Neurofeedback Basics
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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.

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.

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.

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.

Involuntary Learning
• Self-regulation and a voluntary control of electromyographic brain potentials using mental computational and motor imagery strategies improve the self-regulation of a range functional brain tasks between children and adults and the self-regulation of different tasks within the same task. The mechanisms of self-regulation of brain tasks include the use of visual and auditory feedback, often referred to as “self-monitoring,” and the use of self-talk and self-instructions (Dienes & Taylor, 2008)
How long does it take?

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

Reduction In Symptoms Over 4 Month Period.

When do clients begin to feel better?

Each individual responds differently to neurofeedback. Their sensitivity varies.

- 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.

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

MRI Research & Neurofeedback

Changing Function of the Brain

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

- Functional magnetic resonance imaging (fMRI) study was used to measure the effect of neurofeedback training on the neural bases of selective attention and response inhibition. Twenty unmedicated ADHD children participated in this experiment. Fifteen children who showed normal performance and 5 children who showed impaired responses to the attention-demanding tasks were randomly assigned to the experimental group (EXP) and the control group (CON), respectively. The EXP children were trained to enhance the amplitude of the 12-15 Hz beta activity and decrease the amplitude of the theta activity (4-7 Hz). Subjects from both groups were scanned one week before the beginning of the training (Time 1) and one week after the end of the training (Time 2). A 4x4 factorial design, with Time (T) and Group (G) as factors, was used. The results showed that the EXP group had a greater increase in activation in the right anterior cingulate cortex (ACC), left caudate nucleus, left substantia nigra, and prefrontal cortex, compared to the CON group. These results suggest that neurofeedback training has the capacity to functionally normalize the brain systems mediating selective attention and response inhibition in ADHD children.

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Success Rates

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

- Improved Behavior
- Improved School Performance 1-2 grade levels
- Increase IQ by 5-15 points
- Reduced Medications. (Hammond, 2006)

What Are Brainwaves?

Brainwaves

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.

Neurons in the cortex generate electrical activity from synaptic interaction.

EEG is from the summated pre and post synaptic potentials in the cortex
Synapses generate electrical fields called dipoles

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.

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.

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.

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.
Component Bands & Function

- **Delta:** Related to sleep, brain stem and autonomic functions. Also Fissural 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.

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

The Brain: General Orientation

- **Frontal Lobes:** ST Memory, Emotional Valencing, Attention, Emotional Inhibition
- **Parietal Lobes:** Body Awareness, Association, Location, Annual
- **Occipital Lobes:** Vision, Arousal
- **Temporal Lobes:** Memory, Comprehension, Major Convergence Zones
- **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 coordination between brainstem arousal system and frontal lobe salience networks.

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 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.

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.

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.

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.

Brain Too Fast

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

Brain Too Slow

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

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.

Training Component Bands

We can train component bands up or down with neurofeedback to adjust the brain's distribution.

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.

Beta Above 10uV: EMG

Clenching Teeth On The Right Side

Clenching Teeth EEG Trace Image

Eyes Closed: Eye Movement Image
Amplifier Clipping

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

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.

Shoulder Tensing Artifact

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.

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.

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.

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.

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 paste to the skin site until it sticks.
• Paste, not metal, should be touching the skin.

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.

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.

Training Protocols

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

www.neurodynamictraining.com
Protocol Analysis - Network Analysis
Multivariate Nonparametric Weighting

Two worst networks selected for intervention.

- Networks 7, 11, 12

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.

Avoid Training Labels

- There are multiple 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.

Asymmetry and Activation Co-Occurring During Training

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

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

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.
  If integration continues with anxiety then PTSD Likely - Use AT.

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

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

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

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
Problem Areas are **RED** or **YELLOW**.

Normal Areas are **GREEN**.

Skills in selecting treatments that affect client biology

**Brain Map Interpretation**

Matching Symptom to Location
Correlating Map Co-Ordinates With Area Functions

Based on well researched experimental findings

**10/20 Brodmann Correlations**

**Cognitive Emotional Questionnaire**

Presenting Symptoms - Child - MiniQ

**Client Symptom Endorsements Ranked by Category**

**Symptom Location Correlation**

Understanding the psychobiological basis of clinical behaviors.
Stages of Oxidative Stress Cycle

Phase is the relationship between waves at two locations.

Dimensions of qEEG Analysis

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.
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

- 30% Overall Change
- 32% Overall Change
- 22% Overall Change

Depression

Symptom Changes are Tracked Over Time
Prepping Clients For Change

Change is gradual
Backsliding is due to Metabolics or Retraumatization

Best Measure of Success

• Have the symptoms reduced?

• Do you have 30-40% Overall Change

Cog Testing

Neurofeedback
Case Examples

Pre Post ADHD: 40 Sessions
Significant Theta Reduction

Pre-Post Depression: Alpha Asym Training
8 Year Old: Pre Post Map

30 Sessions
Improved Sleep
Better Concentration
Emotional Stabilization
Temporary Suspension of NFB to focus on metabolics.

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

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.

Pre Post 1 Year NFB Marital Discord

Pre Post 1 Year NFB Marital Separation

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

How Is This Affecting Neurofeedback?

Metabolic Confounds