Neurofeedback Basics

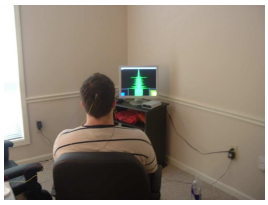
By Richard Soutar, Ph.D.

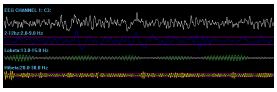
Operant Conditioning

- The individual feels rewarded for his or her training efforts during neurofeedback.
- This reward process is called reinforcement in the psychology of Behaviorism.
- We learn to ride a bicycle in the same manner through the same mechanisms.

What Is Neurofeedback and when is it used?

- Neurofeedback is a method of training brainwaves to alter the structure and function of the brain.
- It is used to help people reduce symptoms of a variety of disorders including ADHD, Depression, Anxiety, TBI, Stroke, Seizure as well many others .





Learning Is Permanent

- Once we learn something it becomes a permanent part of our behavior.
- Follow up studies in neurofeedback show that the effects continue for up to 30 years.

How is it done?

- Sensors are placed on the head and connected to special amplifiers.
- The amplifiers allow the computer to read the electrical activity in the brain.
- When client brainwaves begin to appear properly ordered the computer feeds back that information to the individual.
- This feedback appears in the form of a game, movie or exercise that tells them when they are training just right.
- Through Operant Conditioning individuals learn to change brain structure and function.

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Involuntary Learning

Review

Cell

Learned regulation of brain metabolism

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Self-regulation and voluntary control of circumscribed brain regions using real-time functional MRI (rt-fMRI) allows the establishment of a causal functional link between localized brain activity and behavior and cognition. A long tradition of research has clearly shown the brain's ability to learn volitional control of its own activity and effects on behavior. Yet, the underlying neural mechanism of self-regulation is still not fully understood. Here, we propose that self-regulation of brain activity is akin to skill learning and thus may depend on an intact subcortical motor system. We elaborate on the critical role of the basal ganglia in skill learning and neurofeedback, and clarify that brain-self-regulation need not be an explicit and conscious process as often mistakenly held.

the biological sciences, the road to clinical success turned out to be much longer and stonier than originally expected (Box 1). Only neurofeedback of intractable epilepsy [3] and attention deficit–hyperactivity disorder (ADHD) [4]

Glossary

Amyotrophic lateral sclerosis (ALS – also called Lou Gehrig's disease): progressive atrophy of all voluntary muscles due to degeneration of motor neurons at the motor cortex, brain stem, and spinal cord.
Anterior insula: evolutionarily old cortical area located deep within the sylvian fissure. Often used in neurofeedback experiments because of its strong relationship with perception of emotions and pain.
Blood-oxygen-level-dependent (BOLD) response: a magnetic resonance imaging (MRI) contrast of blood oxyhemoglobin and deoxyhemoglobin. Higher BOLD signal intensities arise from increases in the concentration of oxygenated hemoglobin and decrease in the concentration of deoxyhemoglobin during brain activity.
Brain-machine interface (BMI): control of an external device or computer

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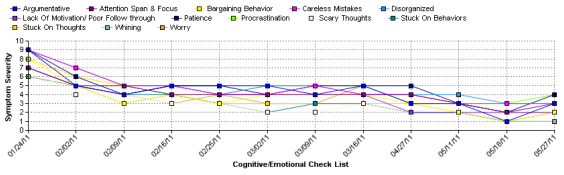
How long does it take?



Reduction In Symptoms Over 4 Month Period.

- Each session is 30-45 minutes long.
- Trainees typically come for 40 sessions of training.
- Clients come twice a week or more.

MRI Research & Neurofeedback

Changing Function of the Brain

MRI Research shows that EEG Biofeedback changes the functioning of the brain.

- **Functional magnetic resonance imaging investigation of the effects of neurofeedback training on the neural bases of selective attention and response inhibition in children with attention-deficit/hyperactivity disorder.**
- Beauregard M, Lévesque J.
- Centre de Recherche en Neuropsychologie et Cognition, Département de Psychologie, Université de Montréal, Montréal, Canada. mario.beauregard@umontreal.ca
- Two functional magnetic resonance imaging (fMRI) experiments were undertaken to measure the effect of neurofeedback training (NFT), in AD/HD children, on the neural substrates of selective attention and response inhibition. Twenty unmedicated AD/HD children participated to these experiments. Fifteen children were randomly assigned to the Experimental (EXP) group whereas the other five children were randomly assigned to the Control (CON) group. Only subjects in the EXP group underwent NFT. EXP subjects were trained to enhance the amplitude of the SMR (12-15 Hz) and beta 1 activity (15-18 Hz), and decrease the amplitude of theta activity (4-7 Hz). Subjects from both groups were scanned one week before the beginning of NFT (Time 1) and 1 week after the end of NFT (Time 2), while they performed a "Counting Stroop" task (Experiment 1) and a Go/No-Go task (Experiment 2). At Time 1, in both groups, the Counting Stroop task was associated with significant activation in the left superior parietal lobule. For the Go/No-Go task, no significant activity was detected in the EXP and CON groups. At Time 2, in both groups, the Counting Stroop task was associated with significant activation of the left superior parietal lobule. This time, however, there were significant loci of activation, in the EXP group, in the right ACC, left caudate nucleus, and left substantia nigra. No such activation loci were seen in CON subjects. For the Go/No-Go task, significant loci of activation were noted, in the EXP group, in the right ventrolateral prefrontal cortex, right ACcd, left thalamus, left caudate nucleus, and left substantia nigra. No significant activation of these brain regions was measured in CON subjects. These results suggest that NFT has the capacity to functionally normalize the brain systems mediating selective attention and response inhibition in AD/HD children.
- PMID: 16552626 [PubMed - indexed for MEDLINE]

When do clients begin to feel better?

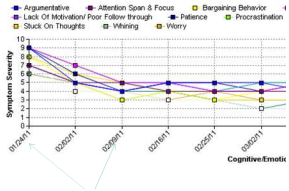
Each individual responds differently to neurofeedback. Their sensitivity varies.

The greater their sensitivity to neurofeedback the more quickly they feel its effects.

Sensitivity to drugs often predicts sensitivity to neurofeedback.

Some individuals feel changes in 1 to 5 sessions.

More typically noticeable changes begin to occur around 15 to 20 sessions.



First 5 Sessions

Neurofeedback Changes Brain Structure

Neurofeedback Training Induces Changes in White and Gray Matter

Clinical EEG and Neuroscience
00(0) 1-8
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DOI: 10.1177/1550059413476031
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SAGE

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Abstract

The main objective of this structural magnetic resonance imaging (MRI) study was to investigate, using diffusion tensor imaging, whether a neurofeedback training (NFT) protocol designed to improve sustained attention might induce structural changes in white matter (WM) pathways, purportedly implicated in this cognitive ability. Another goal was to examine whether gray matter (GM) volume (GMV) might be altered following NFT in frontal and parietal cortical areas connected by these WM fiber pathways. Healthy university students were randomly assigned to an experimental group (EXP), a sham group, or a control group. Participants in the EXP group were trained to enhance the amplitude of their β1 waves at F4 and P4. Measures of attentional performance and MRI data were acquired one week before (Time 1) and one week after (Time 2) NFT. Higher scores on visual and auditory sustained attention were noted in the EXP group at Time 2 (relative to Time 1). As for structural MRI data, increased fractional anisotropy was measured in WM pathways implicated in sustained attention, and GMV increases were detected in cerebral structures involved in this type of attention. After 50 years of research in the field of neurofeedback, our study constitutes the first empirical demonstration that NFT can lead to microstructural changes in white and gray matter.

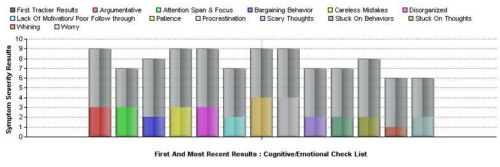
Keywords

neurofeedback, structural magnetic resonance imaging, white matter, gray matter, sustained attention

Disorders Responsive To Neurofeedback

1. ***Anxiety***
2. ***Depression***
3. ***Insomnia***
4. ***Migraine***
5. ***Fibromyalgia***
6. ***Seizure Disorder***
7. ***Bipolar Disorder***
8. ***Irritable Bowel Syndrome***
9. ***TMJ***
10. ***Vestibular Disorders***
11. ***Traumatic Brain Injury***
12. ***Stroke***
13. ***ADD***
14. ***Learning Disabilities***
15. ***Autistic Spectrum Disorder***
16. ***OCD***
17. ***Auditory Processing Deficits***
18. ***PTSD***

Success Rates



- Depression- 90%
- Anxiety- 75%
- ADHD- 90%
- Bipolar- 60%
- OCD- 50%
- Autism- 30-45%

Estimates Of Average Percent Symptom Reduction Based On Clinical Experience

Typical Changes In ADHD

- Improved Behavior
- Improved School Performance 1-2 grade levels
- Increase IQ by 5-15 points
- Reduced Medications.

(Hammond, 2006)

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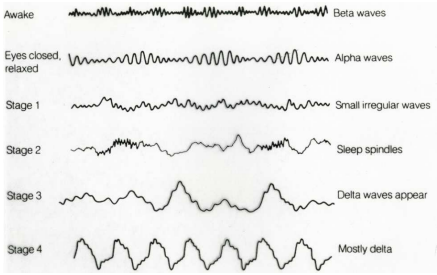
Brainwaves



What Are Brainwaves?

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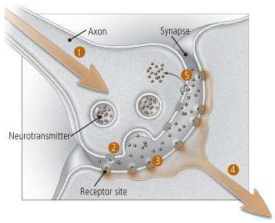
Neurons in the cortex generate electrical activity from synaptic interaction.



Synaptic Gap

Electrical potential builds prior to neurons firing.

Electrical Activity In The Brain

- The brain produces enough energy to light a 30 watt lightbulb.

- Brainwaves are a reflection of the ongoing energy exchanges between cell assemblies in the brain.

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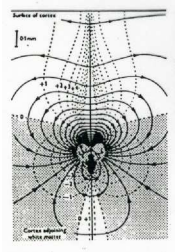
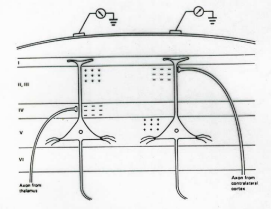
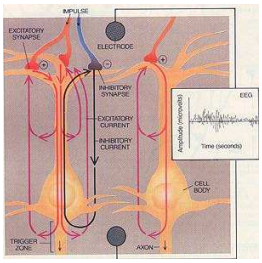
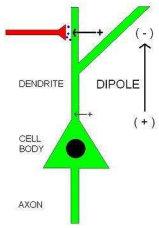
EEG is from the summated pre and post synaptic potentials in the cortex





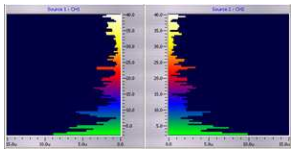
Synapses generate electrical fields called dipoles





Frequency Spectrum

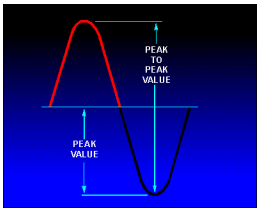
- The brain produces most of its activity in the frequencies between one and 24 cycles per second.
- Recent research indicates high frequencies up to 40 cycles per second or 40hz can be important as well.
- This entire range of frequencies is called a frequency spectrum.
- Your equipment will display this spectrum in a series of bar graphs running from low to high.



Cycles Per Second

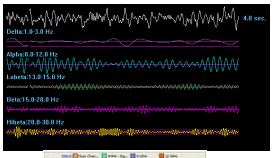
The EEG: Peak Value vs Peak To Peak

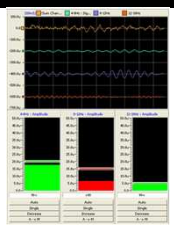
- EEG is a form of alternating current.
- It can be measured in terms of Volts or Power.
- Voltage is measured in terms of how high it swings above and below the 0 value line.
- The volt is defined as the potential difference across a conductor when a current of one ampere dissipates one watt of power.



Component Bands

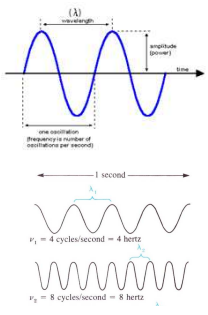
- The frequency spectrum is divided into component bands.
- The most basic divisions from low to high are delta, theta, alpha and beta.
- Delta is 1-4hz, theta is 4-8hz, alpha is 8-12hz and beta is 13hz and higher.



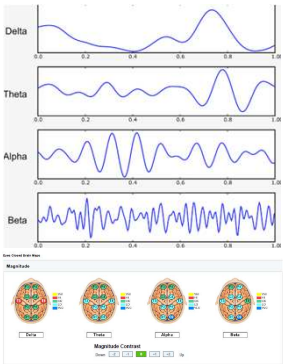


Frequency

- A cycle is when a brainwave swings from zero to a positive peak, then down to a negative peak, then back to zero.
- One cycle every second is called one cycle per second or one hertz.
- Frequency is the number of cycles that occur in one second.



Component EEG Bands



Component Bands & Function

- **Delta:** Related to sleep, brain stem and autonomic functions. Also Fascicular Continuity.
  Diffuse & Elevated or Diminished : Can indicate Inflammation or white matter damage.
- **Theta:** Related to memory, emotion, and emotional brain (Limbic System) functions.
  Focal & Elevated or Diminished : Can indicate cortical lesions or perfusion issues.
- **Alpha:** Related to resource allocation.
  Diffuse and Elevated or Diminished: Can indicate processing incapacities.
- **Beta:** Related to activation and processing in the Cortex of the brain.

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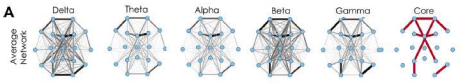
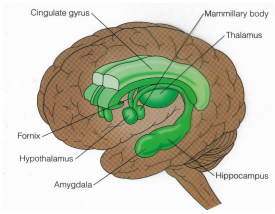


The Limbic System

Theta Frequencies

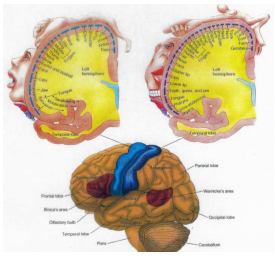
- The limbic system is below the cortex.
- It is considered the source of emotional activity.
- It is the major source of theta in a healthy brain.



Anatomy

Sensory Motor Rhythm: SMR

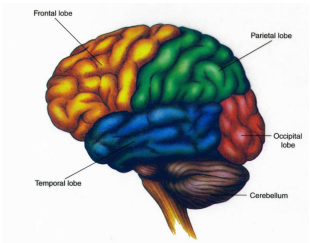
- When SMR (13-15hz) appears over the sensorimotor strip, the sensory flow from the thalamus to the cortex is reduced (gated) (Sterman & Bowersox, 1981).
- The body is calmed and the somatic system reduces in tone.
- The cortex is alert but not heavily processing.
- The sensorimotor strip is mapped to the body and can be trained locally.



The Brain: General Orientation

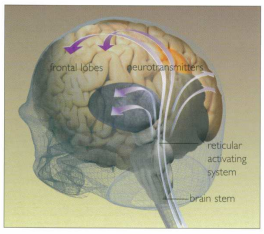
The Cortex and Beta Frequencies

- Frontal Lobes
  ST Memory Emotional Valencing
  Attention Emotional Inhibition
- Parietal Lobes
  Body Awareness Location
  Association Arousal
- Occipital Lobes
  Vision Arousal
- Temporal Lobes
  Memory Comprehension
  Major Convergence Zone
- Cerebellum
  Balance Motor Sequencing
- Brain Stem
  Primary Arousal Consciousness



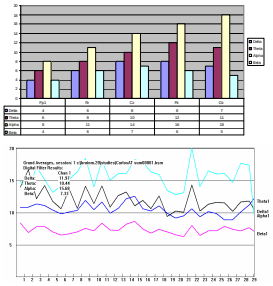
Delta & The Brain Stem

- The reticular activation system (RAS) adjusts basic arousal in the brain.
- The primary neuromodulator mechanisms are norepinephrine and acetylcholine.
- Delta reflects co-ordination between brainstem arousal system and frontal lobe salience networks.



The Normal Distribution

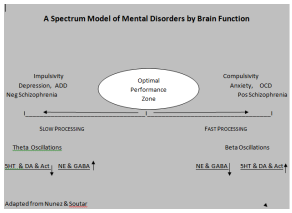
- In general there is a normal distribution or layering of brainwaves when the eyes are closed.
- Alpha is highest, then theta, then delta, then beta.
- Beta is about one half of alpha. Theta is about 2/3 of alpha.



This trainee is normalizing their delta theta layering (note theta increasing over alpha between 13 and 16 minutes..

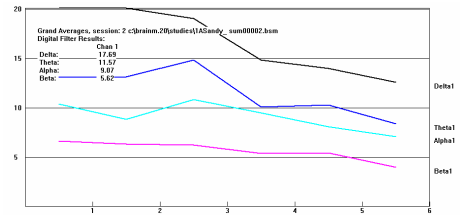
Optimal performance Zone Balancing The Brain

- The brain has an optimal performance zone.
- This zone is represented as the Normal Range in the figure to the right.
- If the brain operates outside this optimal zone and is too fast or too slow, then problems occur.

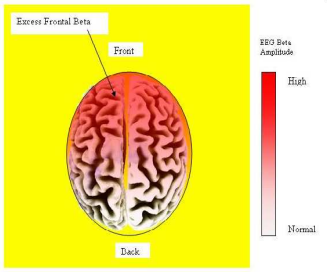


The Eyes Open Distribution

- The eyes open distribution is different from eyes closed.
- Delta is highest, then theta, then alpha, then beta.
- If the distribution is different, then it is abnormal and usually indicates something is wrong.



Brain Too Fast



The red shaded area shows the front of the brain as being overactive and producing too much beta. Common in Anxiety.

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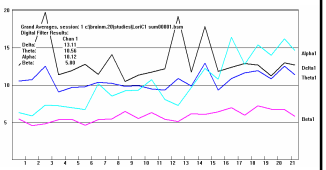
Abnormal Distribution

- When there is a disorder in the brain, the distribution becomes disturbed.
- Neurofeedback is designed to train the brain to a more normal distribution.
- The brain never completely returns to normal but adjusts for a closer approximation.

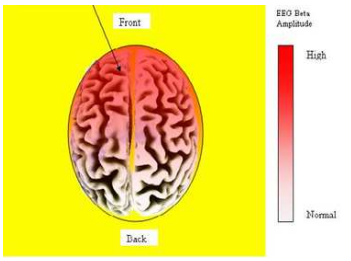
Anxiety Disorder With Low Alpha



Note how low this trainee's alpha (light blue) is at the start of the session. The alpha increases and the alpha to beta ratio (alpha/beta) improves over the training session. Delta and theta come closer to normal as well.

Brain Too Slow

Theta



The red shaded area shows the front of the brain as being underactive and producing too much theta. Common in ADHD.

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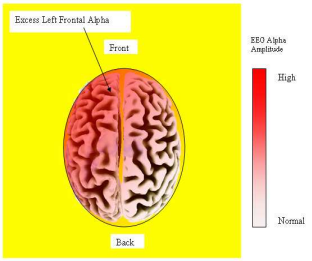
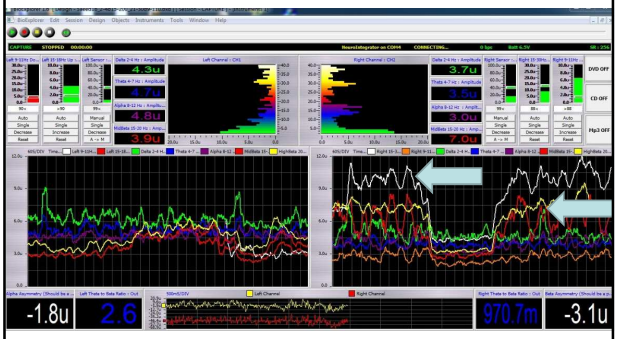
Brain Stuck: Avoidance & Withdrawal



The red shaded area shows the left front side of the brain as being inhibited and producing too much alpha. Common in Depression.[37]

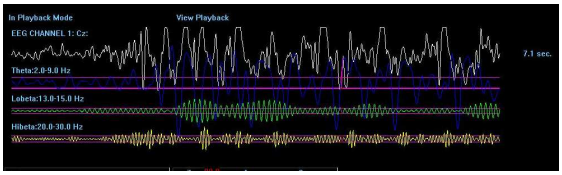
Beta Above 10uv: EMG

Clenching Teeth On The Right Side

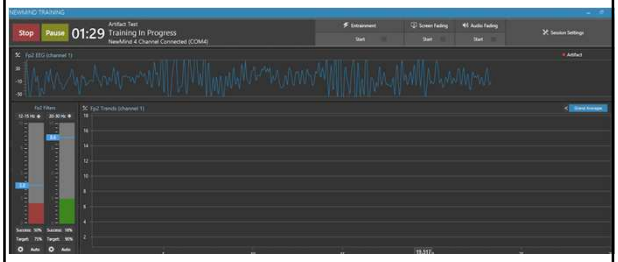


Instability

- With instabilities the whole brain may shift back and forth between too slow and too fast.
- The shift may be very rapid in a matter of seconds or very slowly over a period of months.

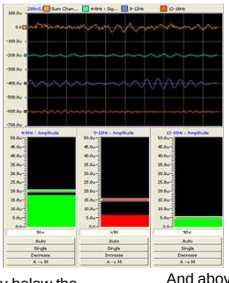


Clenching Teeth EEG Trace Image



Training Component Bands

We can train component bands up or down with neurofeedback to adjust the brains distribution.

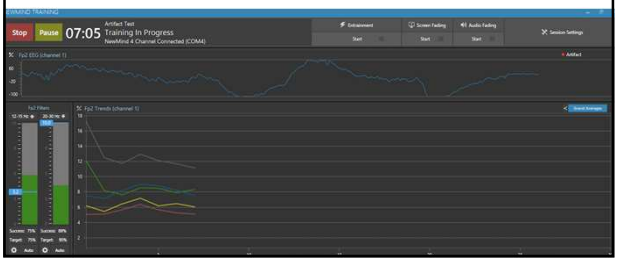


The client is trying to stay below the threshold line in theta,

And above the threshold line in beta.

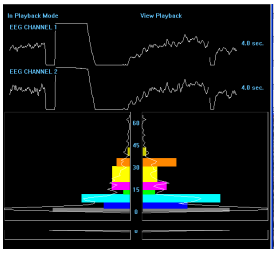
Eyes Closed: Eye Movement

- This is up and down eye movement.
- It inflates the average amplitude of delta.
- Have clients gently place a finger over each closed eye to monitor and control their eye movement.



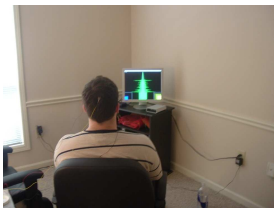
Amplifier Clipping

- When the signal gets to big from eye movement the amplifiers cut off and generate a square looking wave.



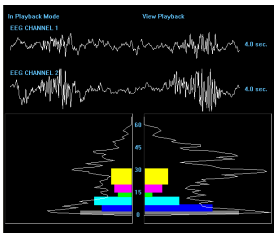
How do I conduct a session? Overview

- 1. Seat the client in front of the training screen.
- 2. Review how they are feeling and list their present symptoms.
- 3. Select the appropriate protocol for training.
- 4. Hook the trainee up.
- 5. Start up the training program.
- 6. Record a baseline if necessary.
- 7. Train the trainee for the recommended time period.
- 8. Record the results.
- 9. Disconnect the trainee.
- 10. Display the training results and encourage the trainee.



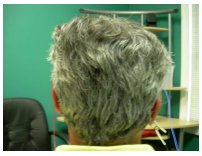
EMG Artifact

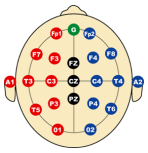
- T3-T4 is the most likely location to find muscle artifact.
- A large number of individuals with disorder clench their teeth.
- It is often impossible to stop this unconscious habit.



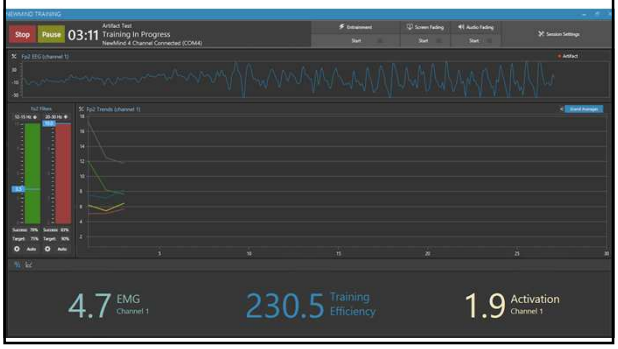
Hook the client up.

- Place the ground wire on one ear.
- Place the reference wire on the other ear.
- Be consistent in placing the same wire on the same ear at each session.
- Place the active leads on the designated training locations- such as F3-F4.
- Inspect the quality of the raw EEG to be sure the impedance is correct.



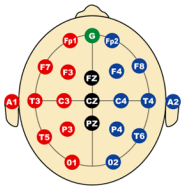


Shoulder Tensing Artifact



The 10-20 system is a co-ordinate system for the scalp

- Electrode placement is based on the 10-20 system.
- Protocols are described in terms of the 10-20 system.
- The 10-20 system is not based on neuroanatomy.



Prepping the skin

- Before placing an electrode at a site, the skin must be cleaned of oil and dirt.
- Use an alcohol swab and apply a small amount of Nu-prep (a mild abrasive).
- Gently scrub the area where the electrode is to be applied.

Determining a 10-20 location

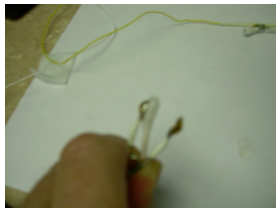
- One of the best ways to learn the 10-20 locations is to place an electrocap on a volunteer and use it as a reference to practice placing electrodes on a second volunteer.

Getting at the scalp

- Be sure to part the hair with the thumb and forefinger.
- You should be able to see the white of the scalp.
- Holding the hair in place with one hand scrub the white of the scalp.
- It is a good idea to hold the electrode lead in the hand scrubbing the scalp.

Disconnect the Client.

- Remove the electrodes.
- Wipe the electrode sites clean.
- Clean each electrode with the proper solution.
- Provide the trainee with a tissue to wipe their ears.



Applying Paste

- Paste conducts electrical impulses from the skin to the electrode.
- A plastic knife is often used to scoop paste from the jar.
- Apply a pea sized dab of paste to each electrode.
- Be sure to use a generous portion of paste.
- Gently press the electrode to the skin site until it sticks.
- Paste, not metal, should be touching the skin.

Training Protocols

Peer Reviewed Protocols

Protocols Supported by Peer Reviewed Journal Articles
According to Joel Lubar 2001 Workshop

Disorder	10-20 Site	Number Of Sessions	Protocol Enhance	Protocol Inhibit
ADD	Fz age 7-9 Cz age 10-15 Fz age 16-25 Fz age 26-50	30-40	16-20Hz 16-20Hz 16-22Hz 16-24Hz	4-8Hz 6-10Hz 6-10Hz 6-10Hz
ADHD	Cz or C3	20-30	12-15Hz	4-8Hz Or 6-9Hz
Seizure Disorder	Cz or C3	30+	12-15Hz	4-8Hz Or 6-9Hz
Disorders Dyslexia	P3 or P5	30+	beta	4-8Hz Or 6-10Hz
Dysphonetic Dyslexia	P3 or P5	30+	beta	4-8Hz Or 6-10Hz
Tourettes Syndrome Tic Disorders	Cz or C3	30+	SMR	4-8HZ
Anxiety Disorders	P4 or O2	Varies	alpha	beta
Depression	F3 & F4	20+	alpha F4 Or train ratio of alpha F4 to F3	alpha F3
OCD	AF4 or F4 P6	20+	alpha	beta
Insomnia (Sleep Onset)	Cz or Fz	Varies	theta	beta

Initially all protocols were based on clinical experience confirmed by research. The protocols to the left were reported in peer review articles as being effective. Over time, many clinicians began to use qEEG more often to determine protocols.

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Protocol Analysis- Network Analysis
Multivariate Nonparametric Weighting

Two worst networks selected for intervention.

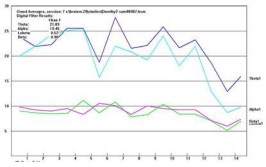
Protocol Number	Left Protocol	Right Protocol	Sites	Entrain. Freq.	Entrain. Color
17	2-7d 15-20u	2-7d 9-11u	O1/O2	10Hz	Green
2	4-7d 15-20u	4-7d 13-15u	F3/F4	18Hz	Yellow

Suggested Primary Z-Score Locations
O2
O1
F3
F4

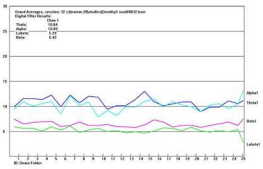
•Networks 7, 11, 12

Single Channel Training: Downtrain Theta Only
Acquisition & Consolidation Phases
Pre Post Seizure 40 sessions

Acquisition Phase



Consolidation Phase



Horizontal vs Vertical Domains of Training

- Horizontal focus is on limbic integration.
  Anxiety and Mood Stabilization.
- Vertical focus is on cognitive integration.
  Arousal relating to attention and memory.

Training one domain normalizes the compensating domain.

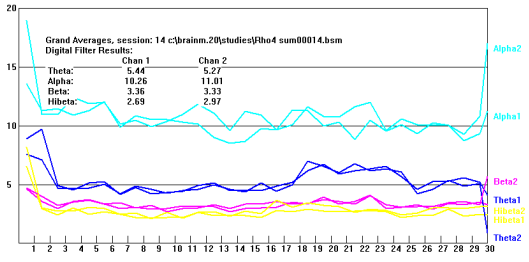
Asymmetry and Activation
Co-Occurring During Training

- As alpha and beta lines converge magnitude decreases globally and activation increases as activation values drop.

Avoid Training Labels

- There are mutliple qEEG subtypes of each DSM label ie ADHD, OCD etc.
- We discontinued training labels a decade ago.
- We train networks based on statistical analysis of dysregulated electrical activity.
- We choose locations based on a statistically derived hierarchy of neurophysical dysregulation.
- We track changes empirically, both quantitatively and qualitatively with trend screens, pre-post qEEG and client symptom trackers.

Two Channel Bilateral Training



LH Beta Up, Alpha down, High Beta Down

RH Lo Beta up, Beta down, High Beta Down

Normal EEG Amplitudes

Eyes Open- Dorsal
- Delta- 12uv
- Theta- 10uv
- Alpha- 9uv
- Beta- 5uv

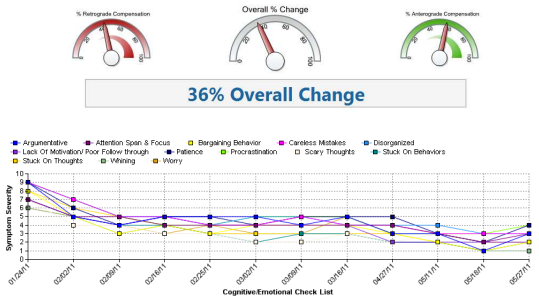
+/- 30%

Eyes Closed- Dorsal
Alpha- 12
Theta- 10
Delta- 9
Beta- 6
+/- 30%

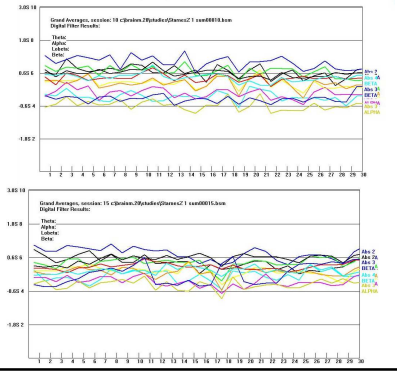
Ventral – Reduce above values by 30-40%

These Are Rough Estimates

Tracking Symptom Changes



Z Score Training: 4 Channel

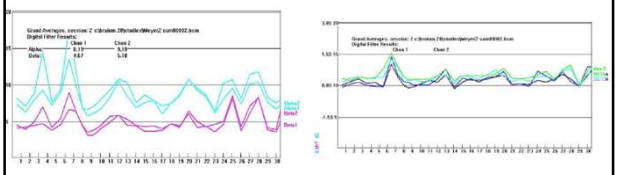


Training Template: Phase 1

- Train Mood first- 15 sessions Horizontal Domain.

Usually Frontal Sites (F3-F4) with asymmetry type of protocol.
Symptoms improve around session 6-10.
Clients may begin dreaming, feel agitation, show irritability and have difficulty sleeping session 10-15.
Integration period may last up to 2 weeks.
Measure changes with symptom tracker and ISI.
Begin Training posterior site for overarousal and anxiety next.
It integration continues with anxiety then PTSD Likely- Use AT.

Training Symmetry vs Z Score



Amplitude Asymmetry

Z Score

Training Template: Phase 2

Train Anxiety Second- 10-15 sessions.

Usually Posterior sites O1-O2 with Asymmetry type protocol.
Anxiety decreases around session 20-30.
May require additional training.
Measure Change with symptom tracker and ISI.
Clients develop insights into behavior and circumstance.
Clients emit novel behaviors that shift locus of control.
Self-awareness increases around ineffective behaviors.
Energy improves and clients are less reactive when challenged.
If unresponsive shift to AT training.
Train Cognitive next.

Training Template: Phase 3

Train Cognitive Function-10-20 sessions.

Usually Frontal sites Fp1-Fp2 or Temporal sites T5-T6 with bi-hemispheric slow wave inhibit. Track with symptom tracker and CPT tests. Number of sessions should be based on CPT changes.

Brainmapping
The Importance of Assessment

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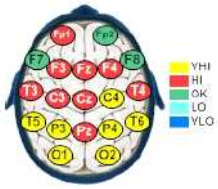
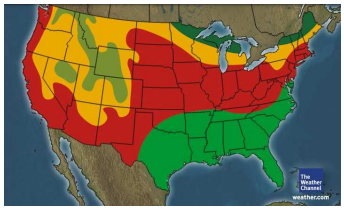
For PTSD Use AT Training 30 Sessions or More

Where is the problem? Let the Brain Map identify.





The brain map is much like a weather map in that it provides us with information about what frequencies or component bands are high or low at different locations.

A powerful tool for treatment planning

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External Factors Interfering With Biofeedback Training

- Poor Sleep
- Poor Diet
- Lack of Exercise
- Physical Trauma
- Mental Trauma
- Trauma Inducing Social Environments
- Trauma Inducing Physical Environments

qEEG Mapping Procedure

Benefits:

- Passive Assessment of Brain Function
- Non-Invasive
- Accurate and Reliable
- Painless
- Widely Used In Brain Research

Making a diagnosis supported by biological measures

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Brain Map Interpretation

Problem Areas are BLUE, RED or YELLOW.

Normal Areas are GREEN.

Skills in selecting treatments that affect client biology

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Cognitive Emotional Questionnaire

Presenting Symptoms - Child - MiniQ

0 = None 1= Mild 2 = Moderate 3 = Severe

1	0	1	2	3	Short Attention Span & Focus
2	0	1	2	3	Lack Of Motivation/ Poor Follow Thru
3	0	1	2	3	Procrastination/Puts Things Off
4	0	1	2	3	Difficulty With Decisions
5	0	1	2	3	Daydreams Or Spaces Out
6	0	1	2	3	Careless Mistakes
7	0	1	2	3	Easily Distracted
8	0	1	2	3	Disorganization/Forgets & Loses Things
9	0	1	2	3	Socially Inappropriate
10	0	1	2	3	Poor Judgment
11	0	1	2	3	Poor ShortTerm Memory
12	0	1	2	3	Constant Worry
13	0	1	2	3	Sensitive To Light & Noises
14	0	1	2	3	List Learning Problems
15	0	1	2	3	Angry & Aggressive
16	0	1	2	3	Emotional Outbursts

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Matching Symptom to Location

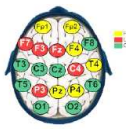
Correlating Map Co-Ordinates With Area Functions

SITE	BRODMANN AREA	FUNCTION
Fpz	10, 11, 32	Emotional Inhibition Oversensitive, Impulsive Motivation & Attention
Fp1	10, 11, 46	Cognitive Emotional Valencing- Lateral Orbital Frontal Irritability, Intrusive, Depression Social Awareness- Approach Behaviors
Fp2	10, 11, 46	Emotional Inhibition- Lateral Orbital Frontal Impulsivity, Tactlessness, Mania Social Awareness- Avoidance Behaviors
F7	45, 47, 46	Working Memory- Visual & Auditory Divided & Selective Attention- Filtering Broca's Area- Semantic Short Term Buffer (Word Retrieval)
F8	45, 47, 46	Prosody Working Memory- Spatial & Visual, Gestalt Facial Emotional Processing Sustained Attention
F3	8, 9, 46	Short Term Memory- Verbal Episodic Retrieval Facial Recognition, Object Processing Planning & Problem Solving- Wisconsin Card Sort (rigidity)
F4	8, 9, 46	Short Term Memory- Spatial/Object Retrieval Vigilance Area- Selective & Sustained Attentional Area
Fz	8, 6, 9	Personality Changes Intention & Motivation- Poverty of Speech, Apathy Possible Anterior Cingulate- Internal vs External Attention Basal Ganglia Output
C3	3, 1, 4	Sensory & Motor Functions
C4	3, 1, 4	Sensory & Motor Functions
Cz	6, 4, 3	Sensory & Motor Functions

Based on well researched experimental findings

Client Symptom Endorsements Ranked by Category

CEC Response Assessment



Category	Response Count	Average Response
Anxiety	12	2.25
Depression	7	2.57
Impulsive	6	2.00
Attention	6	1.67
Memory	2	1.50

CEC Responses

Answer	Question
3	Poor Judgment
3	Constant Worry
3	Angry & Aggressive
3	Emotional Outbursts
3	Restless/Impatient/Easily Frustrated
3	Argumentative
3	Oppositional
3	Verbally Impulsive/ Talks Rapidly
3	Acts Out of Control
3	Scary Thoughts
3	Whines Excessively
3	Stuck On Thoughts
3	Stuck On Behaviors
3	Bargains Constantly

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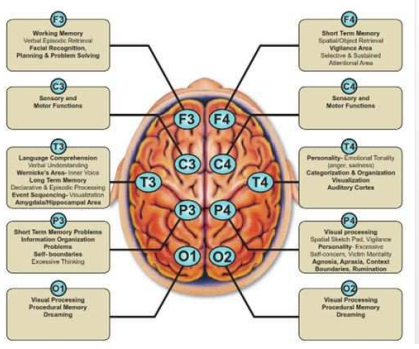
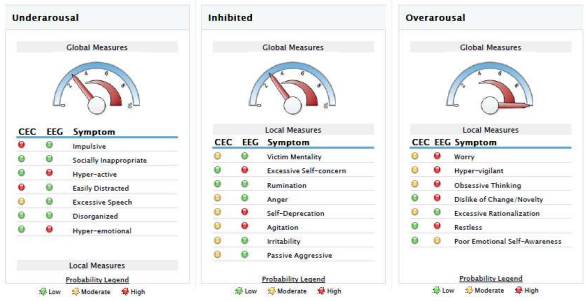
10/20 Brodmann Correlations



Symptom Location Correlation



Understanding the psychobiological basis of clinical behaviors

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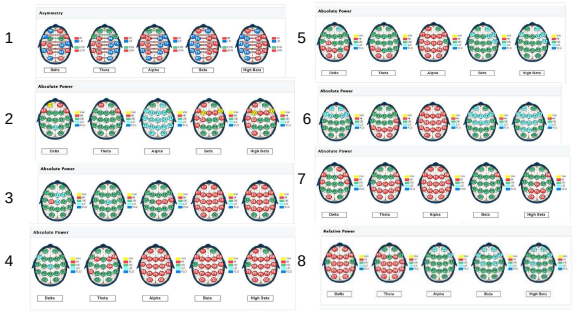
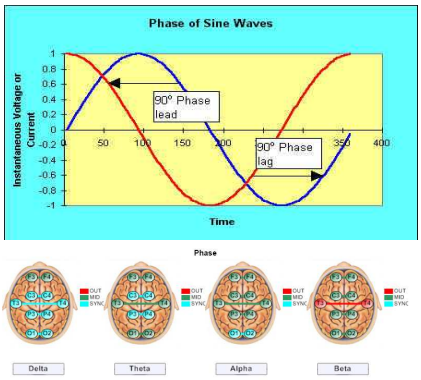
Stages of Oxidative Stress Cycle

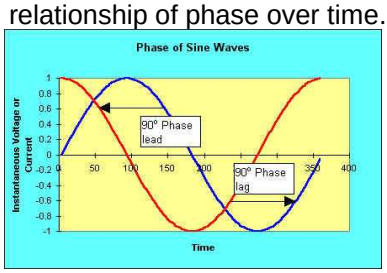


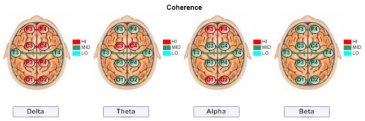
Phase is the relationship between waves at two locations.



Dimensions of qEEG Analysis

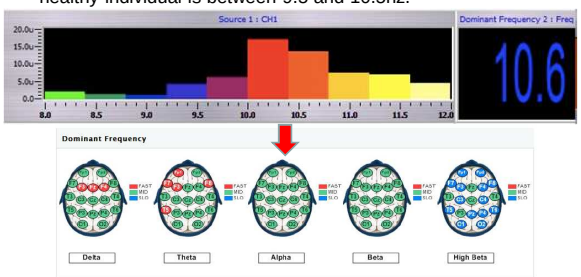
Coherence is about the consistent relationship of phase over time.





Dominant Frequency

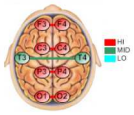
- Dominant frequency is determined by computing which frequency band in a given component band contains the most power.
- In the Alpha component band of 8-12hz, the peak frequency of a healthy individual is between 9.5 and 10.5hz.



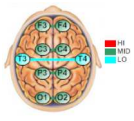
Connectivity

- A map can also tell us how well connected different areas of the brain are compared to a normal level of connectivity.
- This level of connectivity is known as coherence.
- Red indicates too much connectivity usually resulting in lack of flexibility.
- Blue indicates too little connectivity indicating too much flexibility.
- In either case communication between brain locations is poor.

Abnormal

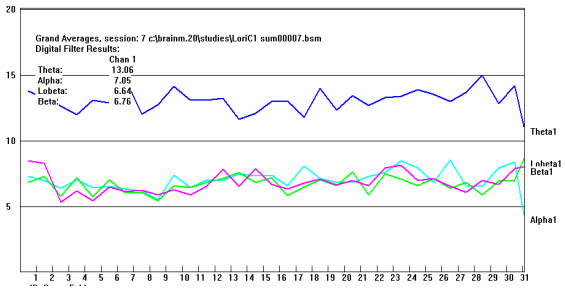


Normal



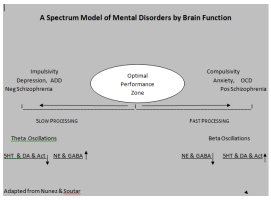
Brain Too Fast

- Anxiety appears as low alpha or high beta..

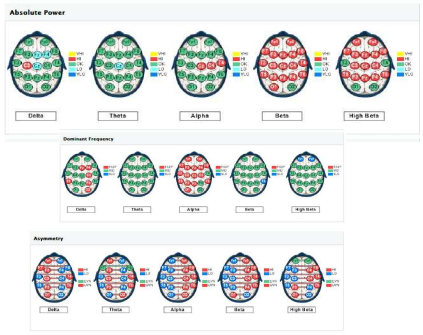


Arousal Level & Disorder Stratification

- **Brain Too Fast: Beta**
  Anxiety, OCD, Mania, Worry
- **Brain Too Slow: Alpha**
  Depression, Lethargy, Fibromyalgia, Hypothyroid, Toxins, Hepatic Issues, Drug Burnout.
- **Brain Very Slow: Theta**
  ADHD, Head Injury, Toxic Encephalopathy, Cortical Damage
- **Brain Extremely Slow: Delta**
  TBI, LD, Dementia, White Matter Damage.



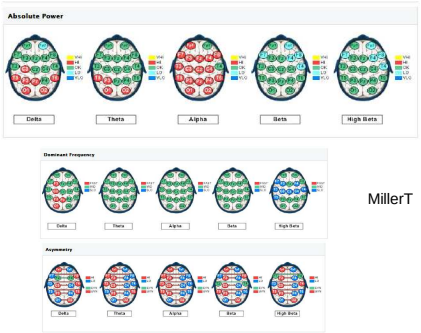
Chronic Anxiety



Stages of Adaptation & Consolidation

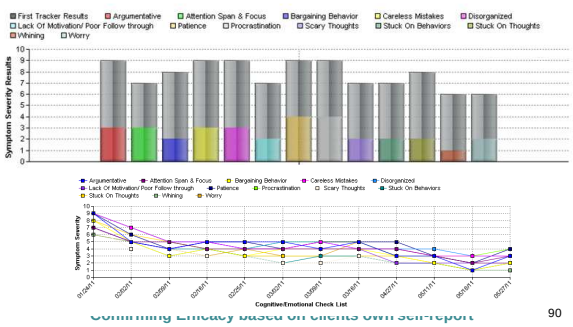
Successive Maps Show Increasing Anterograde and Decreasing Retrograde Z score Changes

Depression



MillerT

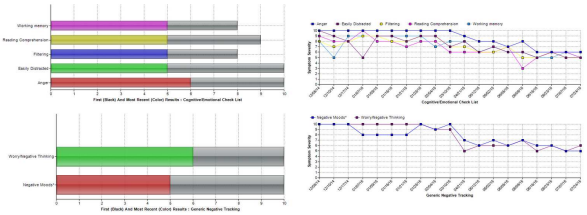
Symptom Changes are Tracked Over Time



Confirming Efficacy based on clients own self-report

Prepping Clients For Change

Change is gradual
Backsliding is due to Metabolics or Retraumatization



Neurofeedback Case Examples

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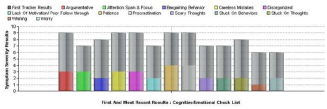
Best Measure of Success

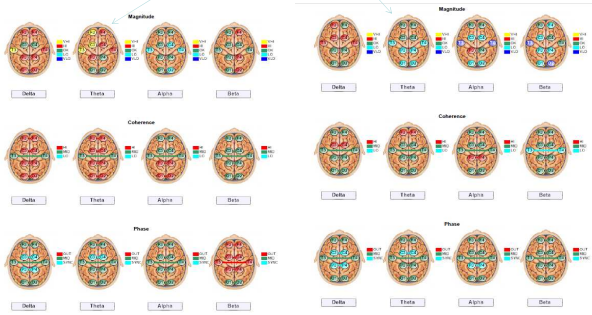
- Have the symptoms reduced?



- Do you have 30-40% Overall Change

Pre Post ADHD: 40 Sessions

Significant Theta Reduction



Inhibit Theta Using Two Channel Protocol #2

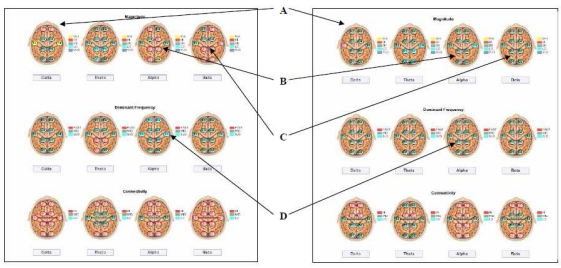
Cog Testing

Cognitive Performance Testing (CPT)

Expanded View | Close Report | Download Report

Cognitive Performance Test	Client Score	Lowest Score	Average	Best Score	Below Average Range	Average Range	Above Average Range
Attention	99	70	90	100	< 85	85 - 95	> 95
Short Term Memory	8	5	7	9	< 6	6 - 8	> 8
Working Memory	5	5	7	9	< 6	6 - 8	> 8
Sequential Memory	6	6	10	14	< 8	8 - 12	> 12
List Acquisition	58	55	65	84	< 60	60 - 70	> 70
Episodic Memory	5	4	6	9	≤ 5	5 - 7	> 7
Spatial Sorting	31	11	28	45	< 23	23 - 33	> 33

Pre-Post Depression: Alpha Asym Training



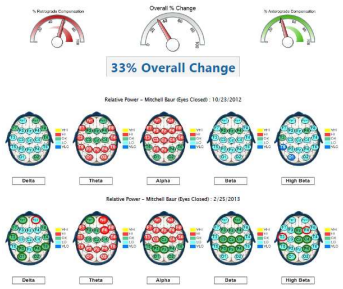
Reduced frontal delta improves socio-emotional processing **A**. Reductions in alpha correlate with reduced depression. **B**. Lower beta amplitude correlates with reductions in anxiety **C**. Increased alpha frequency into normal range correlates with improved energy and metabolic functions **D**.

Map Color Key: Red is too high, Blue is too low, Grey is okay

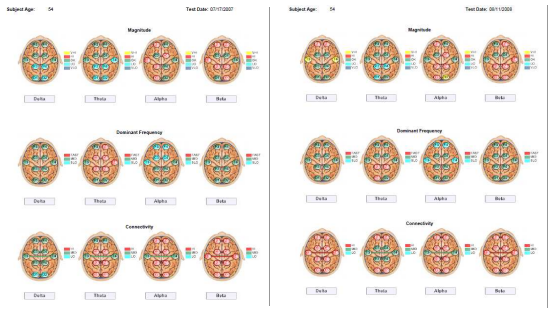
8 Year Old: Pre Post Map

30 Sessions
Improved Sleep
Better Concentration
Emotional Stabilization

Temporary Suspension of NFB to focus on metabolics.

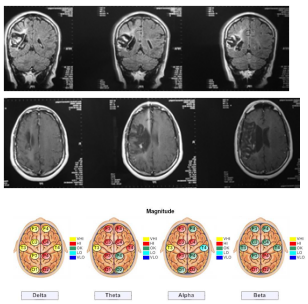


Pre Post 1 Year NFB Marital Discord



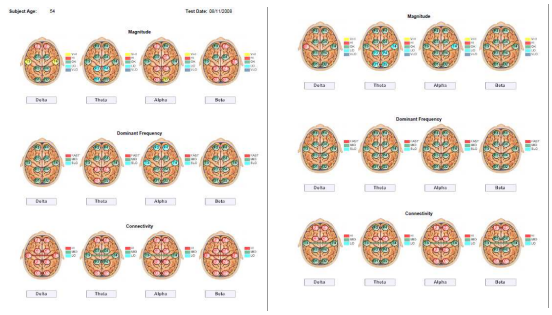
Using Maps to Measure Network Activity

- Magnitude can measure cortical activation.
- Reduced cortical activation indicates reduction of function or damage.
- Magnitude indirectly measures synchrony at the micro level.



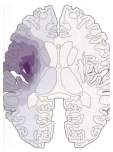
Magnitude reflection of damage due to stroke: Note Elevated Delta & Theta

Pre Post 1 Year NFB Marital Separation

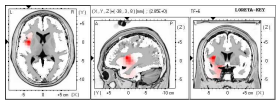


Lesions & Network Degredation

- Over a century of lesion studies in neurology provide insights to what occurs when network nodes are damaged.
- Provides insights to network characteristics.
- Provides insights to functional connectivity.

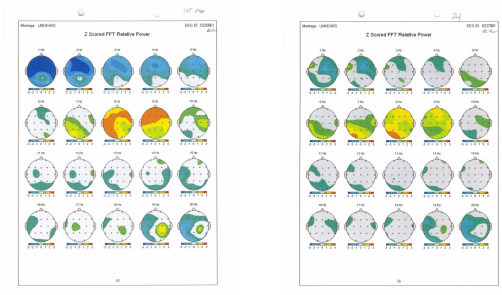


Avg 25 Stroke Patients With Speech Articulation Problems

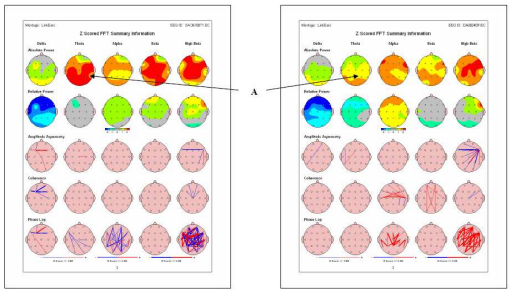


LH Stroke Client- Insular Cortex

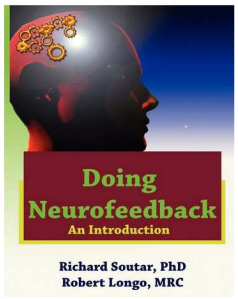
2hrs vs 8hrs Sleep



Monitoring Dietary Changes
Pre Post Maps: Gluten Free Diet



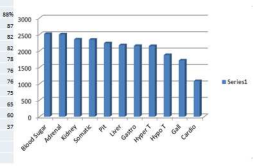
Seizure Disorder: Nine Months On Gluten Free Diet- No Seizures



Metabolic Limits To Training

Clinical Sample of Metabolic Symptom Reports
From 300 U.S. Clinics
(N=2848) New Mind Database

	N=	Mean	SD	%	
Blood Sugar	2515	16	15.8	88%	
Adrenal	2502	18	14.6	87	
Kidney	2348	15	10	82	
Somatic	2342	18	16	82	
Pit	2232	14	6.7	78	
Liver	2173	16	14	76	
Gastro	2152	17	14.7	76	
Hyper T	2147	12	9.5	75	
Hypo T	1876	12	9	65	
Gall	1710	12	10.6	60	
Cardio	1082	13	10	37	
Total N=2848					



How Is This Effecting Neurofeedback?

Metabolic Confounds