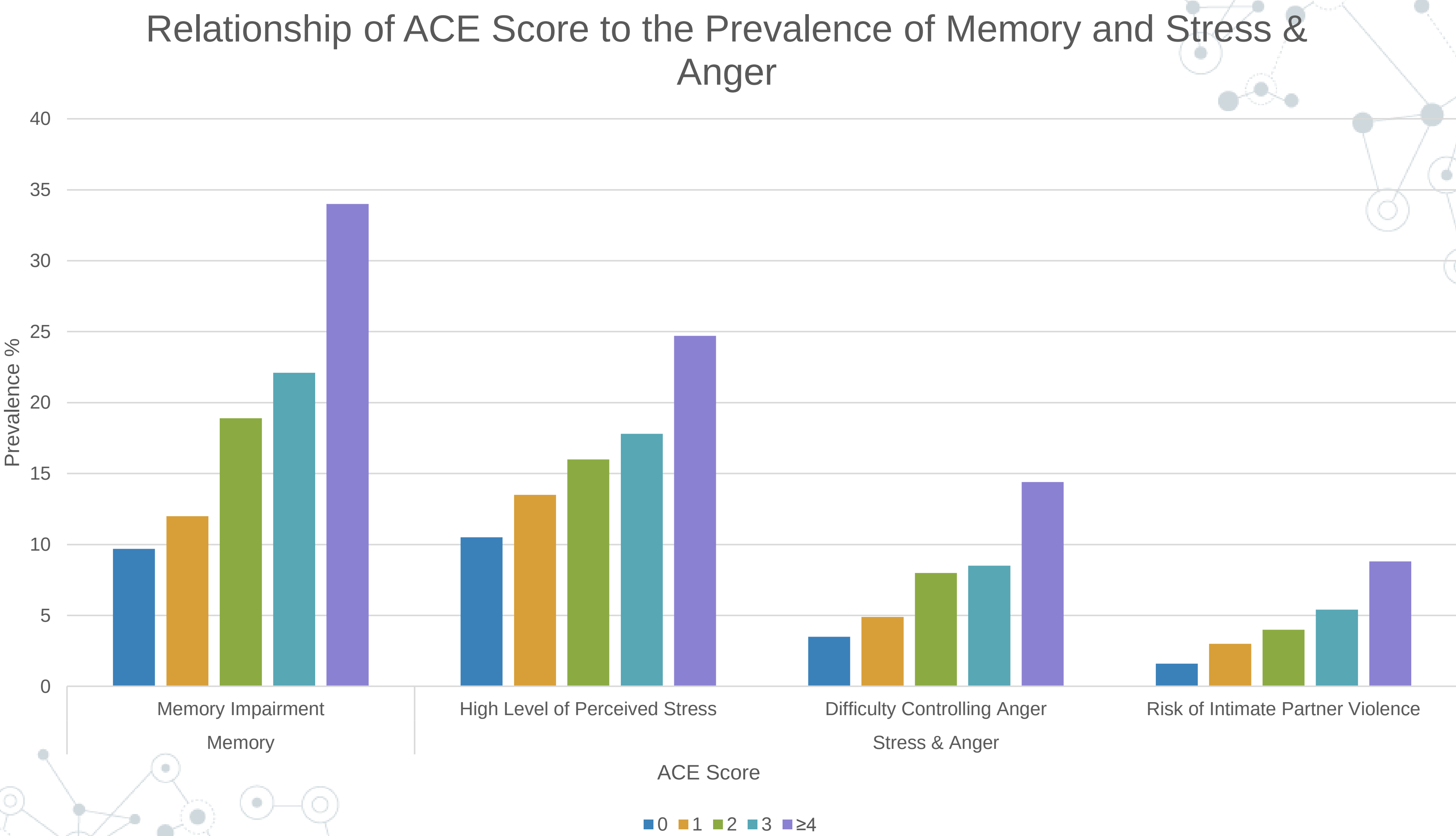
- Study of linkage between epidemiologic and neurobiological evidence of the effects of childhood trauma.
- Questions pertained to respondent’s first 18 years of life.
- Assessed 8 adverse childhood experiences: abuse (emotional, physical, or sexual); witnessing domestic violence; parental marital discord;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



Relationship of ACE Score to the Prevalence of Mental Health Disturbances and Somatic Health Disturbances
Prevalence %
60
50
40
30
20
10
0
Panic Reactions
Depressed Affect
Anxiety
Hallucinations
Sleep Disturbances
Severe Obesity
Multipe Somatic Symptoms
Mental Health Disturbances
Somatic Disturbances
ACE Score
0
1
2
3
≥4

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





Relationship of ACE Score to the Prevalence of Memory and Stress & Anger
Prevalence %
40
35
30
25
20
15
10
5
0
Memory Impairment
High Level of Perceived Stress
Difficulty Controlling Anger
Risk of Intimate Partner Violence
Memory
Stress & Anger
ACE Score
0
1
2
3
≥4

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

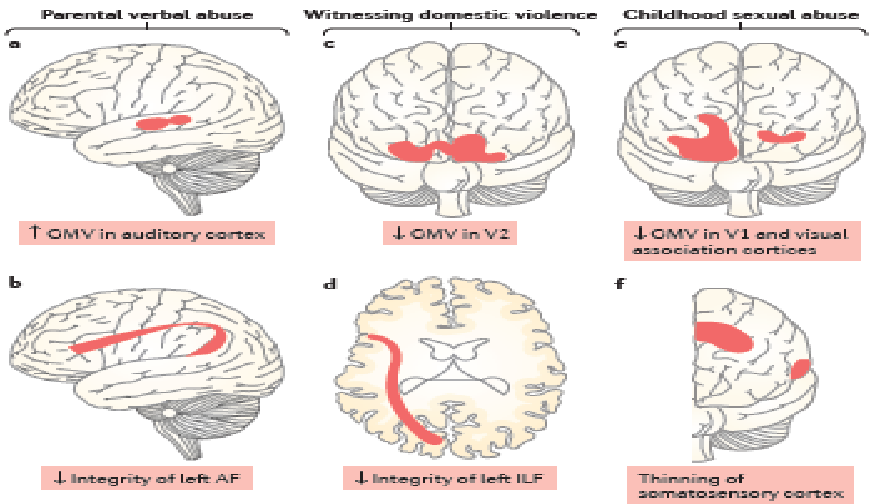


Figure 1 | **Abuse type-specific effects on the developing brain.** Images depicting the potential effects of exposure to specific types of childhood maltreatment on grey-matter volume (GMV) or thickness and fibre-tract integrity. Exposure to parental verbal abuse was associated with increased GMV in 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

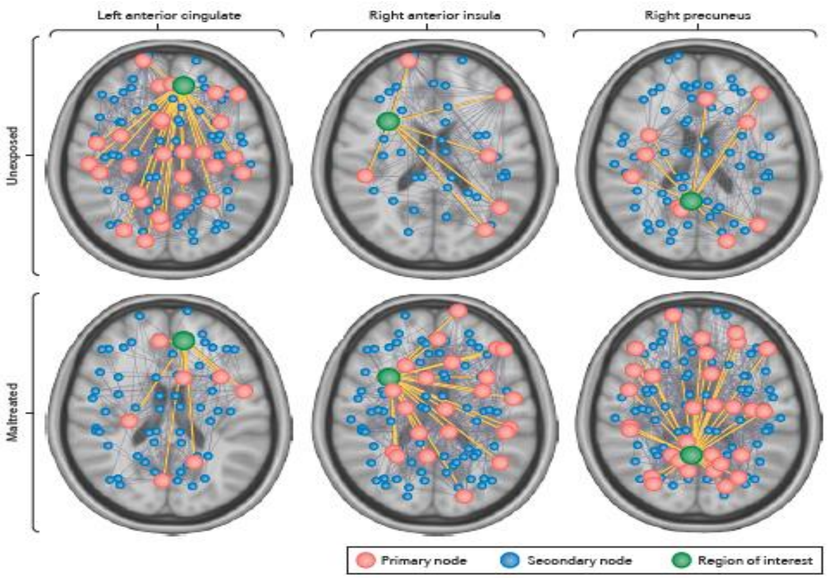


Figure 6 | **Network changes associated with childhood maltreatment.** Maltreatment during childhood has been found to be associated with changes in structural connectivity at the network level. Here, the entire cerebral cortex of young adults with ($n = 142$) or without ($n = 123$) histories of childhood 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.

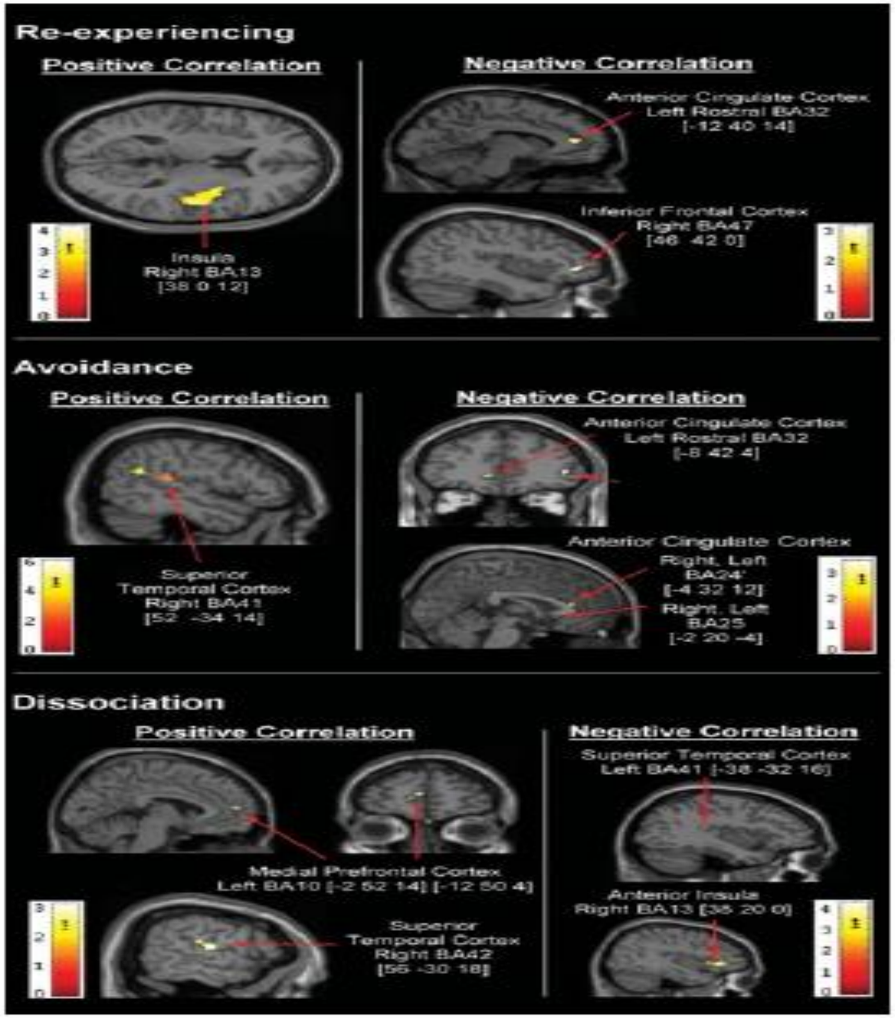
The effects of childhood maltreatment on brain structure, function and connectivity

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

- 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

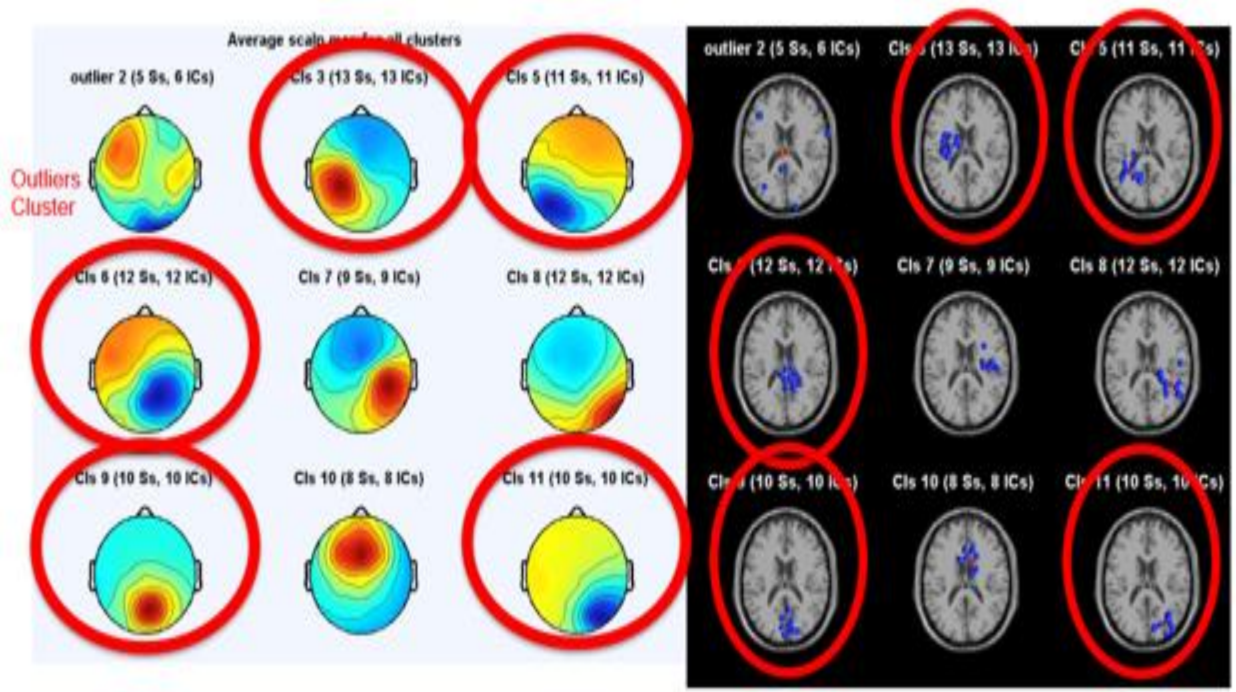
First published: 22 October 2007 Full publication history
DOI: 10.1002/jts.20284 View/save citation

- 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.

Impact of Developmental Trauma on Brain Function and Connectivity

Armes & Coben (2017), presented at ISNR conf Foxwoods, Connecticut

53 adult subjects with DT were compared to 23 controls using 19 channel and high density 64 channel EEG.



Left frontal subgyral white matter

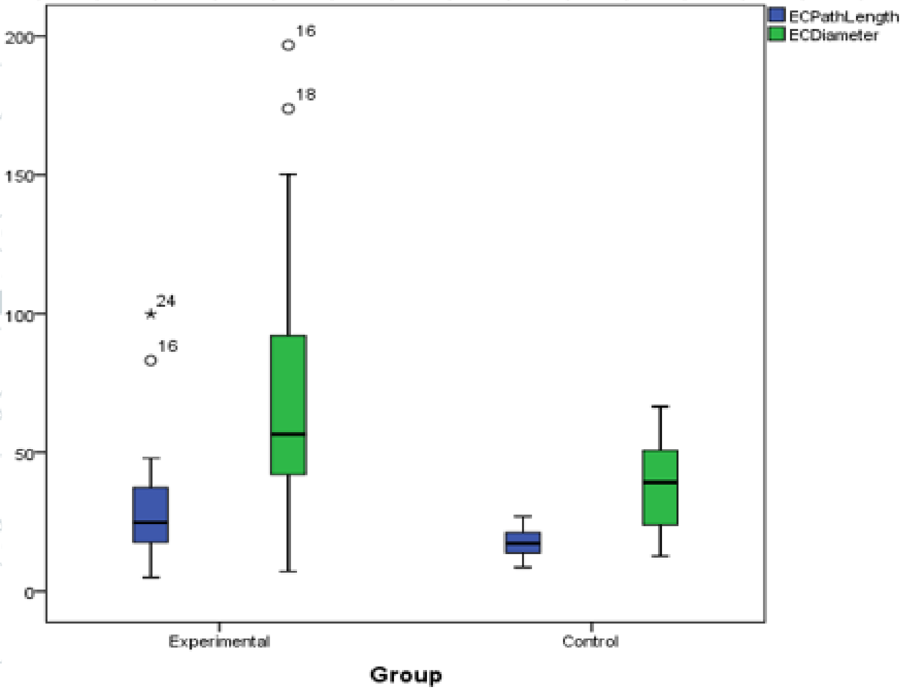
Left middle temporal gyrus white matter

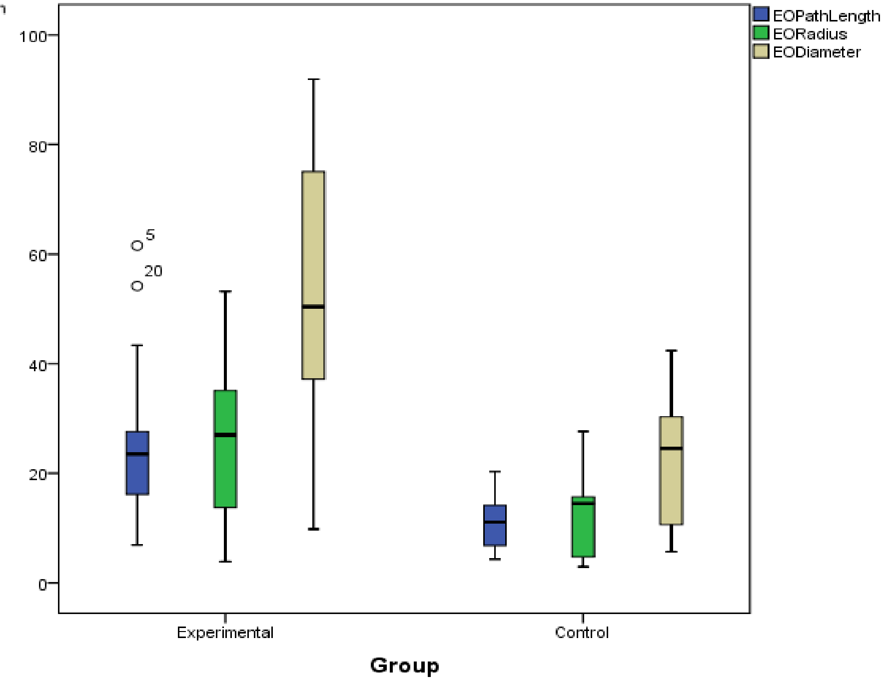
Right frontal paracentral white matter

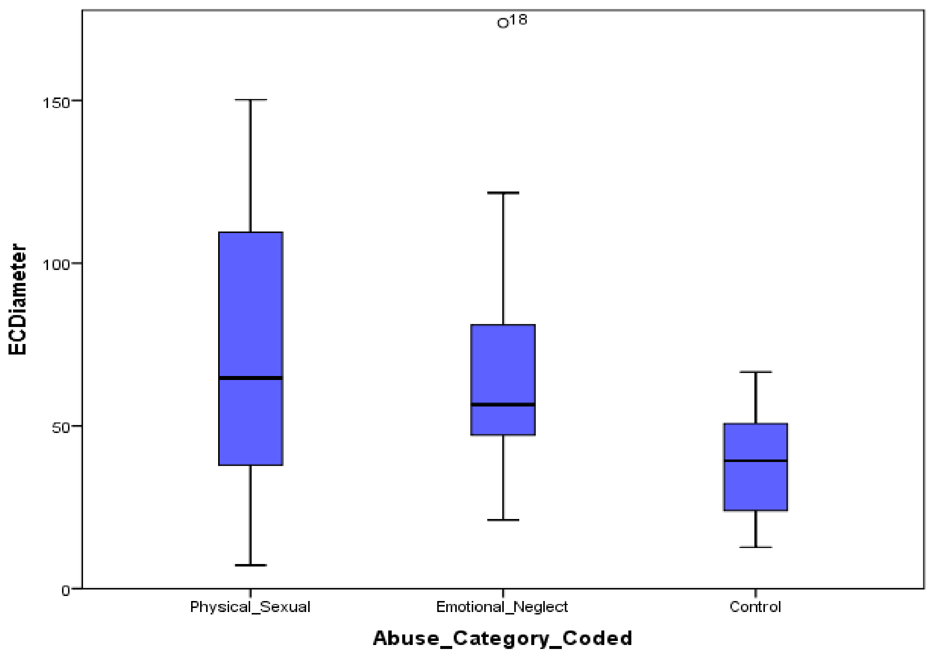
Right parietal precuneus

Right middle occipital gyrus white matter

Midline frontal, anterior cingulate





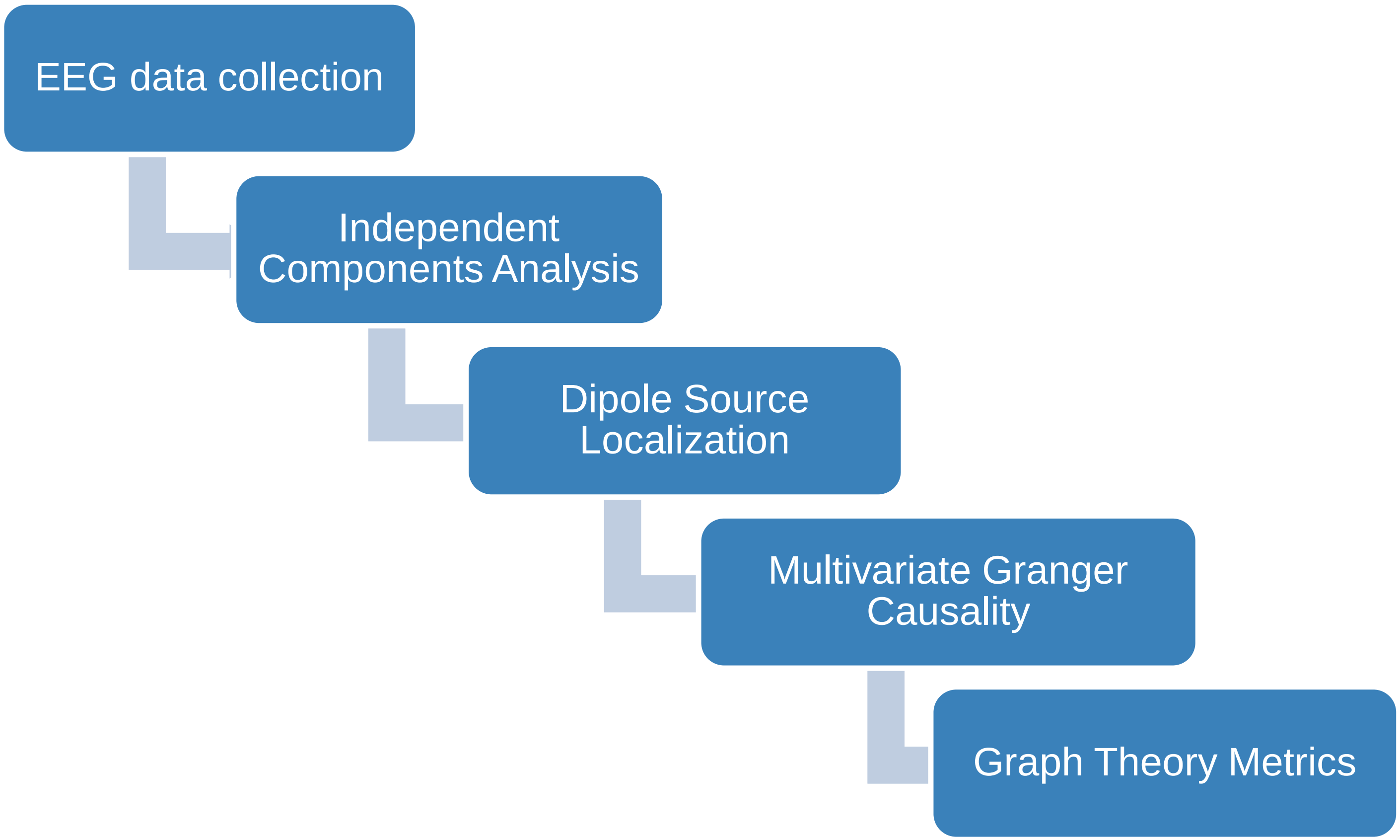


Eyes Closed: significant difference for path length ($p < .038$) and diameter ($p < .011$).

Eyes Open: significant difference for global efficiency ($p < .o1$), path length ($p < .002$), radius ($p < .009$) and diameter ($p < .002$)

Abuse groups differ from controls on diameter ($p < 0.04$), but not from each other.

Novel EEG Analysis pipeline



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
- Georgetown 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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https://doi.org/10.1016/j.jneumeth.2003.10.009

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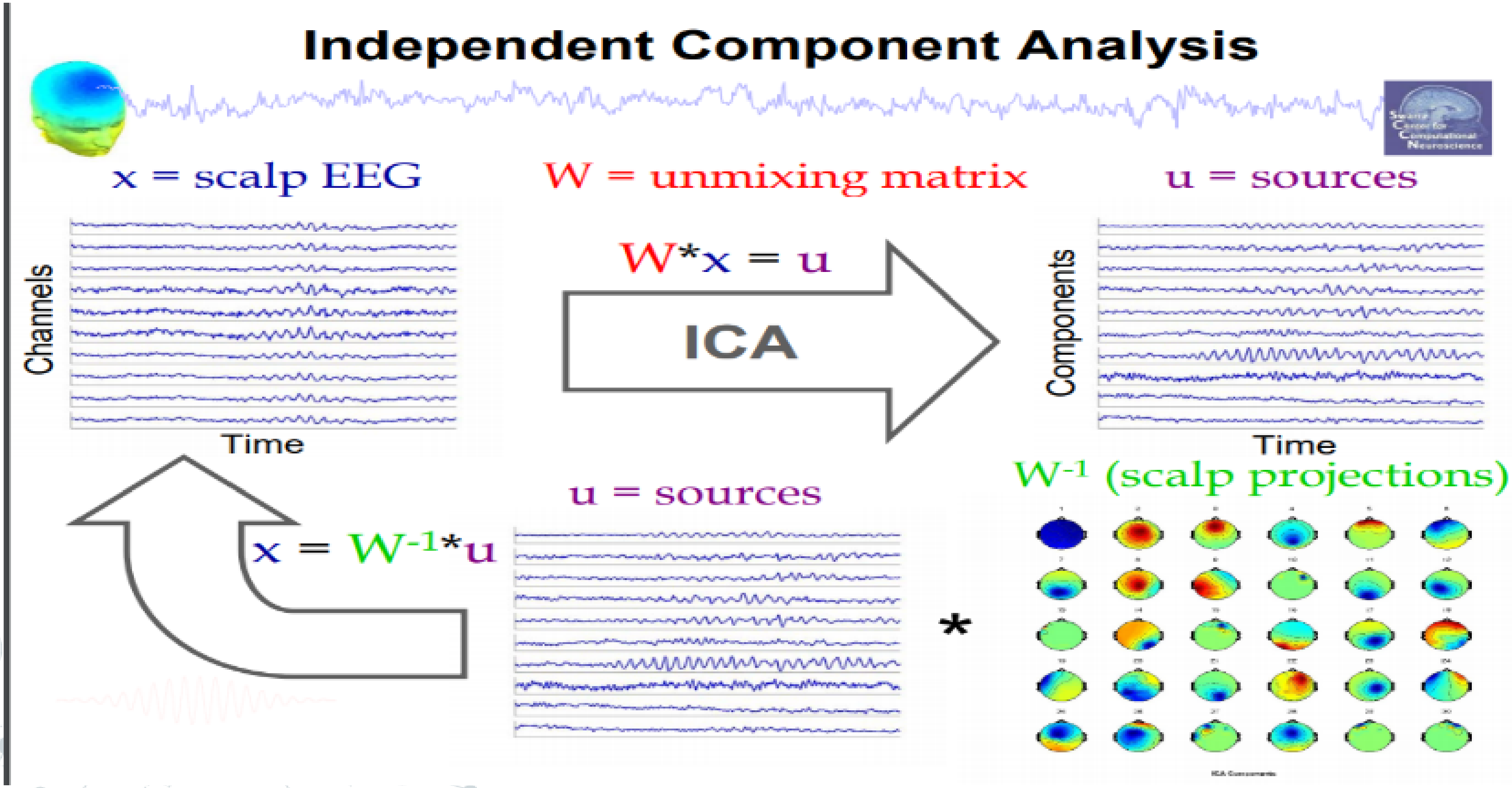
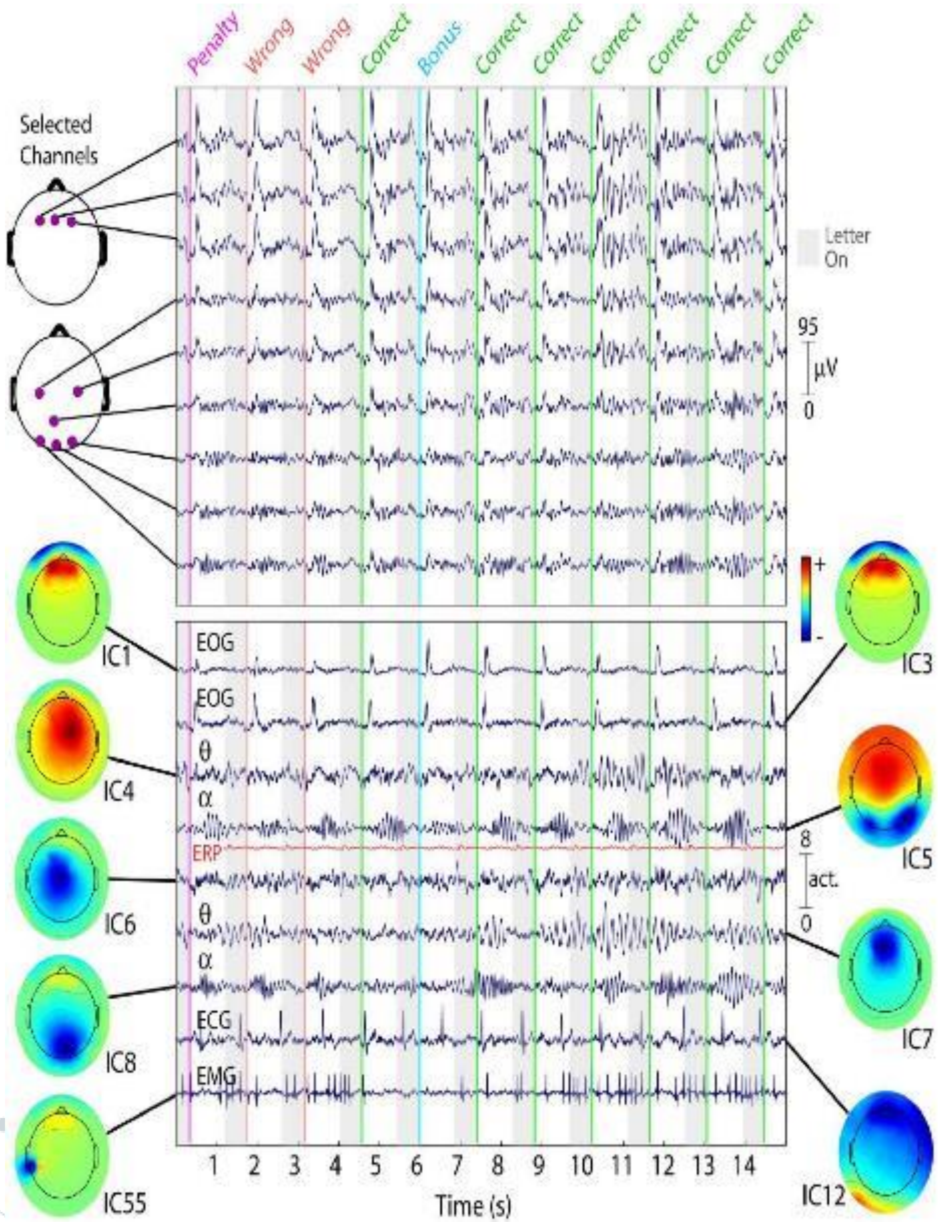
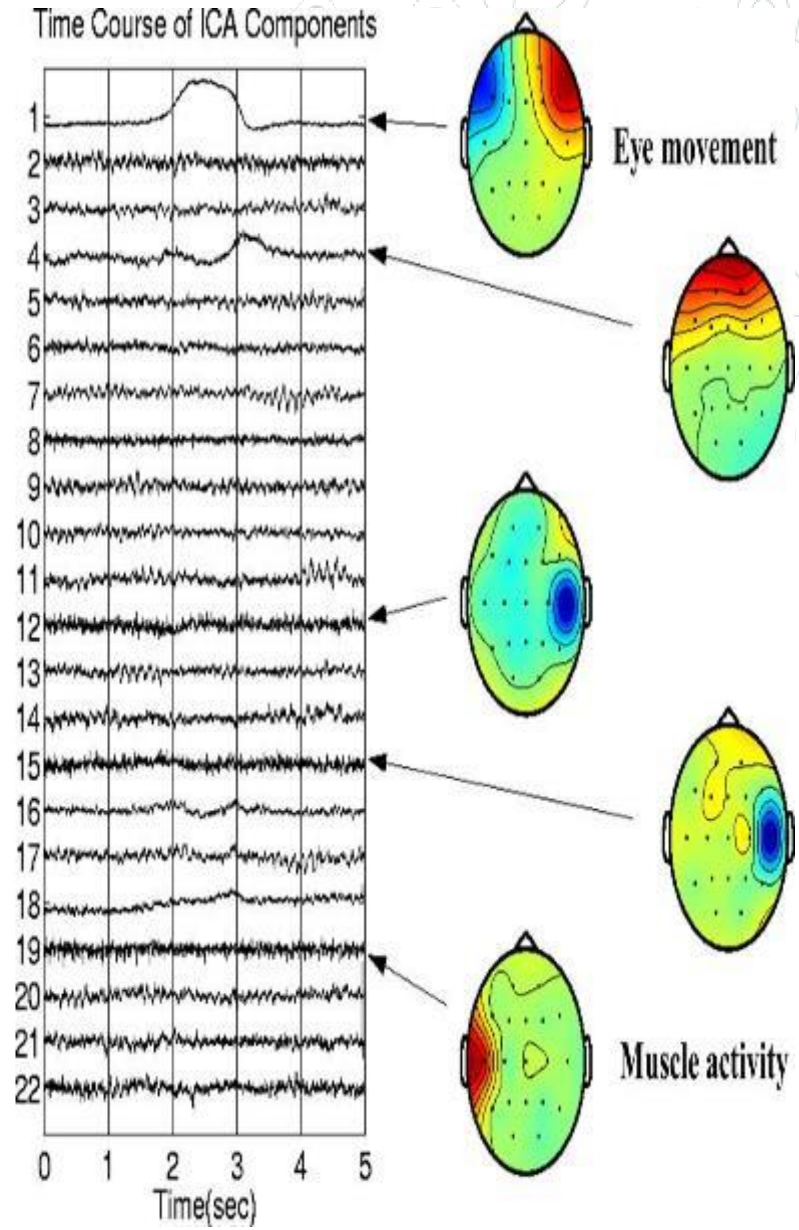
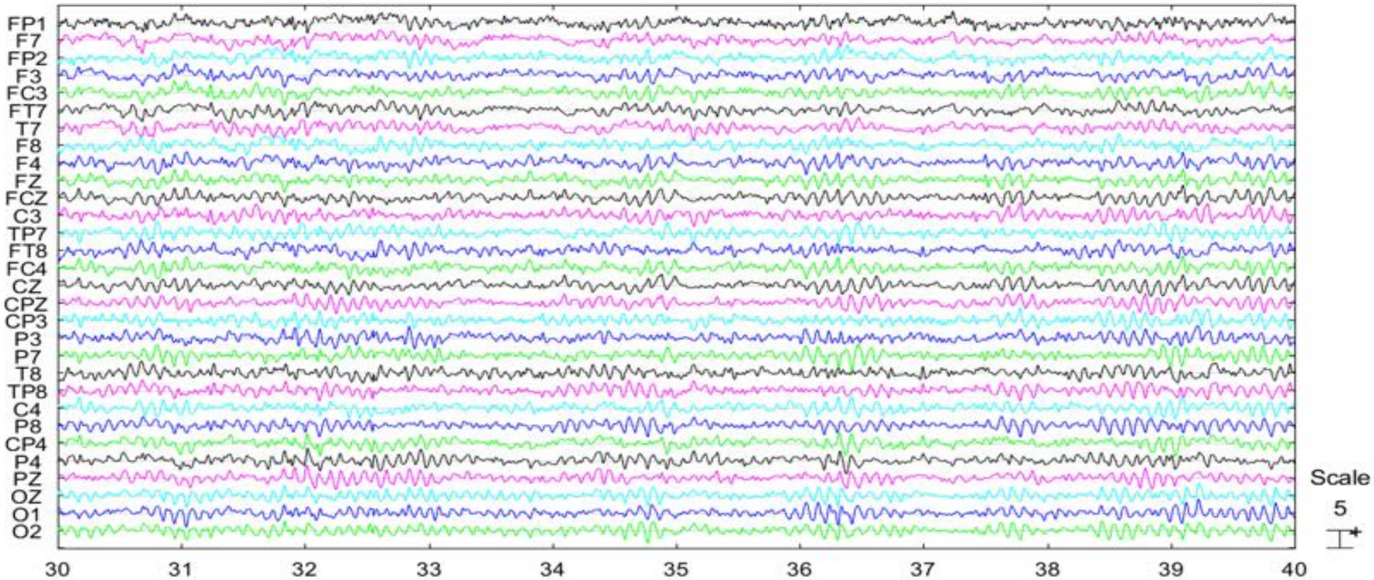
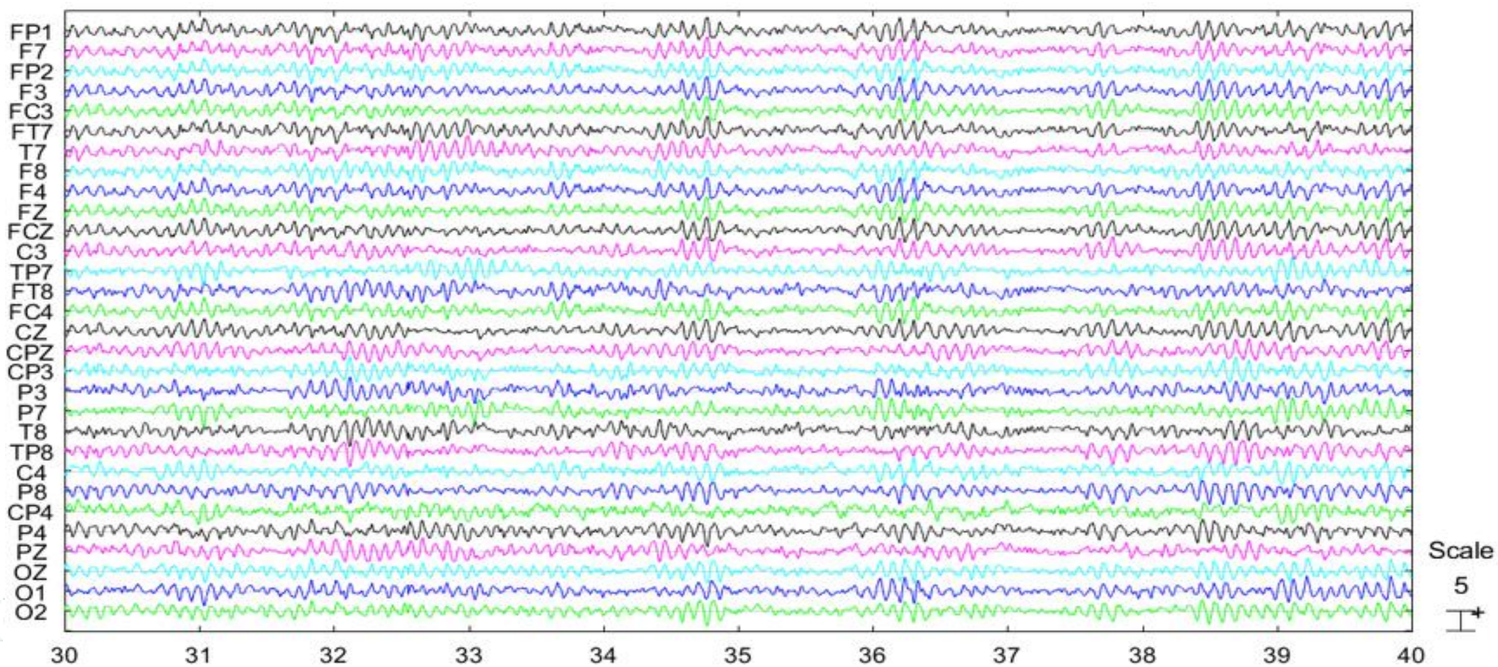


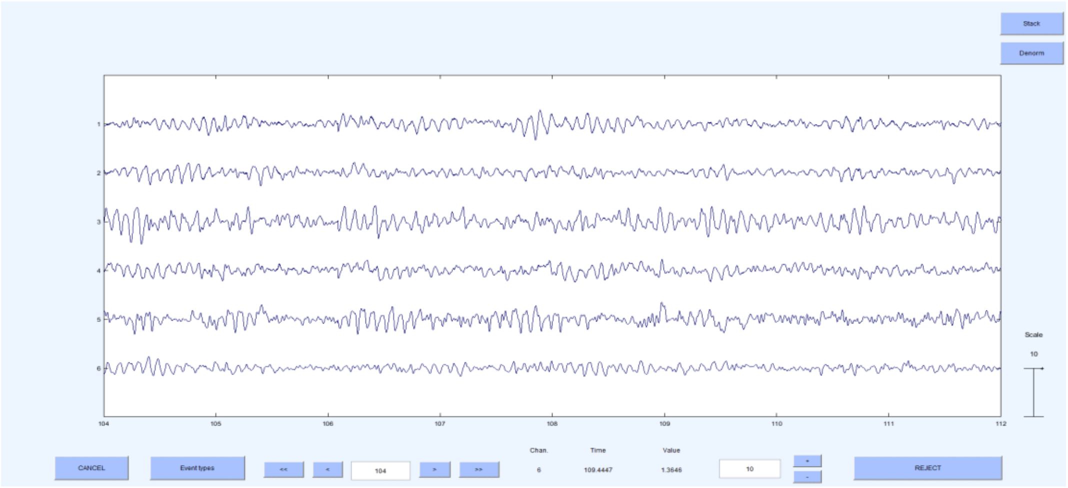

Penalty
Wrong
Wrong
Correct
Bonus
Correct
Correct
Correct
Correct
Correct
Correct
Selected Channels
Letter On
95
μV
0
EOG
EOG
θ
α
ERP
θ
α
ECG
EMG
8
act.
0
IC1
IC4
IC6
IC8
IC55
IC3
IC5
IC7
IC12
Time (s)


Time Course of ICA Components
Eye movement
Muscle activity
Time(sec)

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



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Event types
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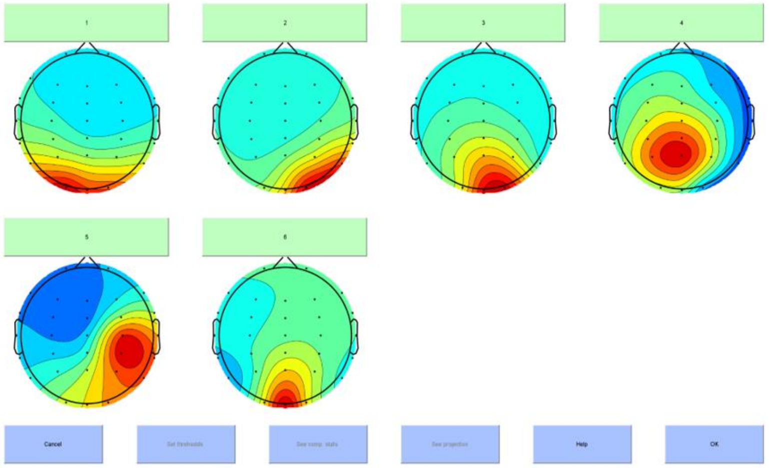
Value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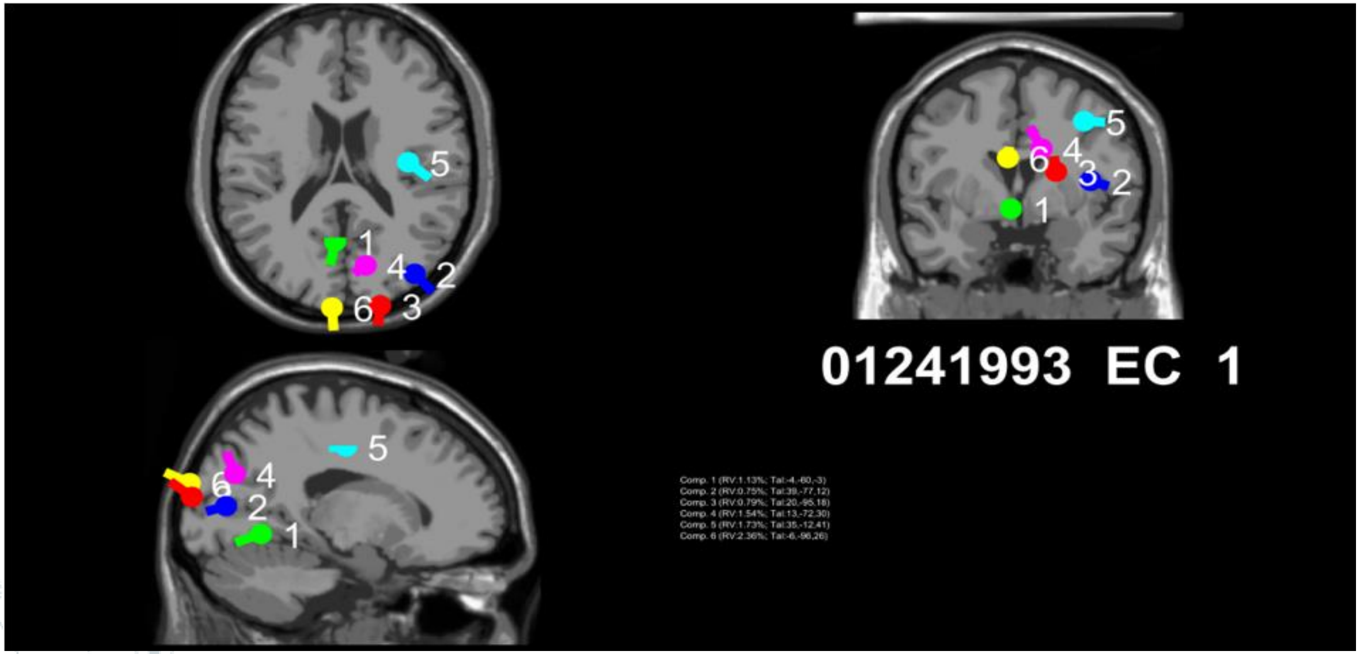
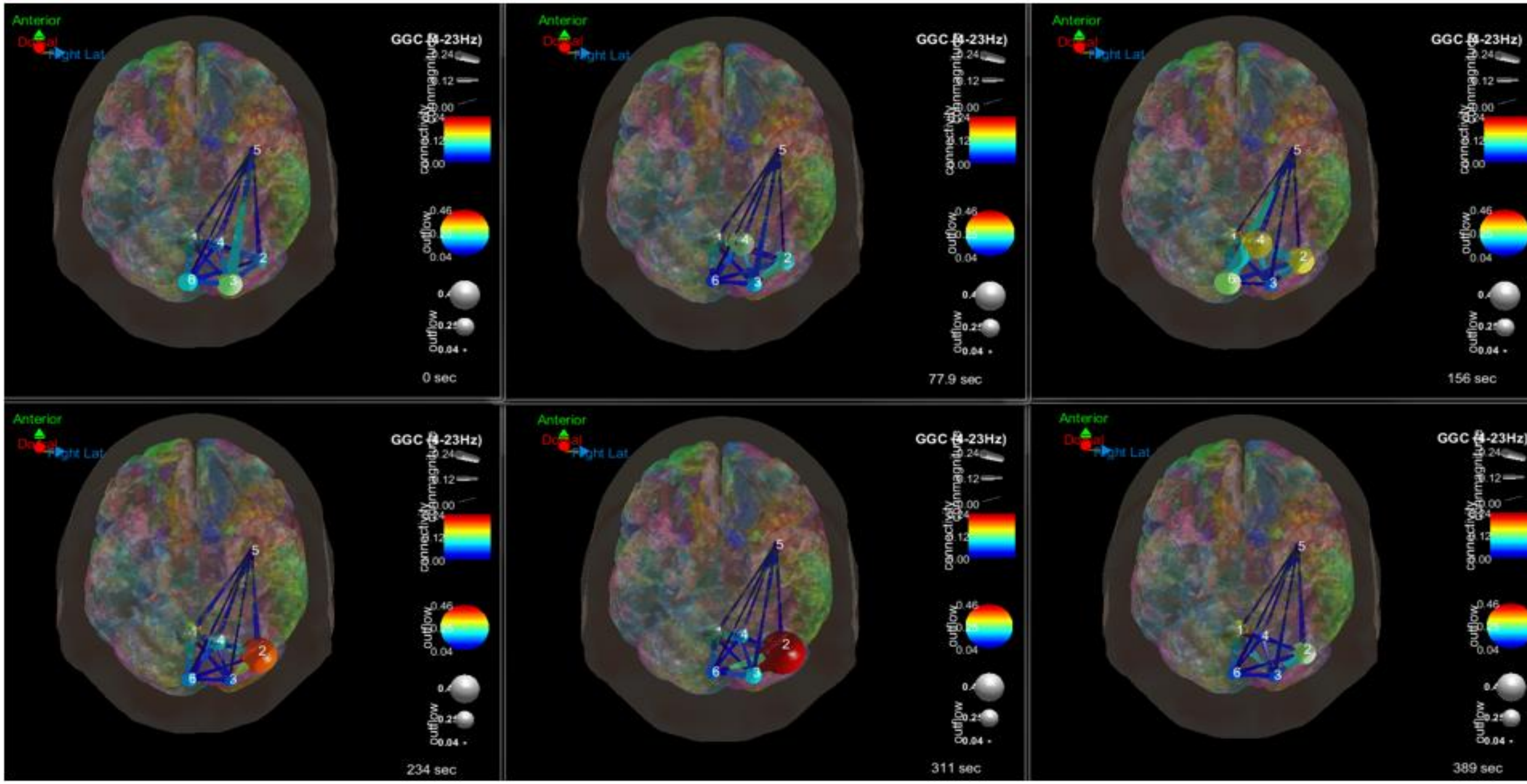

01241993 EC 1
Comp. 1 (RV:1.13%; Tal:-4,-60,-3)
Comp. 2 (RV:0.75%; Tal:39,-77,12)
Comp. 3 (RV:0.79%; Tal:20,-95,18)
Comp. 4 (RV:1.54%; Tal:13,-72,30)
Comp. 5 (RV:1.73%; Tal:35,-12,41)
Comp. 6 (RV:2.36%; Tal:-6,-96,26)



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

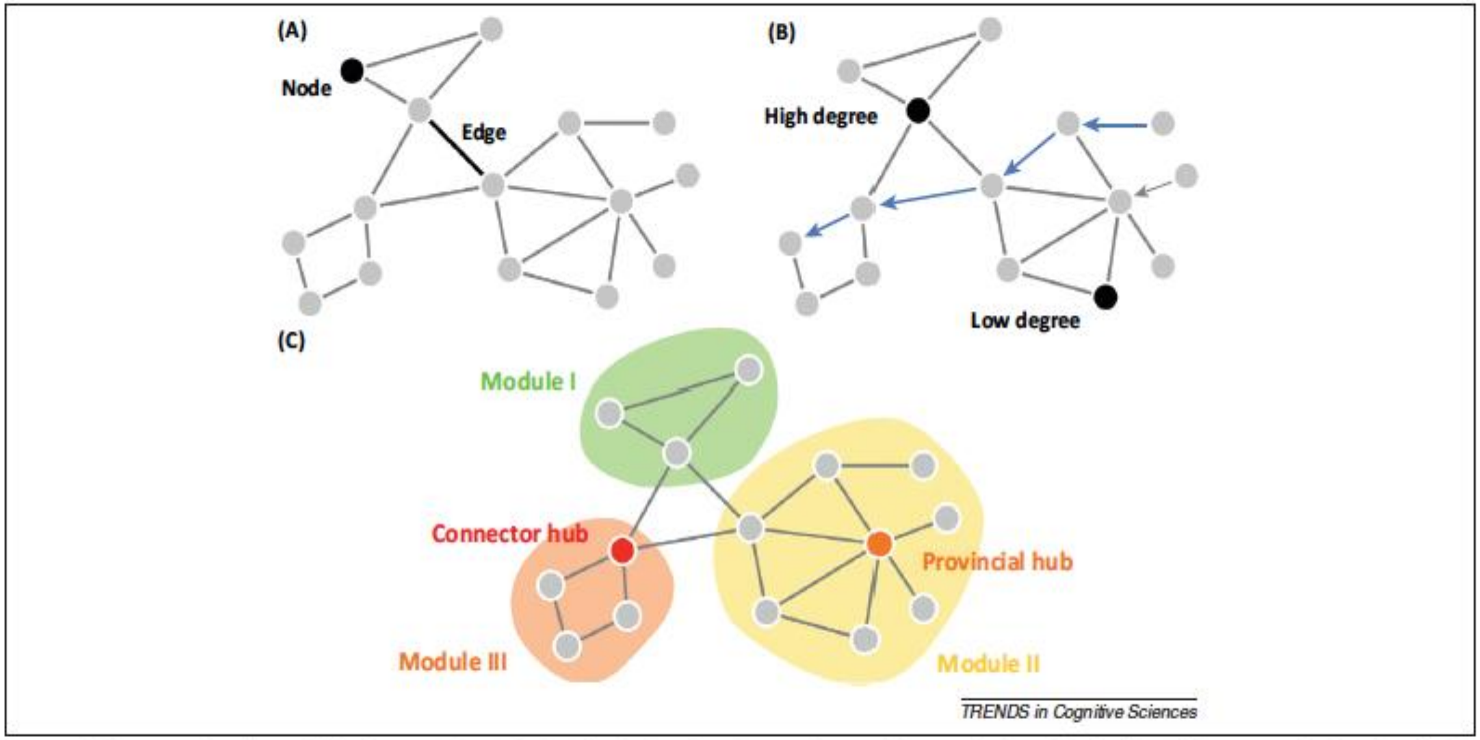
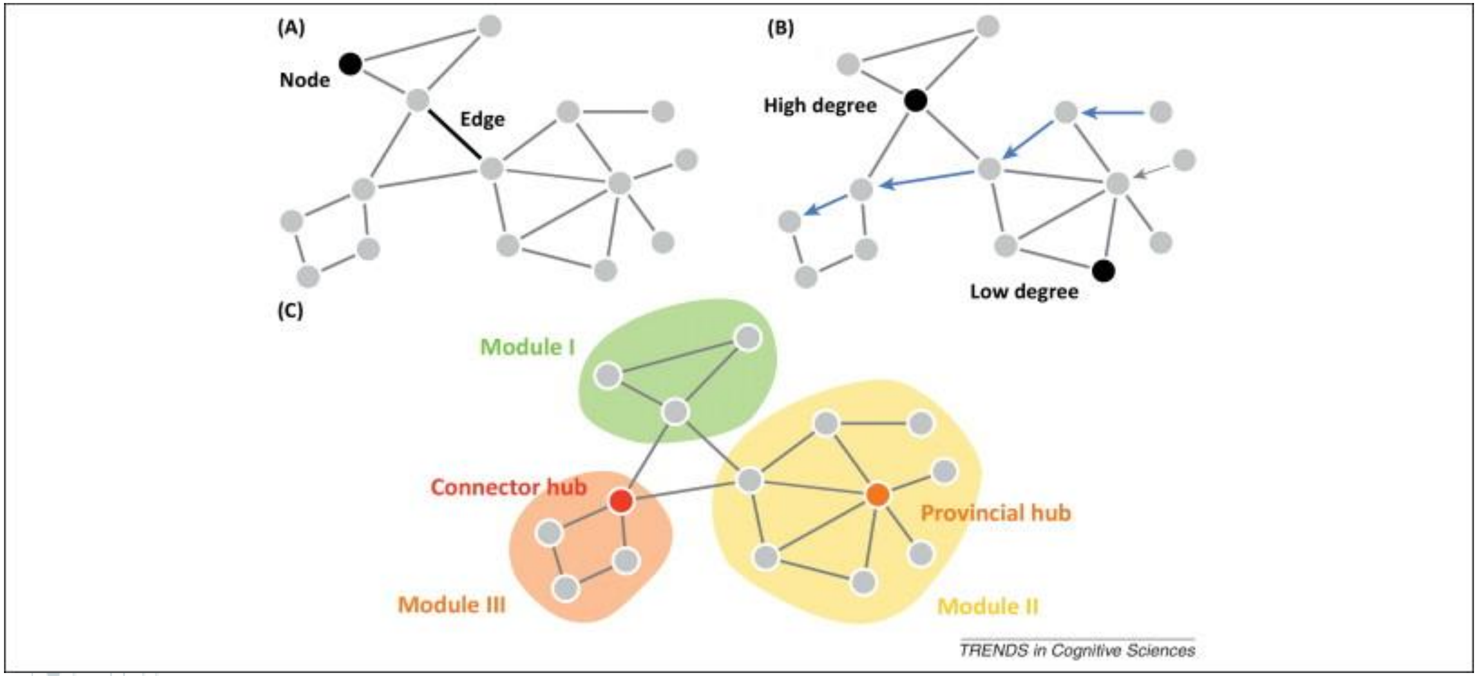
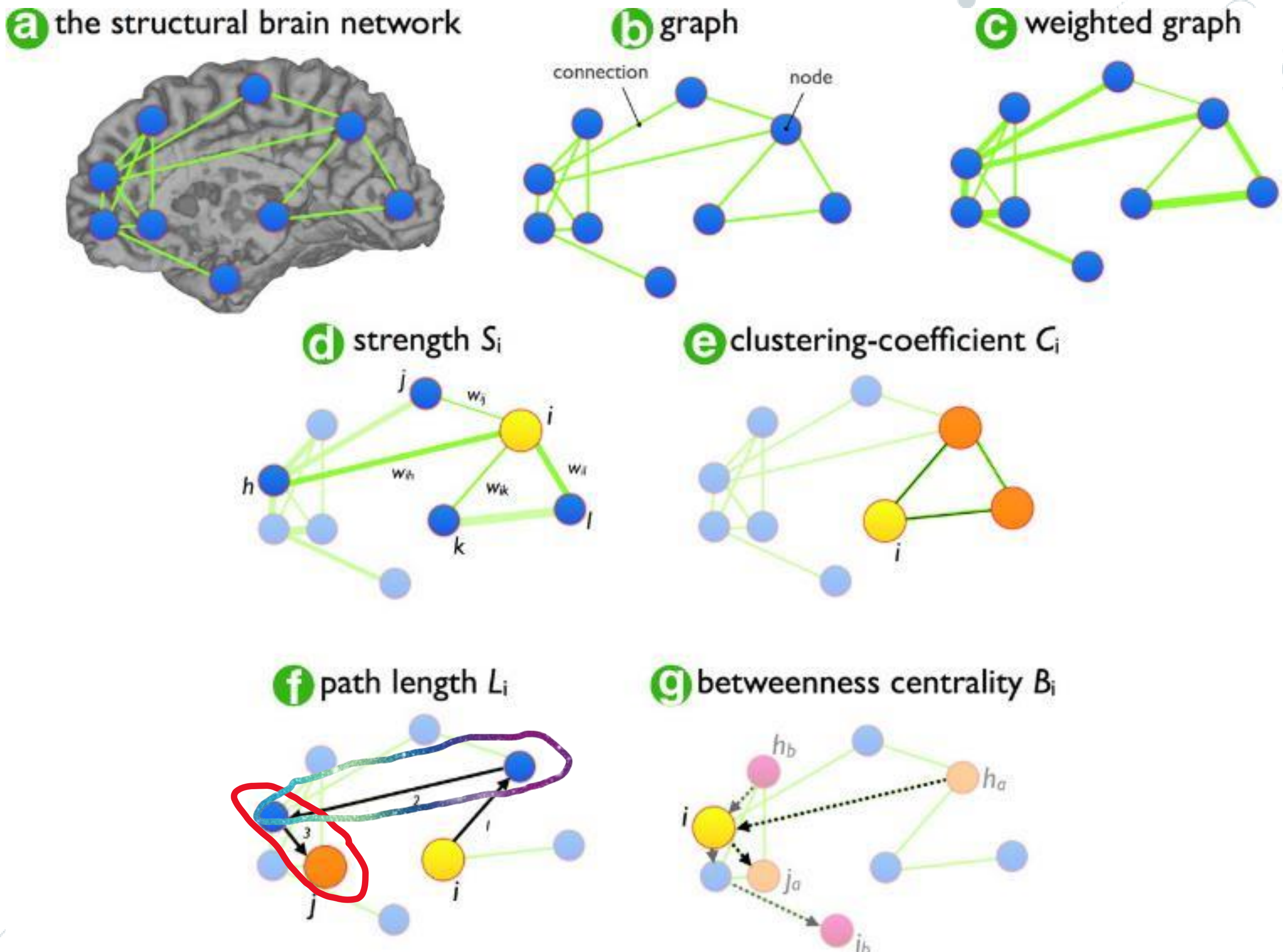


Figure 1. Basic network attributes. **(A)** Brain networks can be described and analyzed as graphs comprising a collection of nodes (describing neurons/brain regions) and a collection of edges (describing structural connections or functional relationships). The arrangement of nodes and edges defines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

frontiers in Neuroscience | Neural Technology
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]

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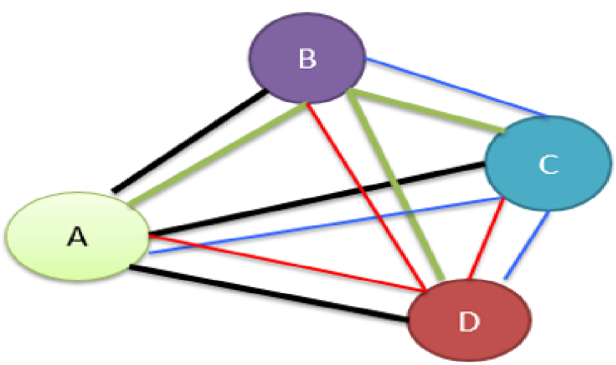
[2]EEG Software, LLC, Gainesville, FL, United States
[3]Department of Psychological Science, University of Arkansas, Fayetteville, AR, United States

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

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

Study Methodology

◎Subjects were assigned to one of two groups (N = 40).

◎These included an experimental group that received the active treatment (four channel multivariate coherence neurofeedback (20),and an alternate treatment comparison group (N = 20) that received individual psychotherapy. All subjects had experienced significant developmental trauma.

◎All subjects in the experimental groups 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.

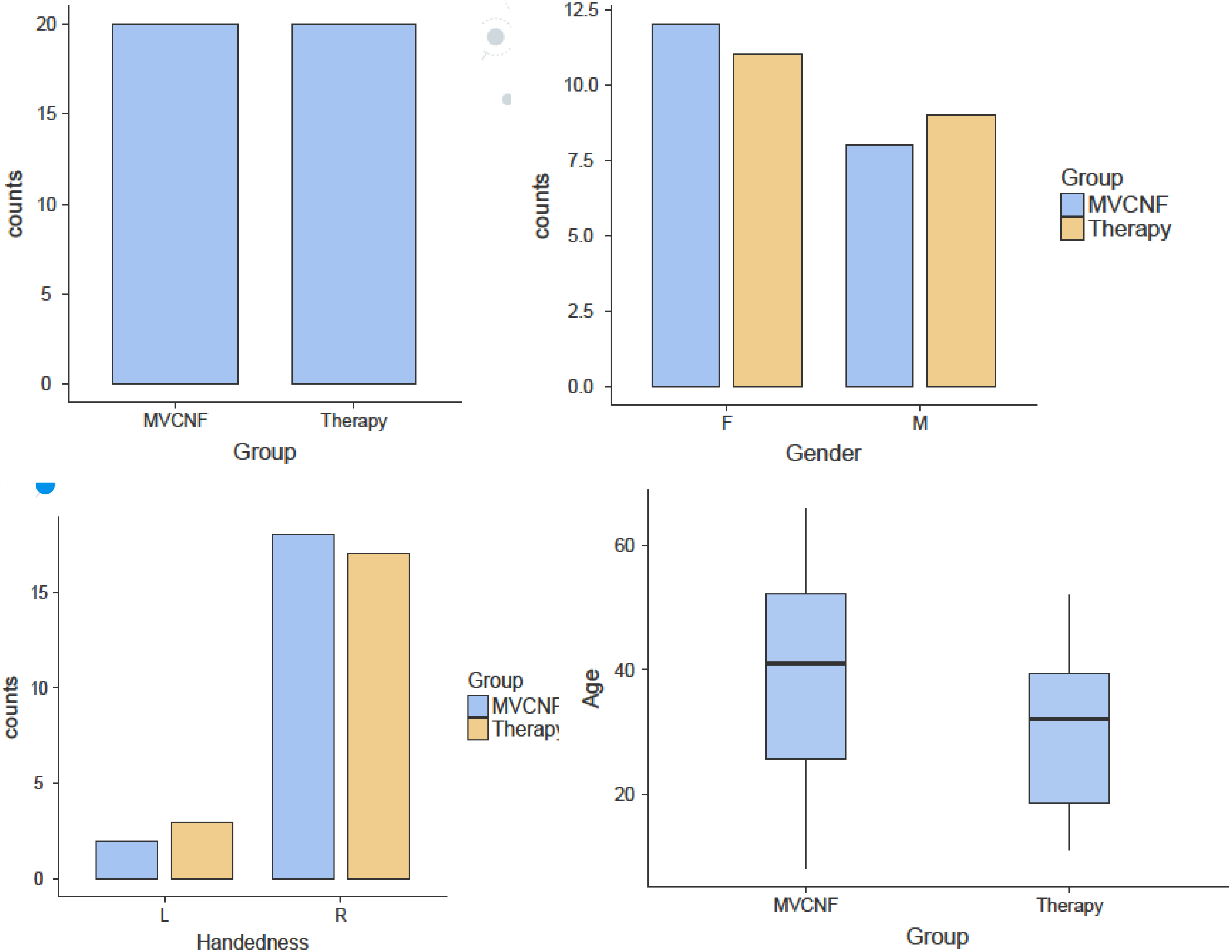
◎Therapist ratings were performed at the completion of training and were based on objective test findings including neuropsychological, behavioral and qeeg findings that reflected change over time.

◎We also tracked the presence of negative symptoms, their severity and resolution during the training/treatment periods.

◎QEEG analysis of change included measures of power at the component level, dipole sources, spectral properties, and multiple measures of graph theory connectivity.

Hypothesis

Individuals with developmental trauma will demonstrate greater clinical improvement of statistical significance through 4-channel multivariate coherence training compared to those in psychotherapy. We also theorize that multivariate connectivity metrics will significantly improve among the experimental group.



counts
20
15
10
5
0
MVCNF
Therapy
Group
counts
12.5
10.0
7.5
5.0
2.5
0.0
F
M
Gender
Group
MVCNF
Therapy
counts
15
10
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L
R
Handedness
Group
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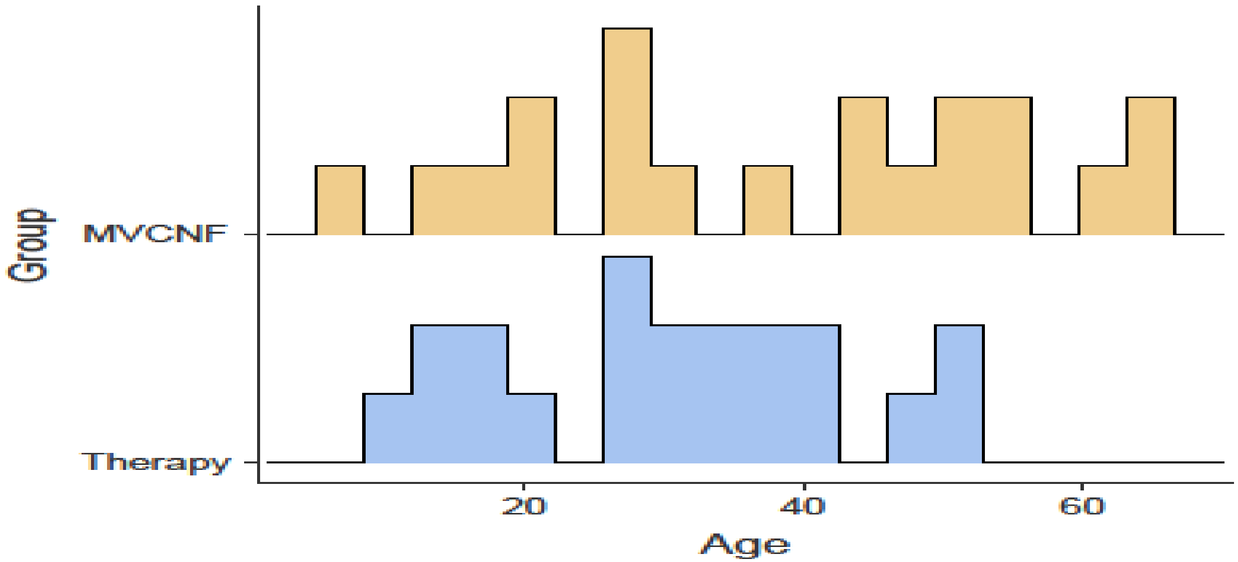
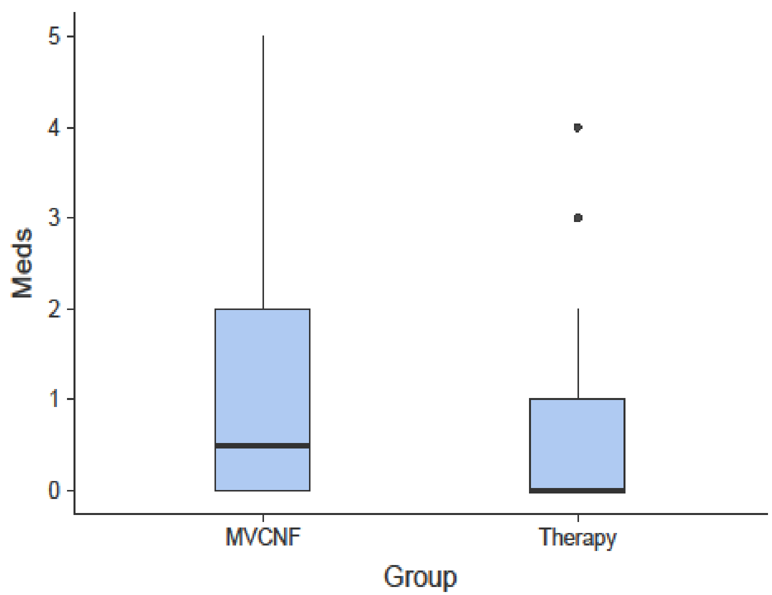
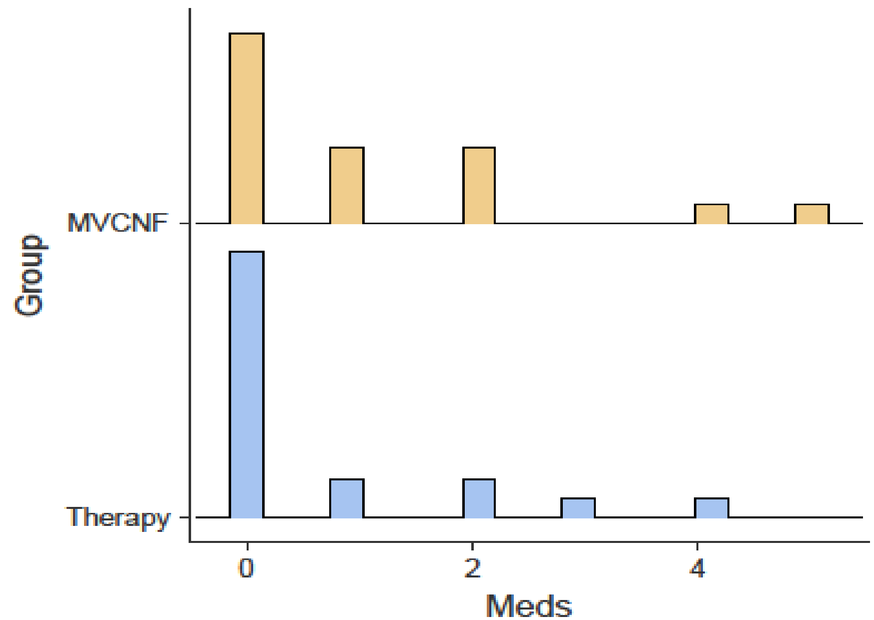
Therapy
Age
60
40
20
MVCNF
Therapy
Group


Group
MVCNF
Therapy
20
40
60
Age


Meds
0
1
2
3
4
5
MVCNF
Therapy
Group


Group
MVCNF
Therapy
0
2
4
Meds

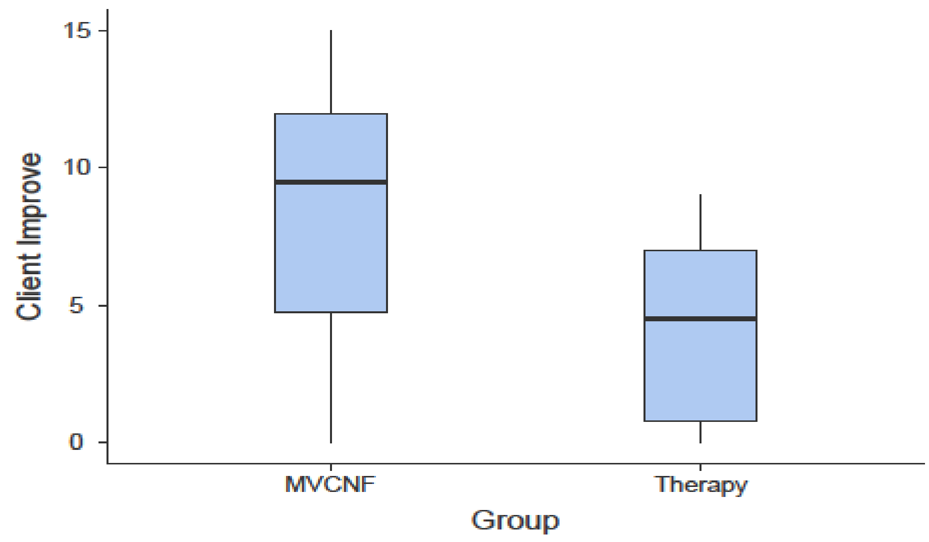
Statistical comparisons for demographics across groups

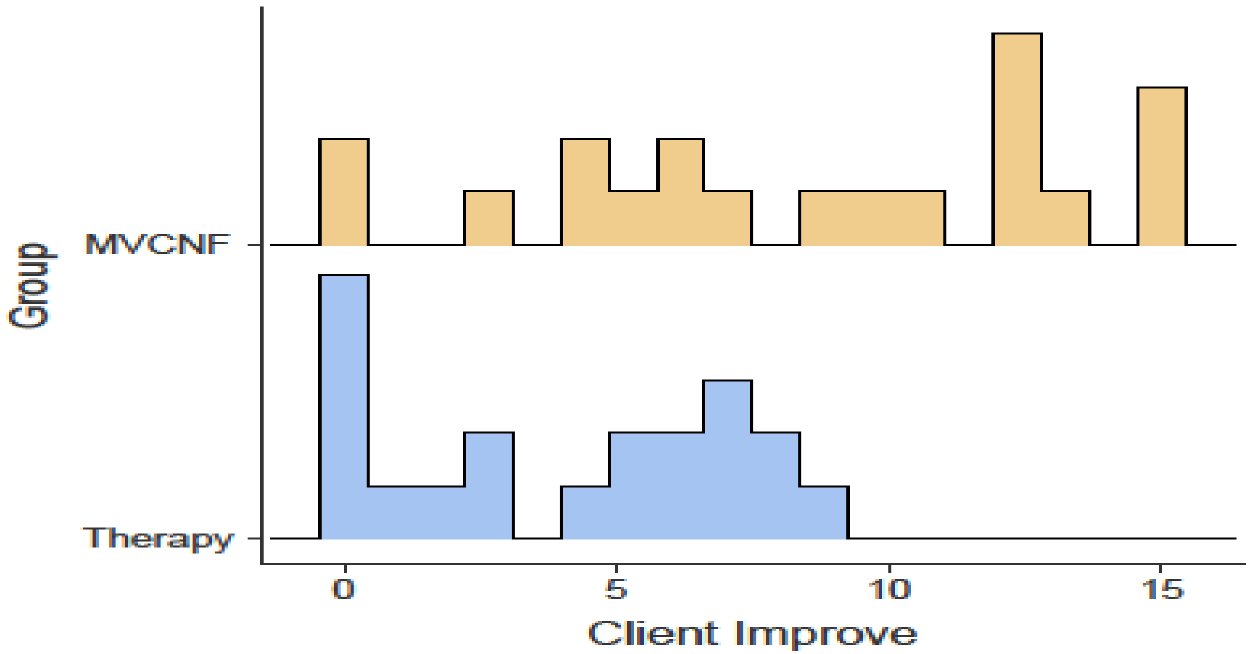
Age	Gender	Handedness	Medications
$F = 2.32$	$X^2 = 0.102$	$X^2 = 0.229$	$F = 0.928$
$p = 0.136$	$p = 0.749$	$p = 0.633$	$p = 0.341$

ANOVA

ANOVA

	Sum of Squares	df	Mean Square	F	p
Group	202	1	202.5	12.1	0.001
Residuals	636	38	16.7		

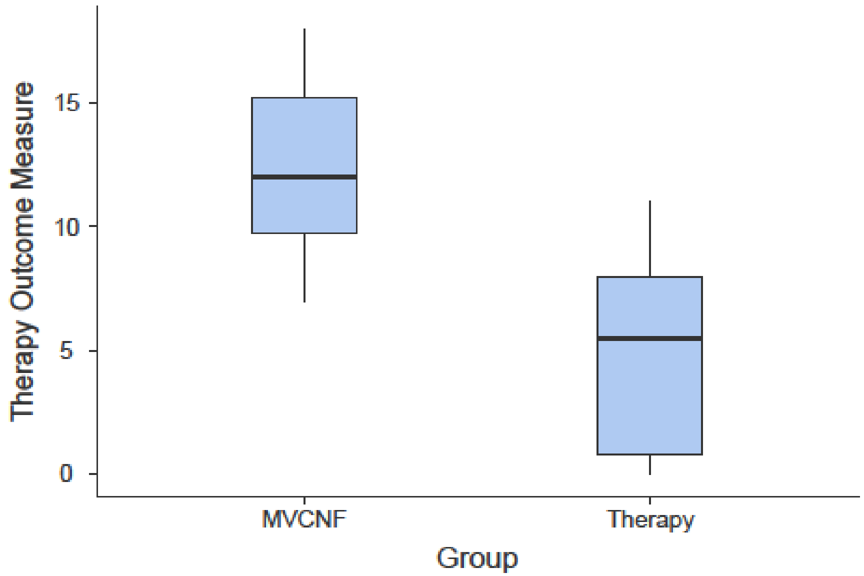


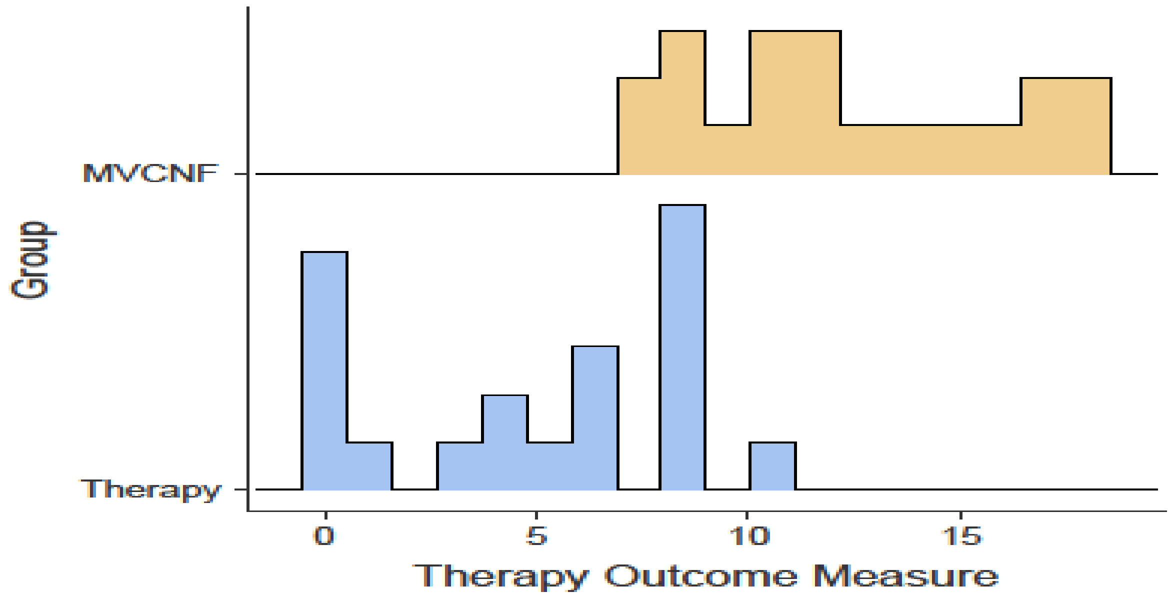


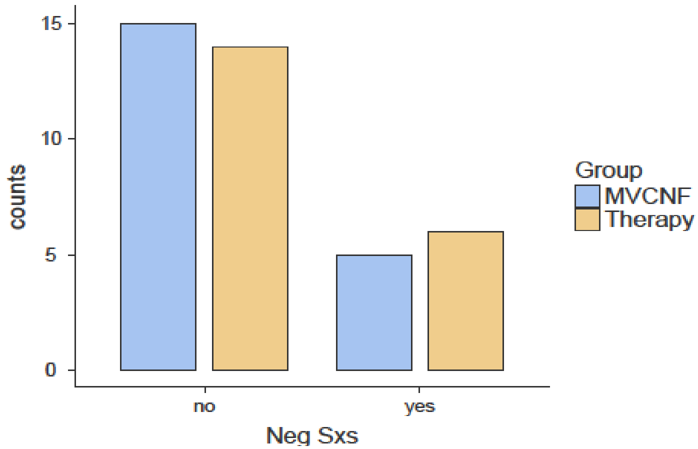
ANOVA

ANOVA

	Sum of Squares	df	Mean Square	F	p
Group	578	1	577.6	45.1	< .001
Residuals	486	38	12.8		

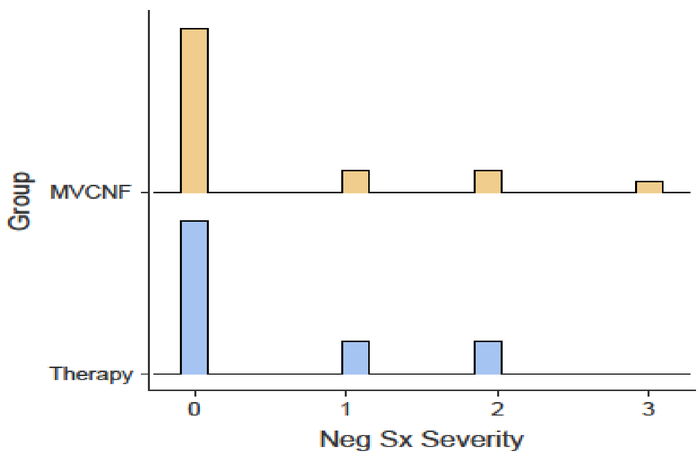






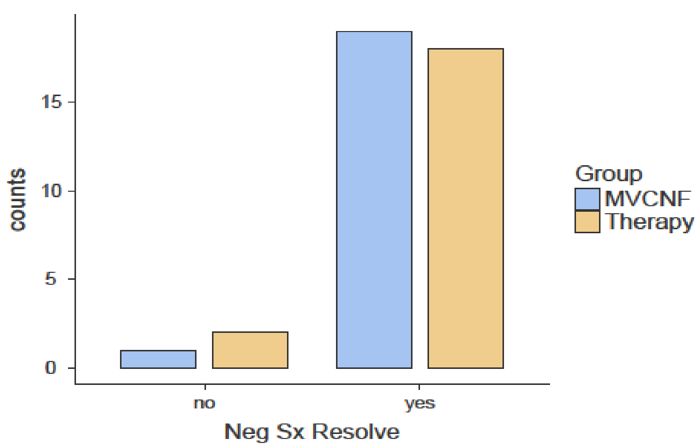
χ^2 Tests

	Value	df	p
χ^2	0.125	1	0.723
N	40		



ANOVA

	Sum of Squares	df	Mean Square	F	p
Group	0.0	1	0.000	0.00	1.000
Residuals	25.9	38	0.682		



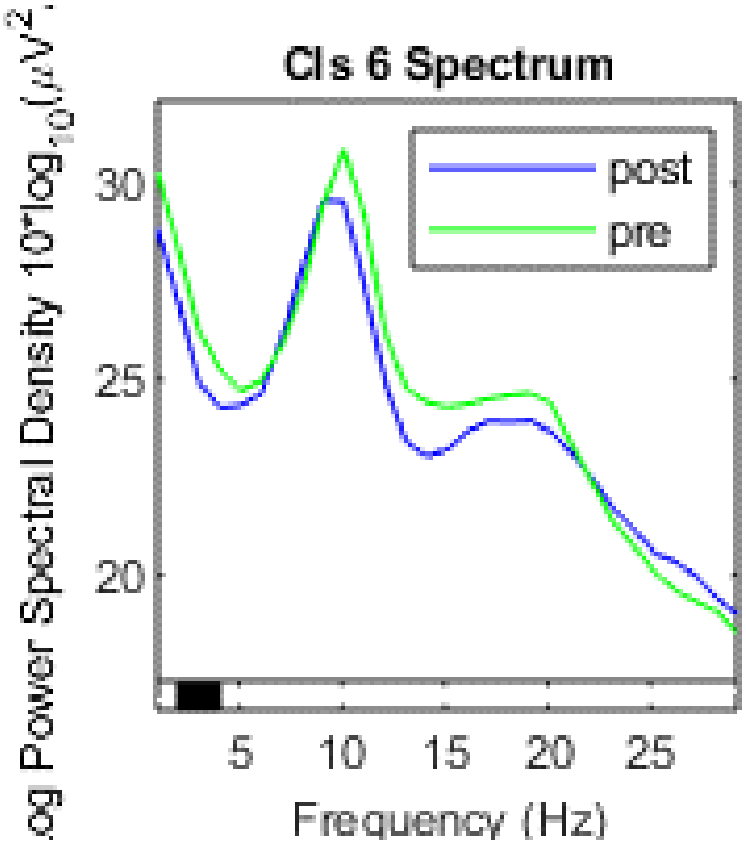
Contingency Tables

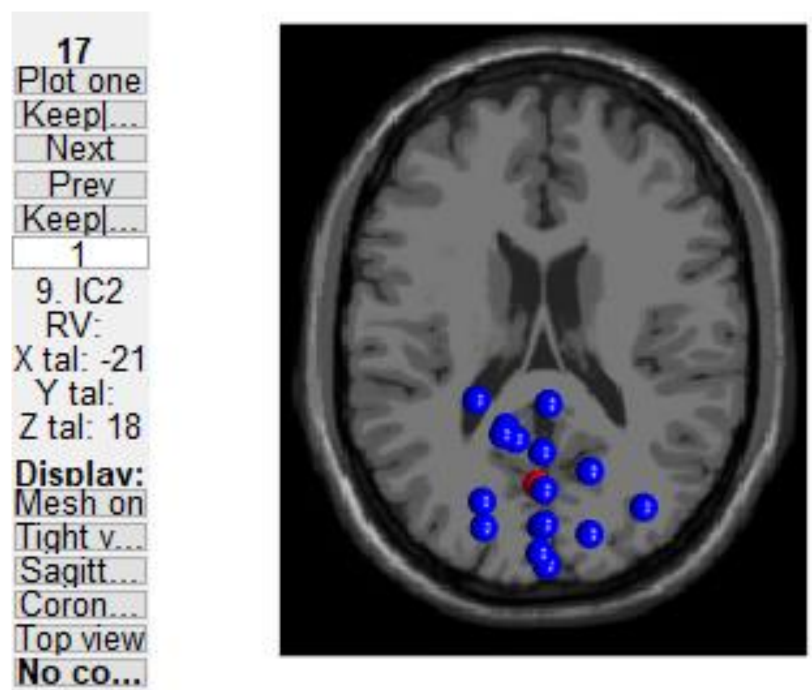
Contingency Tables

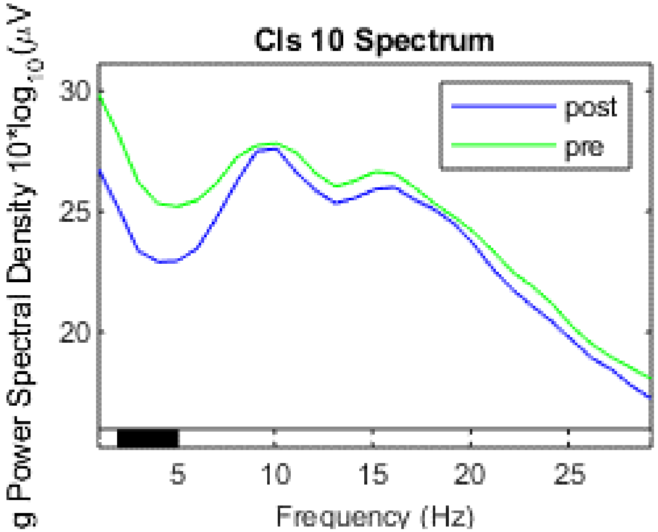
	Group		
Neg Sx Resolve	MVCNF	Therapy	Total
no	1	2	3
yes	19	18	37
Total	20	20	40

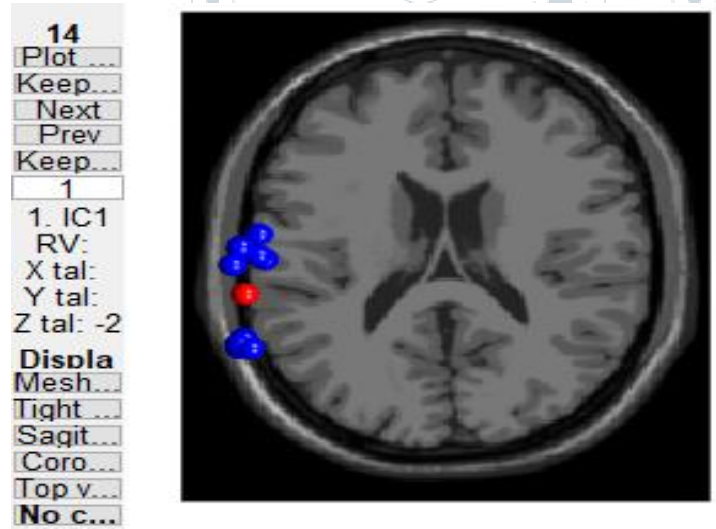
χ^2 Tests

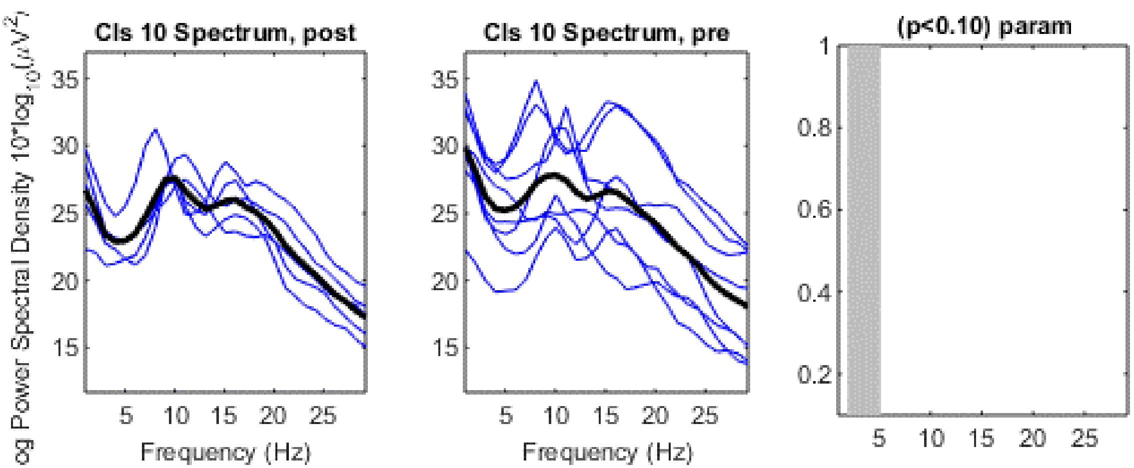
	Value	df	p
χ^2	0.360	1	0.548
N	40		

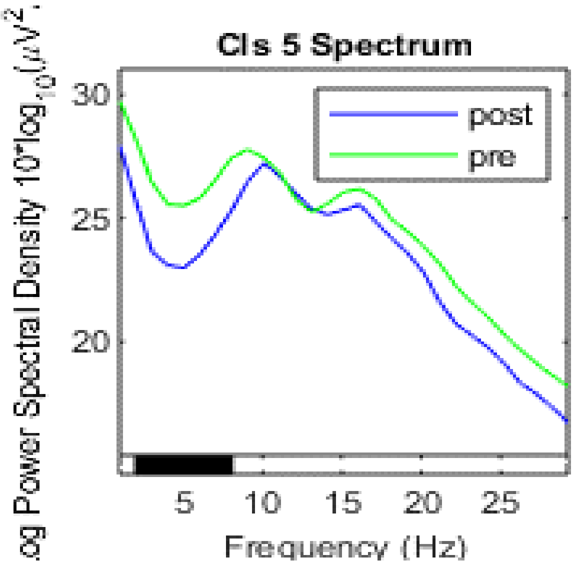

Cls 6 Spectrum
post
pre
30
25
20
5
10
15
20
25
Frequency (Hz)
og Power Spectral Density 10*log10(μV2

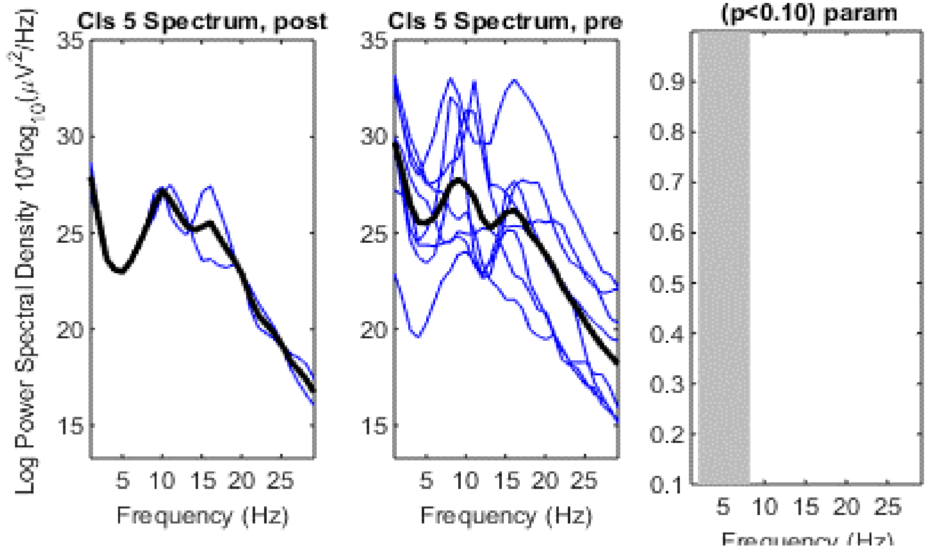

17
Plot one
Keep|...
Next
Prev
Keep|...
1
9. IC2
RV:
X tal: -21
Y tal:
Z tal: 18
Displav:
Mesh on
Tight v...
Sagitt...
Coron...
Top view
No co...

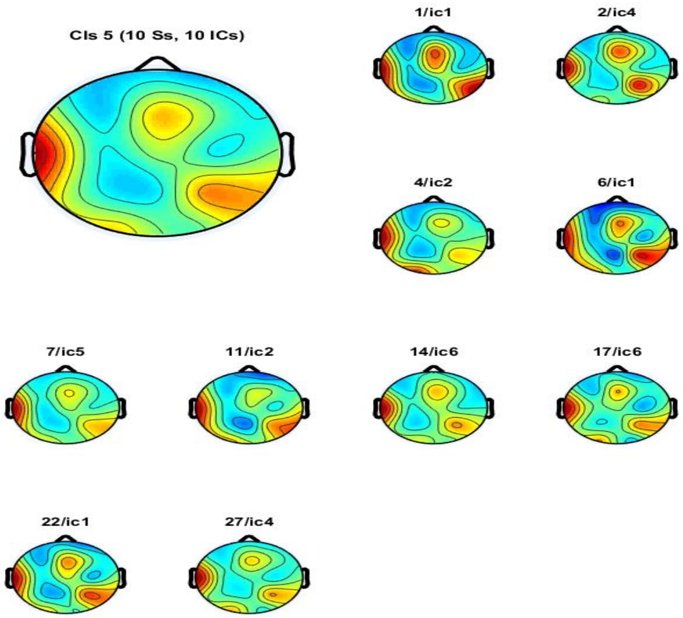

Cls 10 Spectrum
post
pre
g Power Spectral Density 10*log10(μV
30
25
20
5
10
15
20
25
Frequency (Hz)

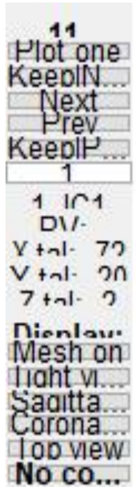

14
Plot ...
Keep...
Next
Prev
Keep...
1
1. IC1
RV:
X tal:
Y tal:
Z tal: -2
Displa
Mesh...
Tight ...
Sagit...
Coro...
Top v...
No c...

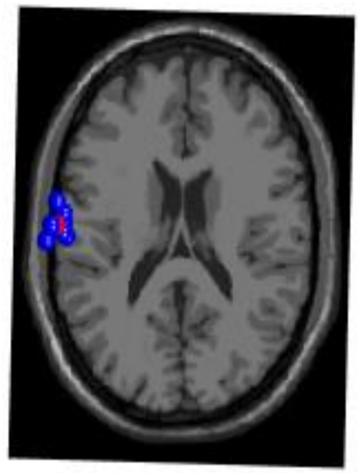

Cls 10 Spectrum, post
Cls 10 Spectrum, pre
(p<0.10) param
og Power Spectral Density 10*log10(μV²)
35
30
25
20
15
5
10
15
20
25
Frequency (Hz)
1
0.8
0.6
0.4
0.2

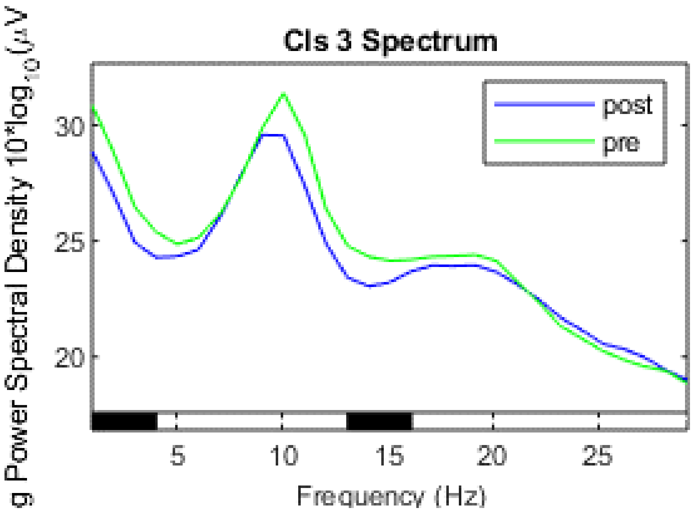

Cls 5 Spectrum
post
pre
Frequency (Hz)

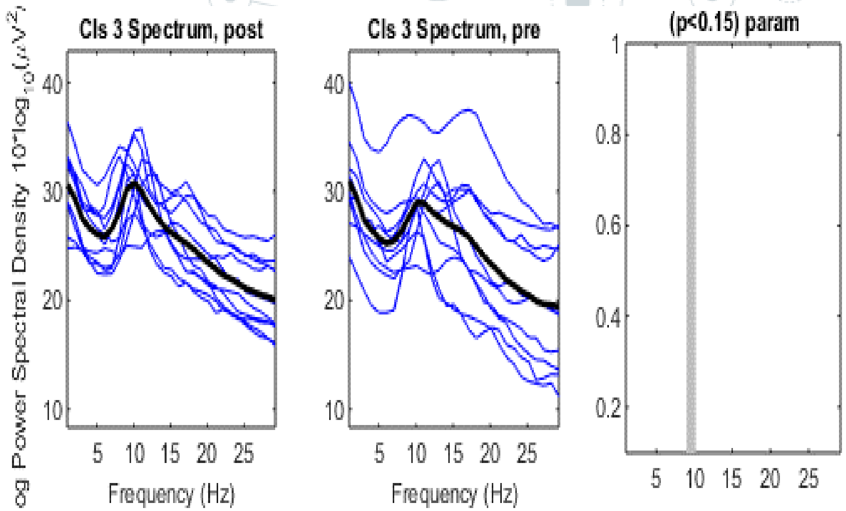

Cls 5 Spectrum, post
Cls 5 Spectrum, pre
(p<0.10) param
Log Power Spectral Density 10*log10(μV²/Hz)
Frequency (Hz)

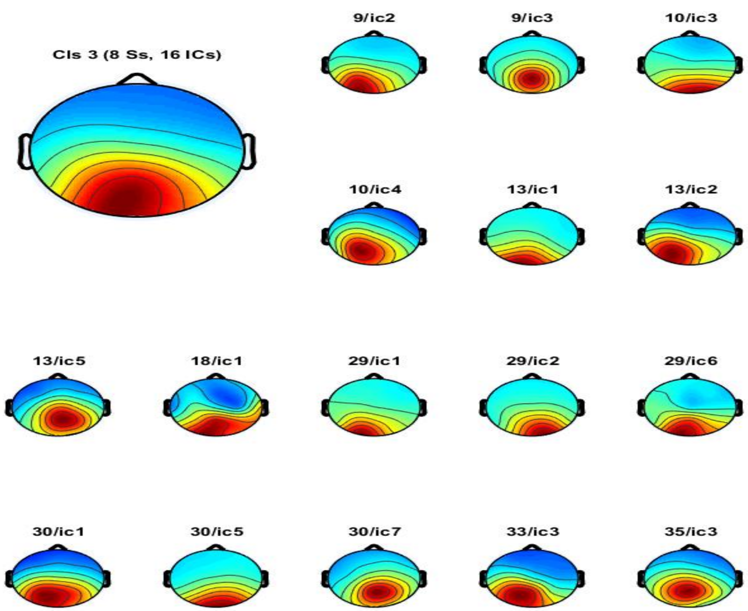

Cls 5 (10 Ss, 10 ICs)
1/ic1
2/ic4
4/ic2
6/ic1
7/ic5
11/ic2
14/ic6
17/ic6
22/ic1
27/ic4

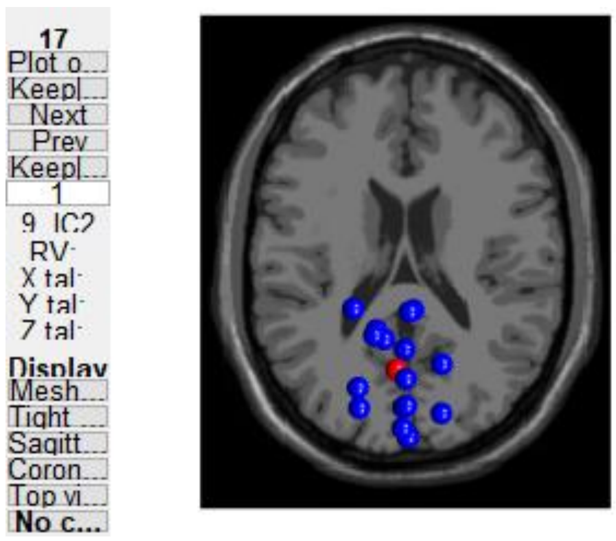

Plot one
Next
Prev
Mesh on
Top view

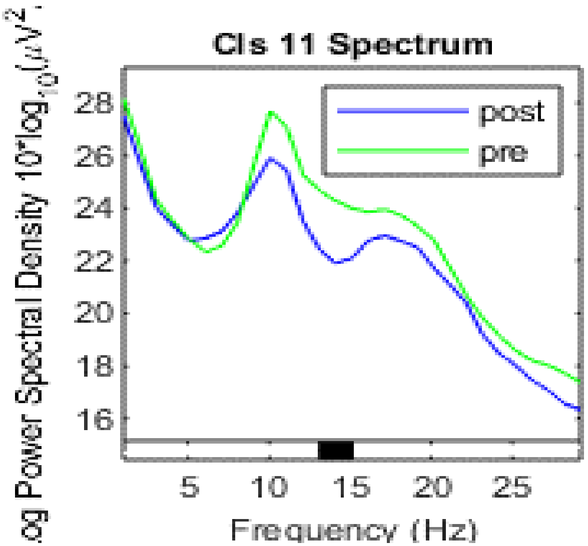



Cls 3 Spectrum
post
pre
g Power Spectral Density 10*log$_{10}$(μV
30
25
20
5
10
15
20
25
Frequency (Hz)

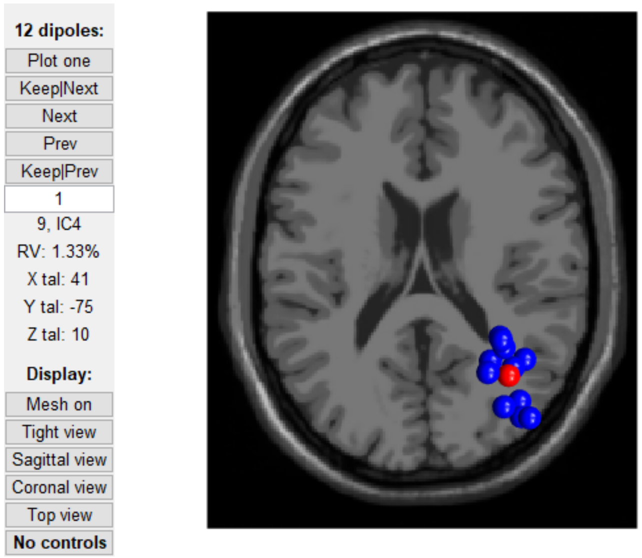

Cls 3 Spectrum, post
Cls 3 Spectrum, pre
(p<0.15) param
og Power Spectral Density 10*log$_{10}$(μV^2,
40
30
20
10
5 10 15 20 25
Frequency (Hz)
1
0.8
0.6
0.4
0.2


Cls 3 (8 Ss, 16 ICs)
9/ic2
9/ic3
10/ic3
10/ic4
13/ic1
13/ic2
13/ic5
18/ic1
29/ic1
29/ic2
29/ic6
30/ic1
30/ic5
30/ic7
33/ic3
35/ic3

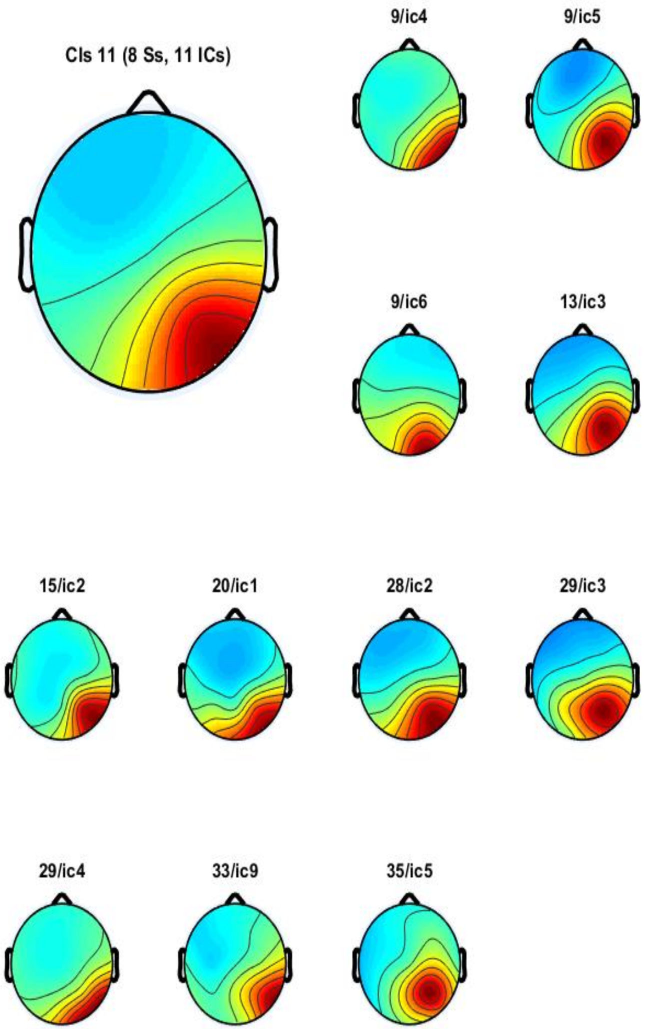

17
Plot o...
Keepl...
Next
Prev
Keepl...
1
9 IC2
RV
X tal
Y tal
Z tal
Display
Mesh...
Tight...
Sagitt...
Coron...
Top vi...
No c...



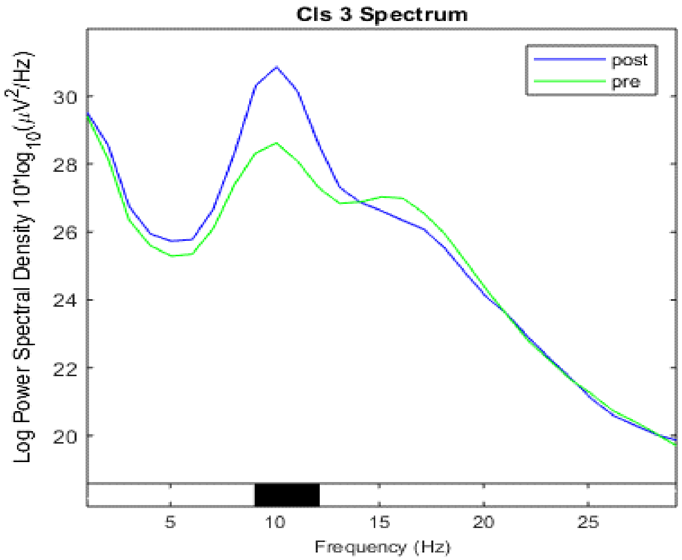
Cls 11 Spectrum
post
pre
Log Power Spectral Density 10*log10(μV²/Hz)
28
26
24
22
20
18
16
5
10
15
20
25
Frequency (Hz)

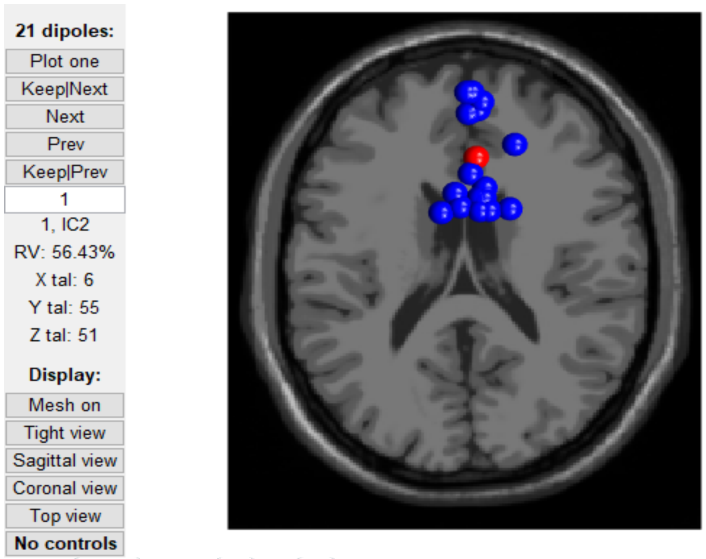


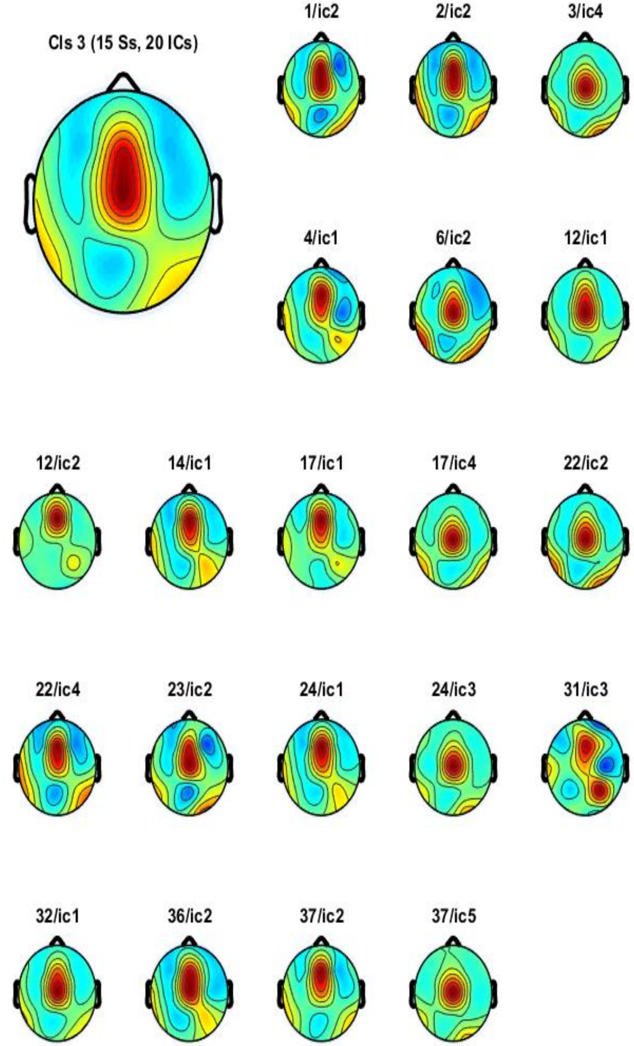
12 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
9, IC4
RV: 1.33%
X tal: 41
Y tal: -75
Z tal: 10
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls

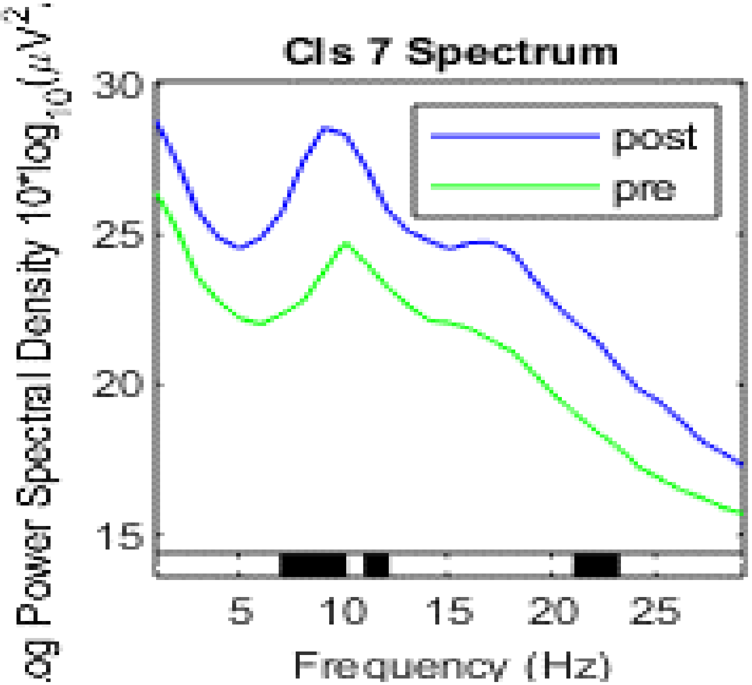


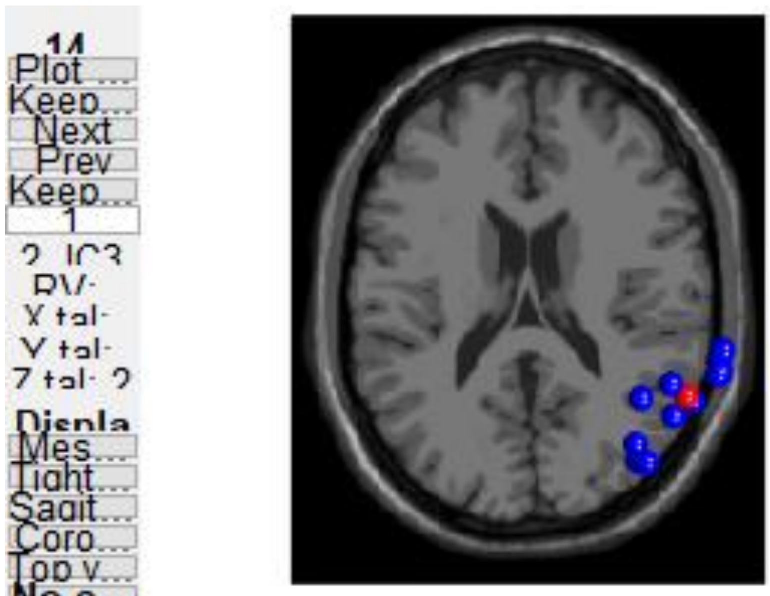
Cls 11 (8 Ss, 11 ICs)
9/ic4
9/ic5
9/ic6
13/ic3
15/ic2
20/ic1
28/ic2
29/ic3
29/ic4
33/ic9
35/ic5


Cls 3 Spectrum
post
pre
Log Power Spectral Density 10*log10(μV²/Hz)
30
28
26
24
22
20
5
10
15
20
25
Frequency (Hz)


21 dipoles:
Plot one
Keep|Next
Next
Prev
Keep|Prev
1
1, IC2
RV: 56.43%
X tal: 6
Y tal: 55
Z tal: 51
Display:
Mesh on
Tight view
Sagittal view
Coronal view
Top view
No controls


Cls 3 (15 Ss, 20 ICs)
1/ic2
2/ic2
3/ic4
4/ic1
6/ic2
12/ic1
12/ic2
14/ic1
17/ic1
17/ic4
22/ic2
22/ic4
23/ic2
24/ic1
24/ic3
31/ic3
32/ic1
36/ic2
37/ic2
37/ic5

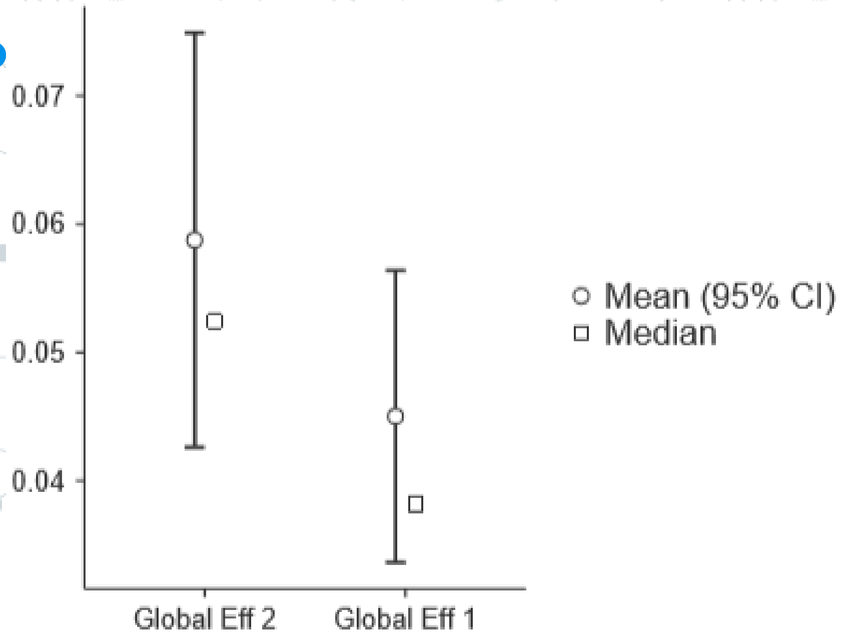

Cls 7 Spectrum
post
pre
30
25
20
15
5
10
15
20
25
Frequency (Hz)
og Power Spectral Density 10*log10(μV²

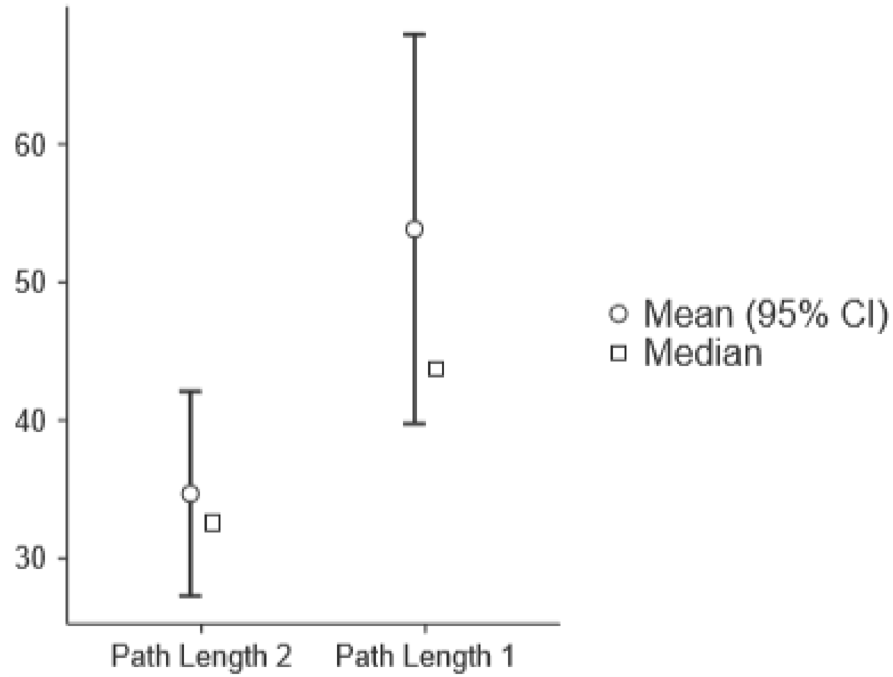

Plot ...
Keep...
Next
Prev
Keep...
1
Mes...
Tight...
Sagit...
Coro...
Top v...
No c...

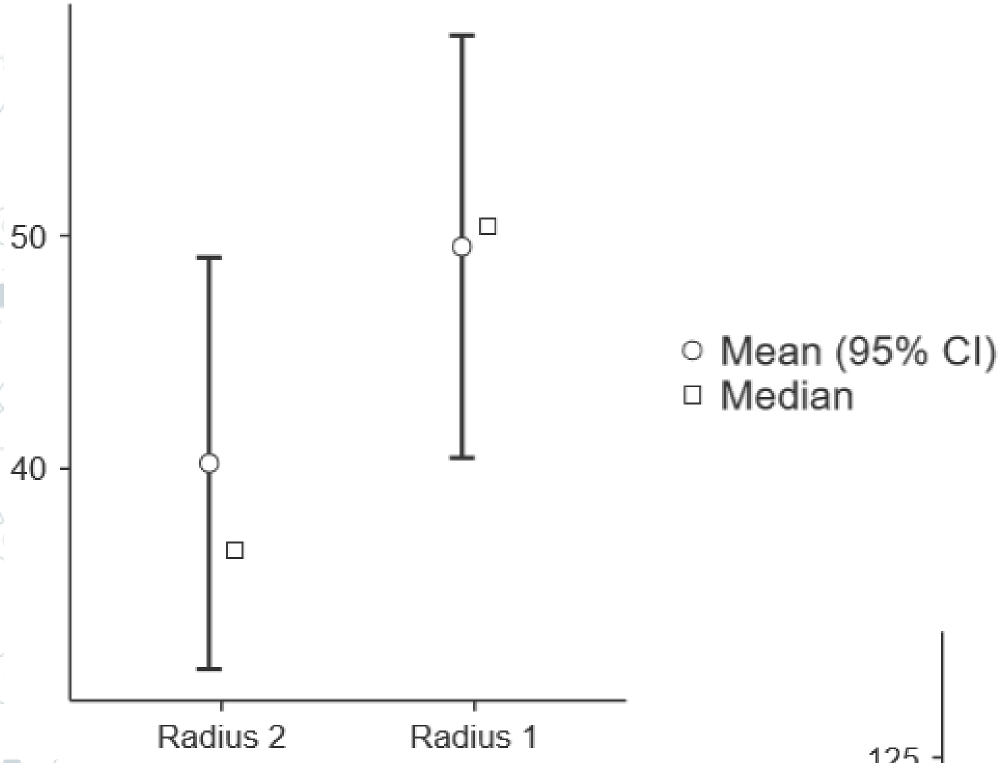
Graph Theory Connectivity Findings

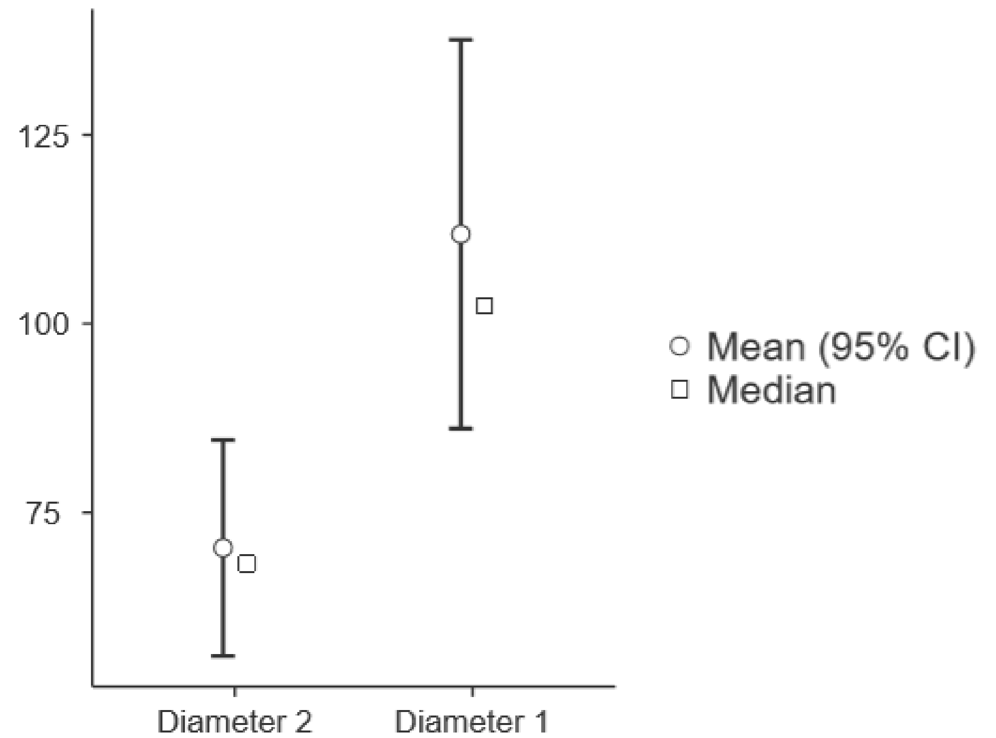
Paired Samples T-Test

			statistic	df	p
Clust Coeff 2	Clust Coeff 1	Student's t	0.827	19.0	0.419
Path Length 2	Path Length 1	Student's t	-3.231	19.0	0.004
Global Eff 2	Global Eff 1	Student's t	2.470	19.0	0.023
Radius 2	Radius 1	Student's t	-2.472	19.0	0.023
Diameter 2	Diameter 1	Student's t	-3.618	19.0	0.002


0.07
0.06
0.05
0.04
Global Eff 2
Global Eff 1
Mean (95% CI)
Median


60
50
40
30
Path Length 2
Path Length 1
Mean (95% CI)
Median


50
40
Radius 2
Radius 1
Mean (95% CI)
Median


125
100
75
Diameter 2
Diameter 1
Mean (95% CI)
Median

Correlation Matrix

		Age	Meds	Client Improve	Therapy Outcome Measure	Neg Sx Severity
Age	Pearson's r	—	0.137	0.061	0.262	-0.044
	p-value	—	0.400	0.710	0.102	0.786
Meds	Pearson's r		—	-0.229	-0.122	0.569
	p-value		—	0.156	0.452	< .001
Client Improve	Pearson's r			—	0.699	-0.437
	p-value			—	< .001	0.005
Therapy Outcome Measure	Pearson's r				—	-0.337
	p-value				—	0.034
Neg Sx Severity	Pearson's r					—
	p-value					—

Model Coefficients

Predictor	Estimate	SE	t	p
Intercept	0.142	0.1299	1.097	0.280
Meds	0.362	0.0845	4.280	< .001
Group:				
Therapy – MVCNF	0.145	0.2190	0.661	0.513

Conclusions

- MVCNF leads to enhanced client and therapist ratings of outcome and to a greater degree than traditional psychotherapy.

- Client and therapist outcome ratings correlate but disagree with therapist ratings being higher (more accurate?).

- Mild, negative symptoms are possible but often can be resolved. These do not differ from psychotherapy and are often related to medication usage.

- Positive response to MVCNF in DT leads to decreases in delta, theta and beta activity over left temporal, precuneus (midline parietal), and right parietal brain regions. There were also increases in alpha and high beta over midline frontal (anterior cingulate) and right parietal-temporal regions.

- Positive responses are also seen with increases in multivariate connectivity, especially long range connectivity.

Thanks to our team:

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Tarik Bel-Bahar, PhD