Neurofeedback:
Engaging the Brain Directly

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Conlifict of Interest Disclaimer

I have no business relationships with any of the people or organizations referenced in this presentation and have received no commercial support for its creation.

I don’t even stand to gain monetarily from my own solo efforts here, since my schedule is full and I can’t take any referrals for neurofeedback right now.

Learning Objectives

Participants will be able to:

1. Describe the basic conceptual mechanism (operant conditioning) and practical application (biofeedback using real-time EEG data) of neurofeedback in a clinical setting.
2. List potential benefits (optimization of patterned electrical activity in the brain) of using neurofeedback to address various psychological/neuropsychological symptoms.
3. Identify peer-reviewed research assessing the effectiveness of neurofeedback and secondary sources synthesizing this information for clinical use, using suggested basic readings and extensive topical bibliography.

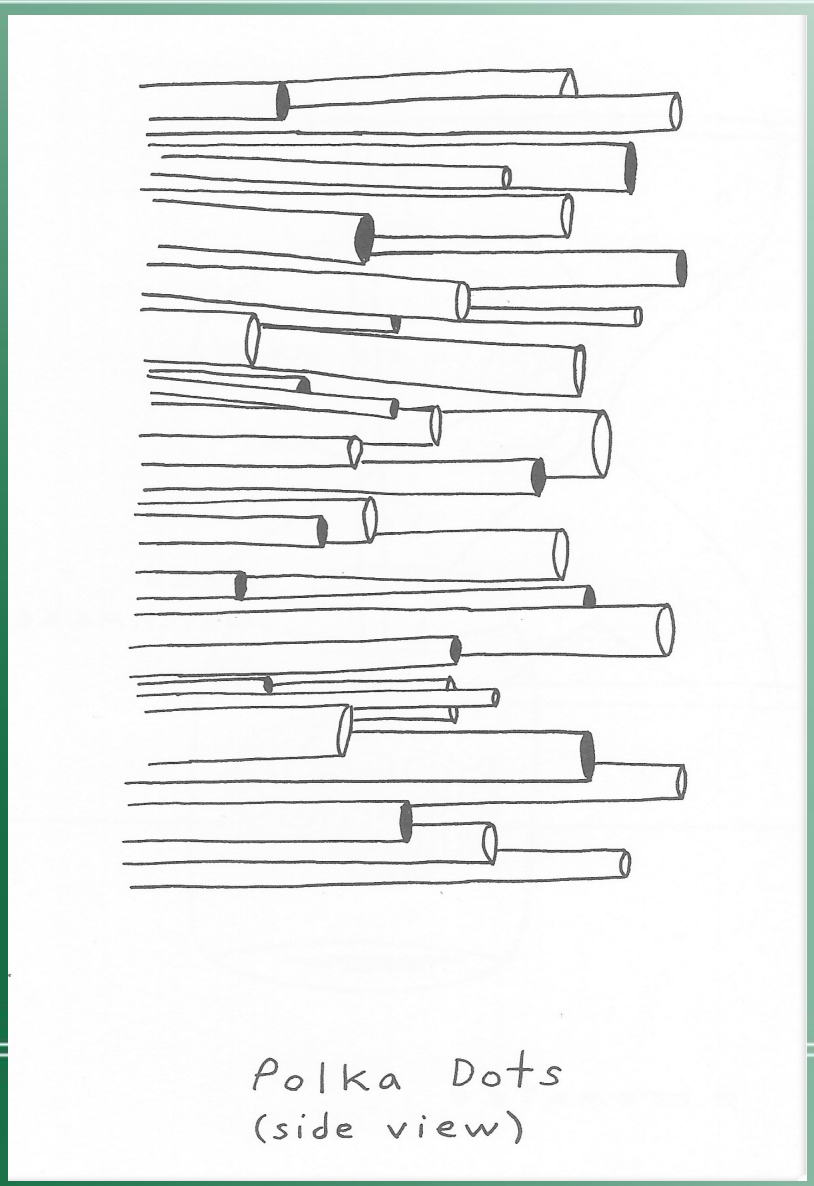
UNBELIEVABLE!

- Outrageous claims seem too good to be true
- Conditions favorably impacted by NFB:

  epilepsy, migraines, depression, anxiety/panic, PTSD, developmental trauma, OCD, ADHD, ASD, insomnia, mood instability, cognitive decline, addictions, chronic pain, brain injuries, learning disabilities, peak performance, and more
- Brain function is fundamental to all of these, and brain activity is as much electrical as it is chemical

Familiar Thing from an Unfamiliar Angle

***image from Martin (2013),* Point Your Face at This**



Curiosity Leads to Unexpected Discoveries

- My first exposure to NFB as a skeptic
- Suspicions of placebo effect hard to maintain without preconceived expectations of effects

- NASA, Sterman's cats, and a surprising connection
- The first NFB treatment

It all began with sleeping cats...

Certainly not a cure-all, but...

"The literature, which lacks any negative study of substance, suggests that [neurofeedback] should play a major therapeutic role in many difficult areas. In my opinion, if any medication had demonstrated such a wide spectrum of efficacy, it would be universally accepted and widely used. It is a field to be taken seriously by all."

– Frank Duffy, MD, Head of Neuroimaging Department and Neuroimaging Research at Boston Children's Hospital, *Clinical EEG* (2000)

Still not mainstream, but...

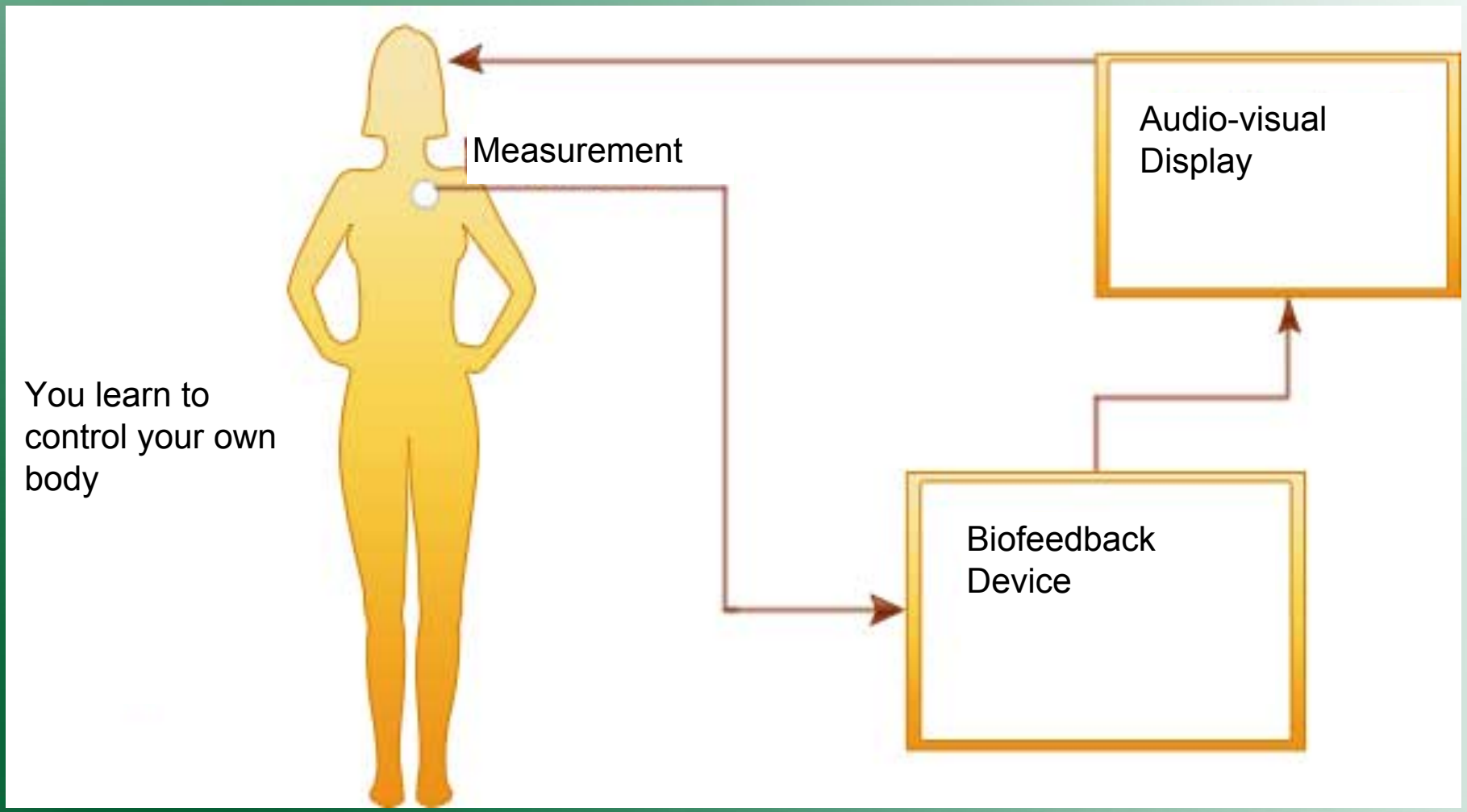
In a special issue of *Child and Adolescent Psychiatric Clinics of North America* (2005), the guest editors (2 psychiatrists and 1 psychologist) stated that, according to the American Academy of Child and Adolescent Psychiatry criteria for rating evidence-based treatment strategies, NFB meets the Clinical Guideline for treating ADHD, seizure disorders, anxiety (OCD, GAD, PTSD and phobias), depression, reading disabilities and addictions.

Biofeedback

- Electronic technology provides information normally unavailable to the trainee, allowing for monitoring and influence of physiological processes otherwise unknown and therefore beyond control
- Examples: sensors may detect heart rate, muscle tension, skin temperature or microscopic sweating, any of which can be brought under deliberate control with the help of feedback

Biofeedback Visualized

image from Institute for Applied Neuroscience, Asheville, NC



Neurofeedback is Brainwave (EEG) Biofeedback

- Sensors monitor brainwave activity, just like EEG
- Computer translates live signal into audio-visual display, telling trainee when brainwave patterns shift in desired direction
- Like children's game of hiding something and telling searcher they're getting “hotter” or “colder”
- With proper feedback and lots of practice, people can actually learn to change their brainwaves!

Operant Conditioning in Biofeedback

- Rewards (intrinsic or symbolic) encourage specific changes, providing motivation to use feedback to gain control over physiological process being monitored
- Trainee may be unable to articulate how influence is exerted because CNS responds to intention in ways that are automatic and outside awareness
- Learning paradigm maximizes sense of mastery and yields results lasting beyond training period

Like riding a bicycle...

- Most of the learning occurs outside awareness
- Once learned, the skill is yours to keep

Brainwaves

- Electrical dimension of brain activity reflecting firing patterns of large groups of neurons
- Categorized according to frequencies in hertz (cycles per second):

Delta (less than 4 Hz)

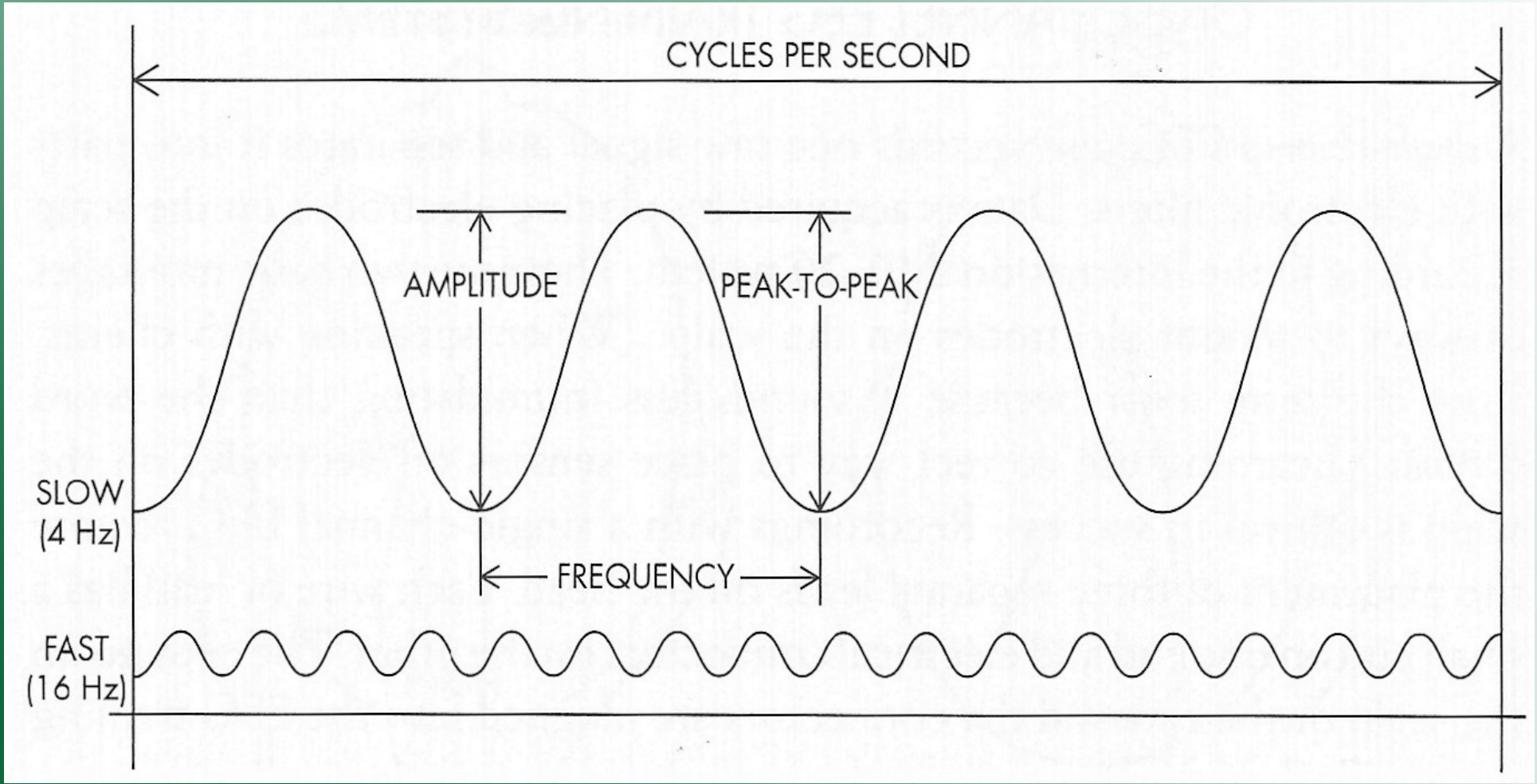
Theta (4-8 Hz)

Alpha (8-12 Hz)

Beta (12-38 Hz) subdivided - SMR, Beta, High Beta

Brainwave Features

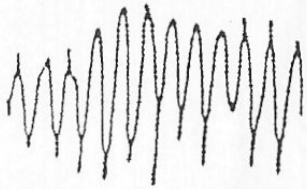
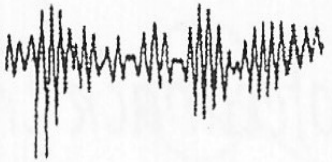
***image from Demos (2005),* Getting Started with Neurofeedback**



Brainwave Types

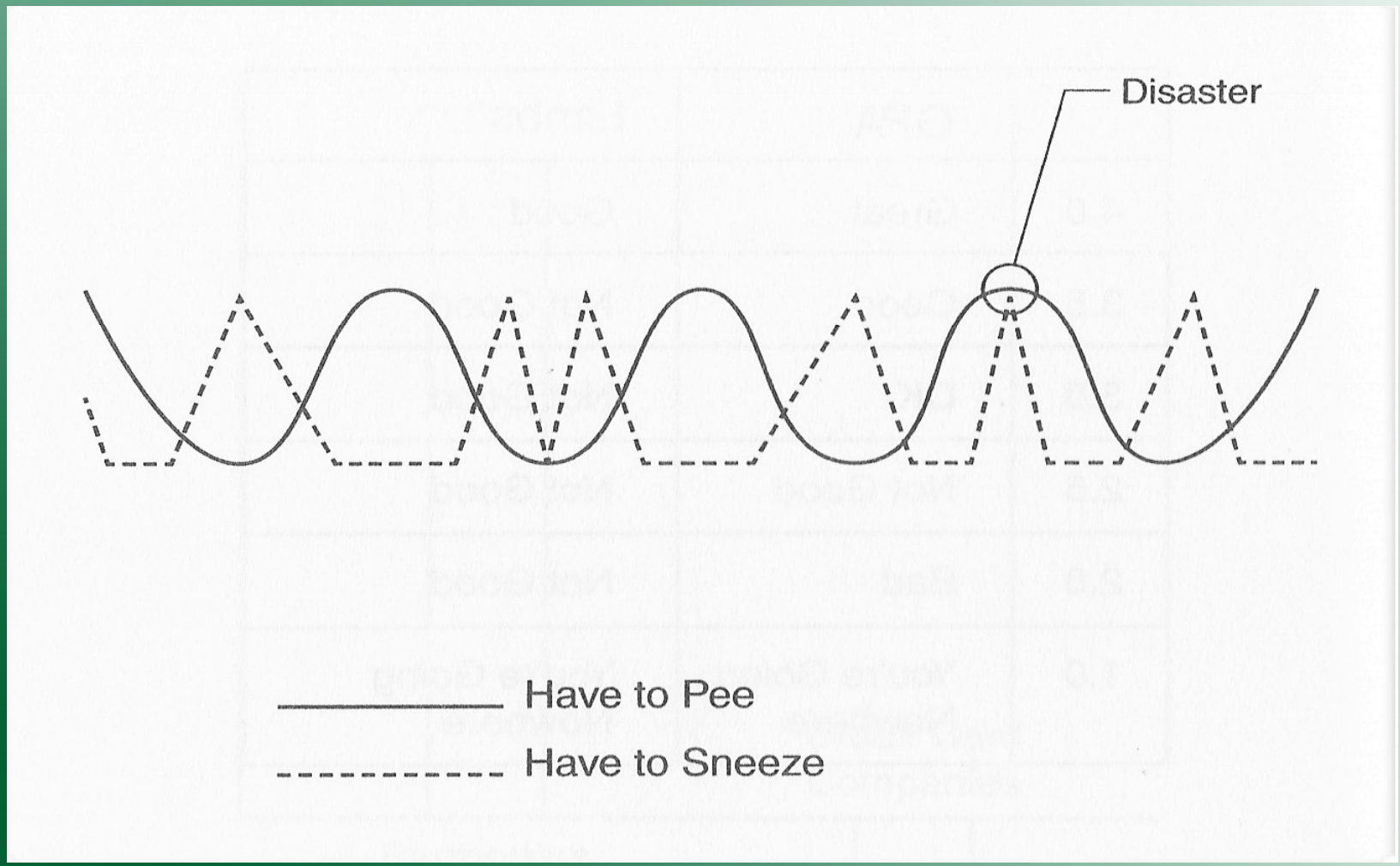
***image from Hill & Castro (2002),* Getting Rid of Ritalin**

cps = cycles per second, or Hertz

DELTA Less than 4 cps	THETA 4–8 cps	ALPHA 8–12 cps	SMR 12–15 cps	BETA 15–18 cps	HIGH BETA more than 19 cps
Sleep	Drowsy	Relaxed Focus	Relaxed Thought	Active Thinking	Excited
					

Waves Occur Together

***image from Martin (2011),* This is a Book**



Frequency, Amplitude and Proportion

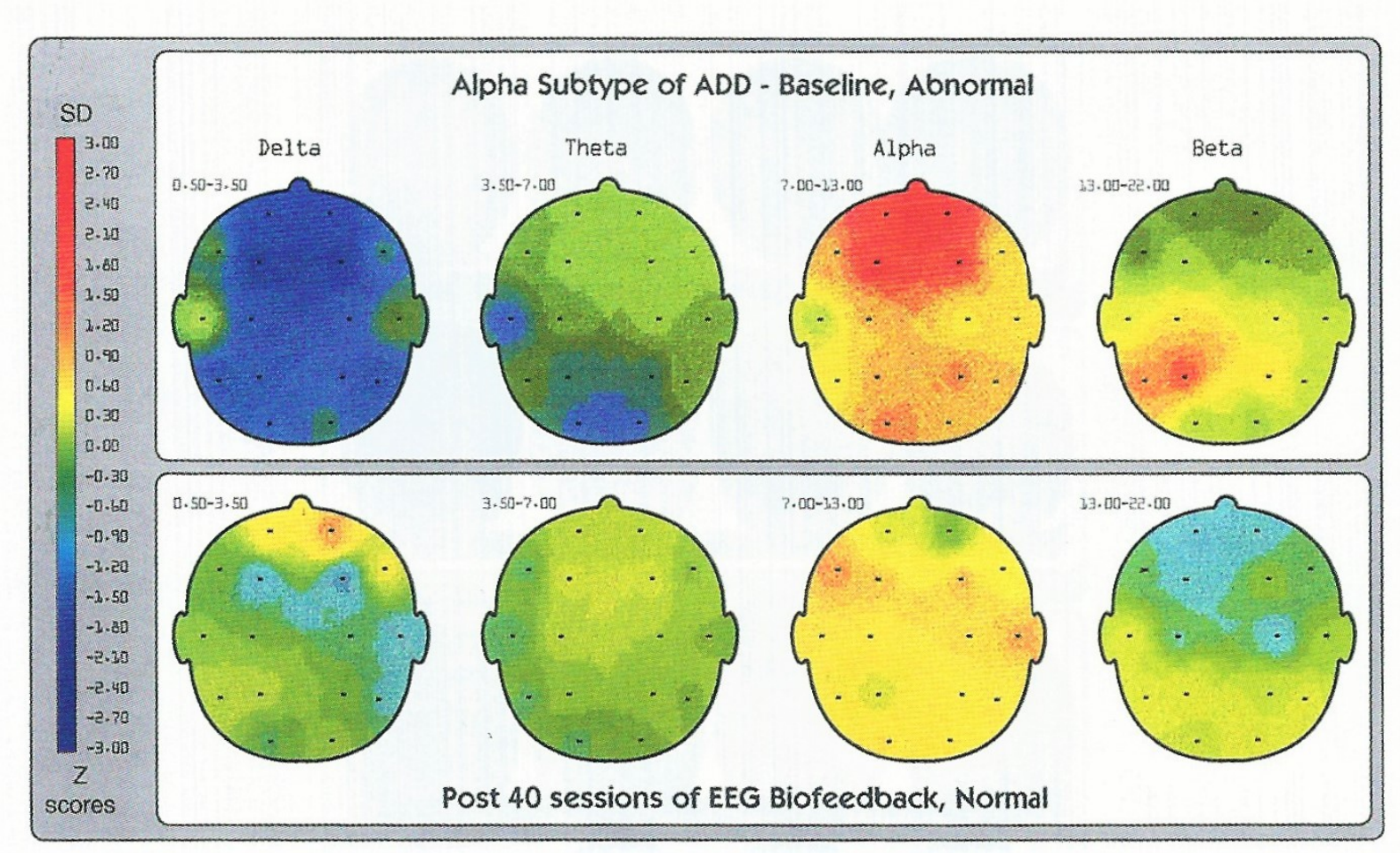
- Frequency related to level of arousal
- Amplitude related to prevalence of frequency
- All frequencies present, but in varying proportions at different locations
- Normative databases suggest how much (amplitude) of each frequency should be present at each location, and how similar different locations should be to each other

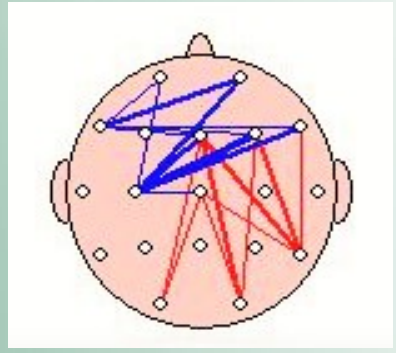
Quantitative EEG (qEEG)

- Regular EEG data run through sophisticated computer analysis – basis of normative databases and individual brain mapping
- Maps show degree, location and type of deviations:
  - Too much or too little (amplitude) of a particular frequency at a particular location
  - Too much or too little similarity between locations

qEEG Brain Map

***image from Demos (2005),* Getting Started with Neurofeedback**





Problem Areas

- Symptoms can be associated with abnormal brainwave patterns
- Based on neuropsychological understanding and/or correlations found in qEEG-based research
- “Diagnosis” in NFB based on brainwave activity, which may not coincide with standard psychiatric diagnostic categories

Facilitating Change

- Problematic brainwave pattern identified with objective measurements or hypothesized on basis of symptom profile
- Desired shift specified (e.g., less theta at location X)
- NFB equipment set to measure relevant activity and reward desired shift
- Brain notices rewards for certain random fluctuations and starts shifting in that direction more "deliberately," exercising *self-regulation*

Establishing New Pattern

- Initial shifts only fleeting and difficult to achieve
- Over time, shifting comes more quickly and easily as brain learns to reliably modify relevant pattern
- Eventually, baseline can change
- May represent normalized proportion of frequencies, improved flexibility or stability, or optimized coordination between locations
- Symptoms improve as self-regulation increases

Like lifting weights...

- Strength training doesn't make you go around lifting heavy things all the time, but when you need to, you can do it
- NFB expands the brain's repertoire of options, allowing it to do what it needs to do, when it needs to do it
- Seamless process; trainees often notice changes only in retrospect

Apparatus and Procedure

- Quite unimpressive now: laptop, additional monitor, small EEG amplifier, several tiny sensors
- Clinician watches EEG and sets reward parameters on laptop to encourage desired brainwave shift
- Trainee watches monitor and listens to auditory signals, “trying” to get rewards
- Really just relaxing and letting the brain do its thing; trying hard is counterproductive

Neurofeedback Session

image from Institute for Applied Neuroscience, Asheville, NC

Experiencing Neurofeedback

- Frustrating at first, with directions coming only from audio-visual feedback
- Trainees may notice effects during, immediately following, or many hours after session
- Effects last longer with accruing mastery; frequent practice required to build momentum
- Others may notice changes before trainee
- Eventually, tedium may become challenging

Sometimes it's just plain boring...

Case Examples

- Boy with most common form of ADHD (high ratio of theta to beta frontally) – lowered theta:beta ratio yielded normalized test scores, improved concentration, impulse control, school performance and transitioning between activities, reduced meds
- Woman with developmental trauma (posterior alpha and theta deficits) – increased alpha and theta production yielded decreased reliance on alcohol, improved sleep, increased affect tolerance and ability to address disturbing topics in psychotherapy

Case Examples (cont'd)

- Elderly man with depression and cognitive decline (frontal beta deficit) – increased beta yielded brighter mood and sharper mental functioning
- Adolescent male with Asperger's Syndrome (excessive lateral similarity, among other abnormalities) – decreased similarity yielded lowered emotional reactivity and greater social awareness

Neurofeedback Risks

- Occasionally, trainees may experience mild fatigue, spaciness, edginess or headache (usually abates within minutes after training); may indicate over-training or errant strategy
- Worsened symptoms can result (briefly) from errant training strategy; easily corrected
- No response (rare; may just indicate errant strategy)
- Seizures can be induced (*extremely* rare and only in people with pre-existing vulnerability)

Neurofeedback Drawbacks and Limitations

- Requires large investments of time and money (from both practitioners and trainees)
- Progress can be slow and requires frequent training (at least twice weekly), though some people are very responsive right from the start
- Rejected as “investigative” by most insurance
- Does not replace psychotherapy or all medication, but can augment effectiveness of both - synergistic

Research Challenges

- Use of single standardized protocol for specific psychiatric diagnostic entity can be problematic
- Practical obstacles to double-blind research paradigm
- Vast number of approaches/protocol options still awaiting robust empirical validation
- NFB research not well-funded
- Senior clinician consultation often best guidance available in absence of specific research findings

Diversity Issues

- Every brain is unique and must be approached as such, even in light of normative databases
- Developing brain undergoes shift in predominance of slow brainwaves; children normally generate more theta than adults do
- Training effects can fade in elderly brain, requiring periodic “booster” sessions to restore benefits
- Further research may reveal additional issues

Professional Organizations

- International Society for Neurofeedback and Research; their peer-reviewed scholarly journal is *NeuroRegulation*
- Association for Applied Psychophysiology and Biofeedback; their peer-reviewed scholarly journal is *Applied Psychophysiology and Biofeedback Journal*
- Various training groups organized around particular approach, teacher(s) or equipment

Introductory Readings

Demos, J. (2005). *Getting started with neurofeedback*. New York: W.W. Norton & Company, Inc.

Fisher, S. (2014). *Neurofeedback in the treatment of developmental trauma*. New York: W.W. Norton & Company, Inc.

Hill, R. and Castro, E. (2009). *Healing Young Brains*. Virginia: Hampton Roads Publishing Company, Inc.

Introductory Readings (cont'd)

Hirschberg, L., Chiu, S., Frazier, J., eds. (2005). *Child and adolescent psychiatric clinics of North America – Emerging interventions, 14,* 1-216

Robbins, J. (2008). *A symphony in the brain: The evolution of the new brainwave biofeedback.* New York: Grove Press

Steinberg, M. and Othmer, S. (2004). *ADD – The 20-hour solution*. Oregon: Robert D. Reed Publishers

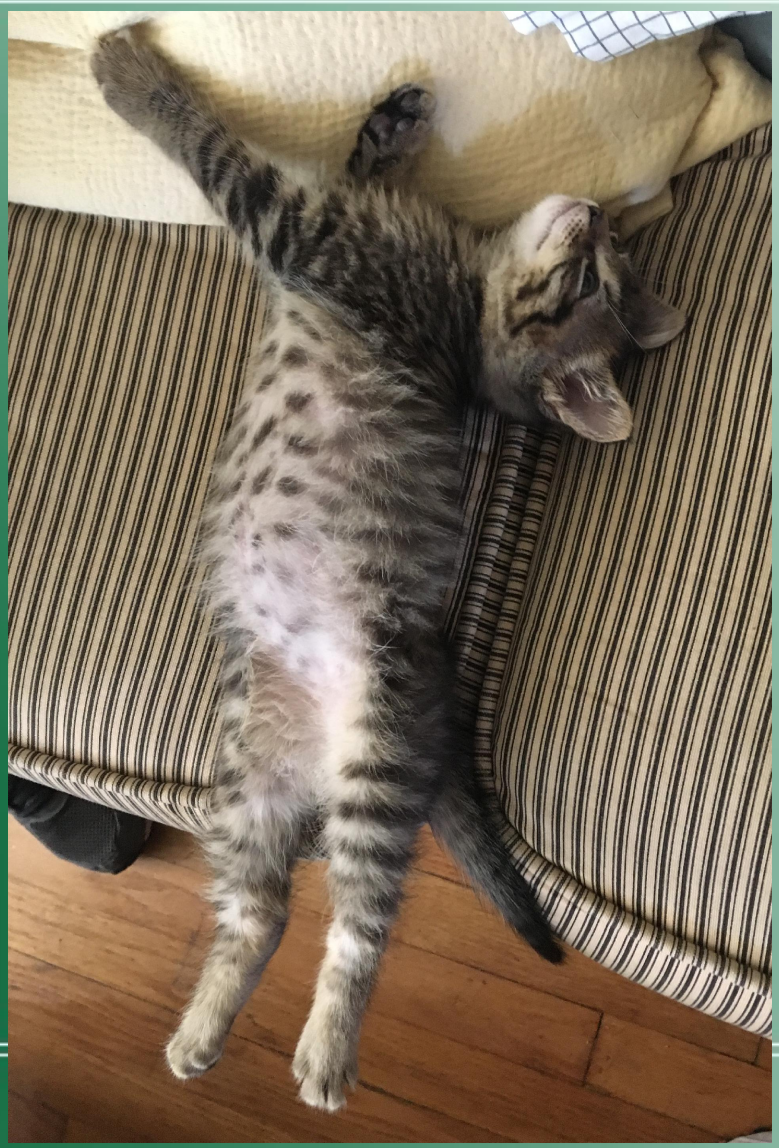
Introductory Readings (cont'd)

Swingle, P. (2008). *Biofeedback for the brain*. New Jersey: Rutgers University Press

van der Kolk, B. (2014). *The body keeps the score*. New York: Viking Penguin

Extensive (68-page) research bibliography, organized by diagnostic themes and other factors, compiled by Corydon Hammond, PhD and Allen Novian, PhD available at: https://isnr.org/wp-content/uploads/2019/07/download.pdf

Are we done yet?



Landmark Research Example: Seizure Disorders

Sterman (2000) *Clinical Electroencephalography*, meta-analysis reviewing 18 studies published over 20 years on NFB and epilepsy

- 82% demonstrated at least 30% reduction in seizure frequency and severity
- Averaged more than 50% reduction
- 5% remained seizure-free for one year (not all studies included follow-up)

Landmark Research Example: Addiction

- Peniston & Kulkosky (1989) *Alcoholism: Clinical and Experimental Results*, randomized, controlled study of severely alcoholic, traumatized inpatients at VA hospital
- Reported 70% abstinence rate three years post-treatment for the NFB group, compared to 100% re-hospitalization rate within 18 months for the group receiving traditional treatment

Landmark Research Example: Anxiety Disorders

Moore (2000) *Clinical EEG and Neuroscience*, meta-analysis reviewing 18 studies published in peer-reviewed journals involving either patients diagnosed with anxiety disorders or volunteers with objective evidence of elevated anxiety

Concluded specific forms of NFB training are effective treatments for GAD, OCD, PTSD and phobic disorders

Landmark Research Example: ADHD

Rossiter & LaVaque (1995) *Journal of Neurotherapy*, reported on two groups of 23 patients receiving NFB or psycho-stimulant medication; no outcome differences between the two groups after 20 sessions of NFB

Landmark Research Example: ADHD (cont'd)

Monastra et.al. (2002) *Applied Psychophysiology & Biofeedback*, assessed 100 patients, all of whom received multi-modal treatments for ADHD, including Ritalin. 51 volunteered to also receive NFB while 49 declined; two-year follow-up was conducted.

- Medication yielded no enduring benefits, but NFB did
- 80% of NFB group reduced meds at least 50%
- By contrast, none of the non-NFB group decreased meds, and 85% of those patients had *increased* doses

Monastra Study Findings (cont'd)

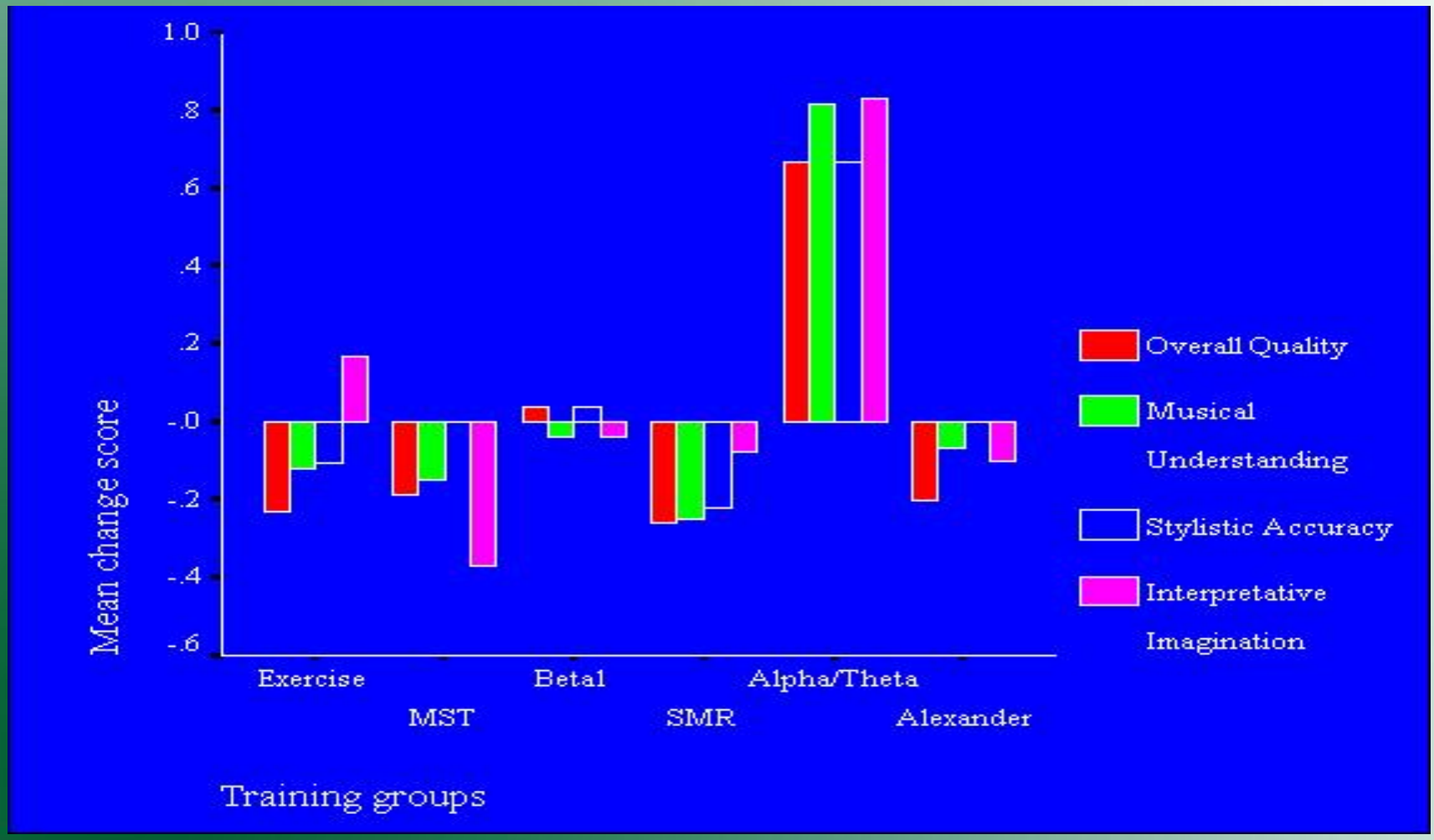
- Post-treatment assessments were conducted with and without Ritalin
- All had improved scores on continuous performance test and symptom checklist when assessed with Ritalin, but only the NFB group sustained improvements when assessed without Ritalin
- qEEG showed significant reduction in excessive slow brainwave activity only in the NFB group

Landmark Research Example: Peak Performance

Gruzelier & Egner, Department of Cognitive Neuroscience and Behaviour, Imperial College, London (2003) *NeuroReport*

- Six groups of elite musicians, each receiving different training: exercise, Alexander Technique, mental skills, and several types of NFB
- 10-15 minute performance of a musical piece assessed before and after training
- Performances were video-recorded, randomised and rated by expert musicians external to the Royal College of Music
- Rating scales were developed specifically from the Associated Boards of the Royal Schools of Music

One neurofeedback group showed dramatic improvements in quality, understanding, accuracy and interpretation



Thanks for your kind attention!