Introduction to Neurofeedback and Neurotherapy Intervention

Prepared for the use of members of the Applied Neuroscience Society of Australasia (ANSA).

by

MICHELLE ANIFTOS, BSocSci, MPsych, MAPS, BCN, FANSA &

C. RICHARD CLARK, BA (HONS), PHD, MAPS, BCN, FASSA

Introduction

- Mental health professionals are encouraged to employ brain-based practices promoting interpersonal neurobiology to help clients improve functioning and well-being.
- A wide range of studies in applied neuroscience have demonstrated the clinical effects of EEG biofeedback therapy (a.k.a. neurotherapy, herein **NFB**).
- This presentation aims to provide a brief introduction to NFB and its potential to contribute to improved well-being, daily functioning and performance.

Options for Health Intervention

Source: Collura, 2014

Modality	*Method*	*Invasive*	*Biological basis*	*Specificity*	*Directedness*
Talk/behavioral Therapy	Learning (various)	No	Moderate (when neuroscience-driven)	Moderate (cognitive/ emotional)	High (can focus on issue or problem)
Pharmaceutical	Altering (chemistry)	Yes	High (chemical change)	Moderate (neurotrans-mitters)	Low (widely distributed in brain, side effects and abreactions can occur)
Stimulation	Altering (electrical)	Yes	High (electrical conduction)	Moderate (location on head)	Moderate (polarity, location)
Neurofeedback	Learning (operant)	No	High (EEG and learning process)	High (site-specific or LORETA)	High (wide range of protocols, settings, sites)

Multi-Modal/BioPsychSocial

1. *Biological - treating the brain*
   - clinical investigation (Paediatrician/Psychiatrist)
   - treat symptoms (typically a medication trial)
2. *Psychological - treating the mind*
   - Develop therapeutic alliance
   - promote treatment compliance
   - employ psychoeducation
   - minimise distress of symptoms and treatment.
3. *Social - facilitating function*
   - family involvement
   - peer relationships – personal and professional
   - functional occupation, employment & education

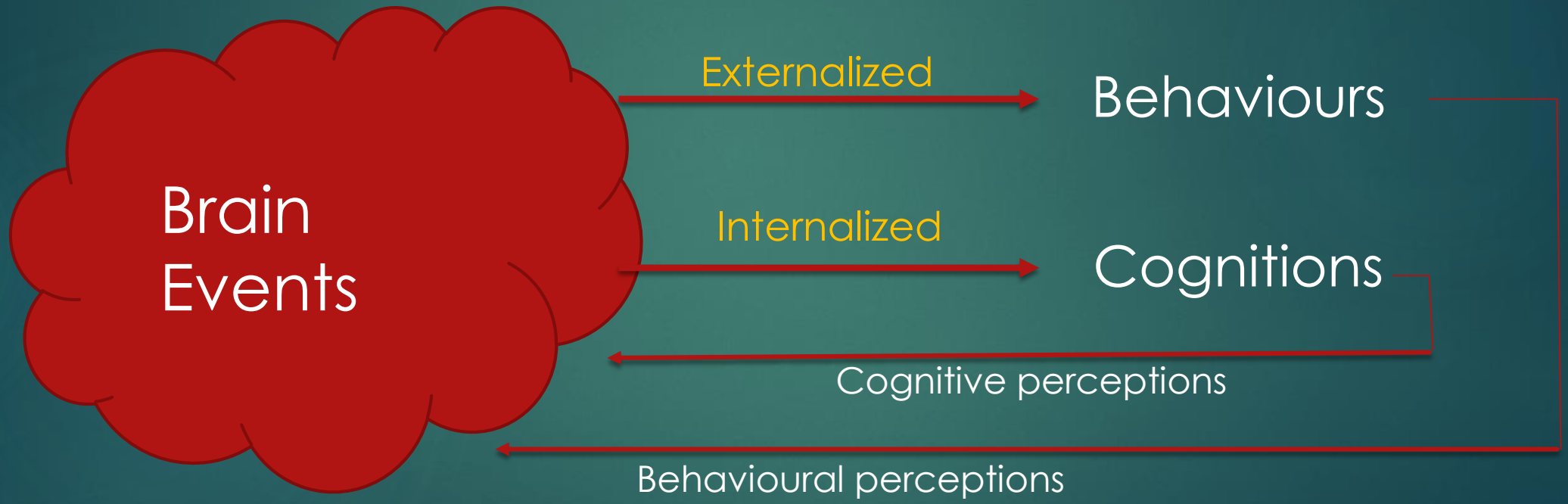
where biofeedback fits the model

Physical symptoms of acute stress:

- accelerated heart rate & palpitations
- muscle tension
- rapid breathing
- perspiration
- headaches, light-headedness or dizziness
- abdominal and digestive complaints
- fatigue & sleep disturbance

CBT potential to influence Brain Events

adapted from Collura, 2014



Biopsychological Limitations of CBT

- level of consciousness/arousal – compromising attention, tracking, and activity rate;
- executive functioning - initiative, goal formulation, planning, carrying out strategies, etc;
- emotional states - anxiety impairs receptive language & memory function; depression dampens cognitive function;
- pain and sleep deprivation can affect cognitive function;
- medication for pain, sleep, anxiety, and some psychiatric conditions, have a sedating effect on body and mind.

Neurological Components of Self-regulation :

- Awareness
  - neuro-sensory stimulation & processing - parietal, midbrain
- Attention/Engagement
  - focus or filter, – prefrontal cortex
- Motivation
  - identity, memory, appraisal – subcortical (limbic), temporal
- Reaction/Response
  - integration of processes into response – basal ganglia, SMR
- Learning
  - neuroplasticity = changing your brain & unlocking potential

Biofeedback: Aid to Self-Regulation

While many of our bodily functions are maintained automatically:

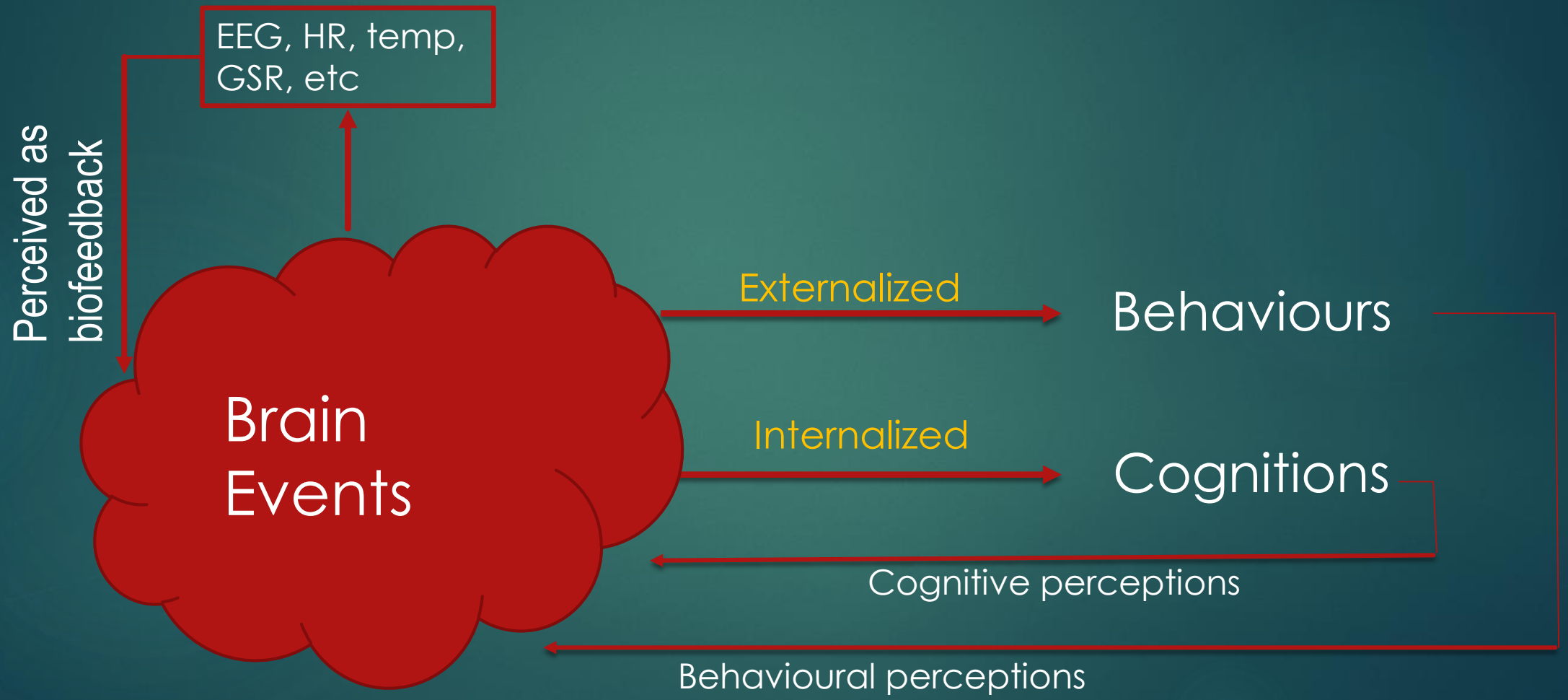
- **Heart Rate**
- **Blood Pressure**
- **Hand temperature**
- **Breathing**
- **EEG (Neurofeedback)**

we can learn to control and influence normally involuntary processes. This knowledge has given rise to various biofeedback techniques e.g. HRV, GSR and EEG. Biofeedback operates on the notion that we can influence the automatic functions of our bodies through the exertion of will and mind. See Mike Cohen's YouTube presentation (2013) at

http://www.youtube.com/watch?v=4Sin4QR4cwo.

Biophysical Component in the Client's Environment

adapted from Collura, 2014



HRV – Heart Rate Variability

- Stress can affect nerves that control the heart. Heart rate can be regulated via controlled breathing for improved heart rate variability (HRV) as a measurement of cardiovascular health. More HRV means your heart is better able to adapt i.e. more resilient to stress. Less HRV means nerves and heart muscle can't respond easily to change thus becoming out-of-rhythm and potentially failing to maintain a beat.
- Stress reduction and exercise aim to soothe and protect the heart through increased HRV. HRV training helps clients to regulate HRV with direct feedback regarding this biophysical indicator of well-being.

Improving Capacity for Self-Regulation

- Biofeedback develops a heightened perception of arousal and function and subjects are soon able to induce changes in their functioning (e.g. heart rate) to achieve positive consequences.
- In NFB, these changes lead to improved flexibility and general stability of the brain waves, leading to improved flexibility and stability of behaviour in response to the external demands of daily living.

The Potential of NFB

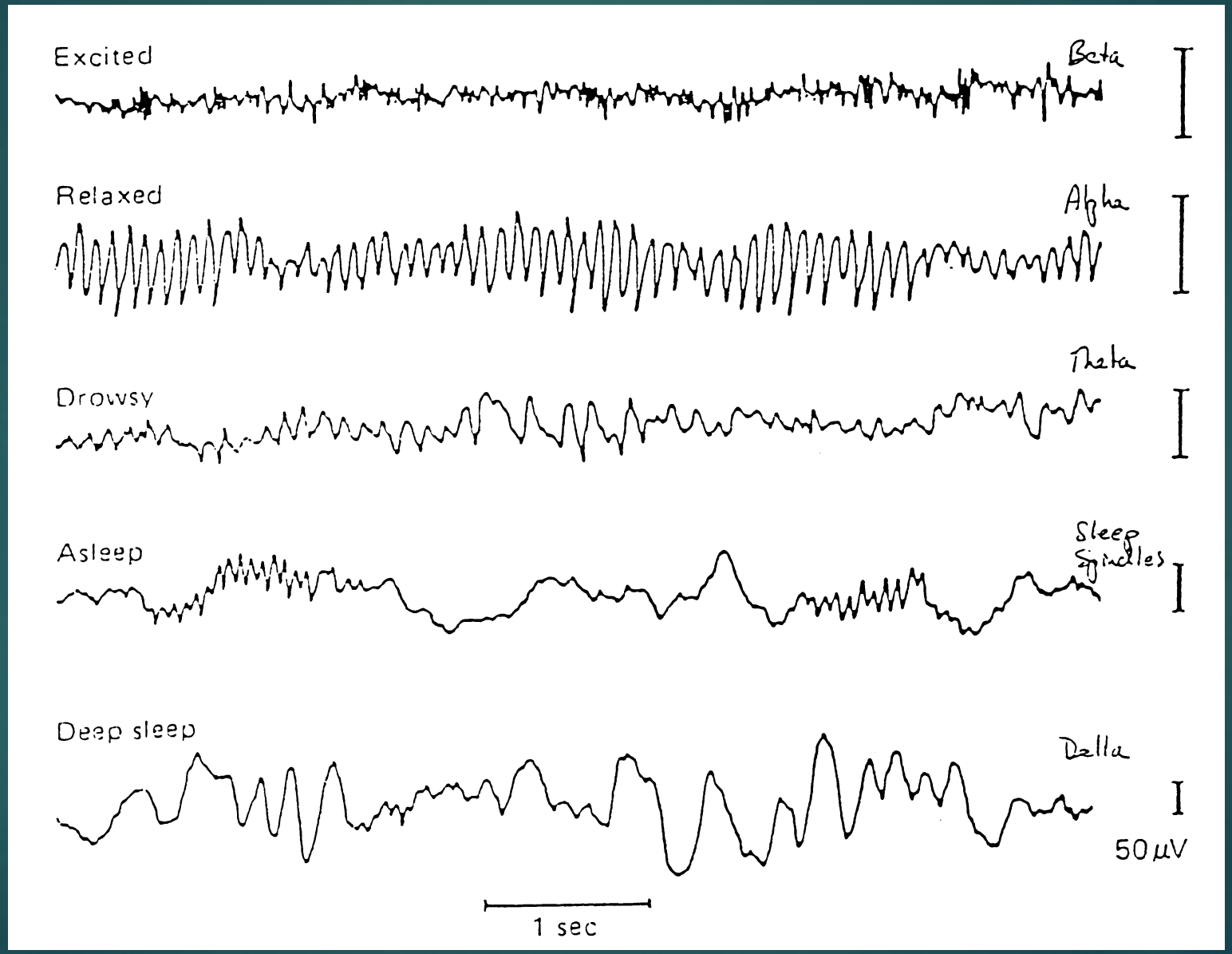
- The clinical effects of NFB have been demonstrated in a range of studies. Just as HRV measures can be retrained or reconditioned, so too can brainwave patterns (Hammond, 2011).
- EEG parameters can be displayed so that a client can observe and learn to control his/her brain activity (voluntary control over-riding automatic brain functions) to:
  - enhance self-regulation,
  - communicate with the external world, or
  - for manipulation of biofeedback devices (Kropotov, 2009).

- EEG remediation is based on 3 scientific facts:
  - Brain state is reflected in EEG parameters
  - EEG features can be voluntarily and selectively altered
  - Plasticity allows the brain to memorize the NFB effect.

EEG - Electroencephalogram

- The spontaneous (self-regulatory) electrical signals produced by neurons of the brain can be monitored and recorded by an EEG typically via electrodes typically placed on the scalp.
- There are excitatory and inhibitory neurons which are balanced for normal neuro-functioning. Excitatory increases likely activation of neurons and inhibitory decreases firing potential.
- The electrical activity is described by classifying the changes in electrical potential into frequency bands e.g. Beta (awake/anxious); Alpha (alert); Theta (drowsy); and Delta (deep sleep).
- Electroencephalograph (EEG) waves reveal moment-to-moment functionality of the brain, with disorder of the brain indicated by dysregulated brainwaves.

EEG and States of Arousal



NFB Remediates Dysregulation

- Traditionally, EEG practitioners claim to remediate three underlying patterns of dysfunction in cortical activity – the arousal model (a qualitative assessment of the symptoms):
  - **Overactive**: e.g. impulsiveness, hyperactivity, anxiety, rage, obsessive-compulsive symptoms, tics, and difficulty falling asleep.
  - **Underactive**: e.g. inattention, low energy, depression and early morning awakening.
  - **Instability**: e.g. seizures, migraine and panic.

- With advances in technology and EEG-analysis methods, we now have qEEG – a quantitative assessment of symptoms & ERPs as an indicator of brain function in response to stimuli.

Arousal Model

	Too Little	Normal	Too Much
Delta (0-4 Hz)	Poor sleep	Restful sleep	Depressed/sluggish
Theta (4-8 Hz)	Robotic	Intuitive	Foggy/daydreamy
Alpha (8-12 Hz)	Exhaustion	Calm/relaxed	Anxiety/hypervigilant
SMR (12-15 Hz)	Scattered	Present/ready	Depressed
Beta (15-32 Hz)	Tired Depressed Unmotivated	Focused Engaged	Mind chatter Unable to relax Tense

Neurophysiological Assessment

- The bands of EEG rhythms, typically observed, range in frequency from 0-70Hz.
- EEG signals represent summated electrical potentials generated by neuronal columns and recorded from scalp electrodes which sit over about 400 columns, containing millions of neurons.
- Alterations in oscillatory patterns of EEG play a critical role in maintenance of brain functions and also indicate brain dysfunction (Kropotov, p.2).
- In the case of observable EEG rhythms (e.g. alpha, beta, theta) there is a force that drives the neuron or the neuronal network from their equilibrium and a force that returns them back, maintaining the equilibrium of the system.

qEEG

- Quantitative Encephalography (QEEG brain mapping) compares electrical activity generated from the brain with a database of normal individuals to locate and describe areas of abnormal functioning.
- The findings of the QEEG are enhanced by our capacity to compile a 3D profile of brain activity based on scalp potentials measured from multiple-channel EEG data.
- QEEG findings may inform neurofeedback protocols to improved the efficacy of intervention. Wright and Gunkelman (1998) showed QEEG evaluation doubled the rate of clinical success for ADHD.

- An extensive review of well-designed EEG and qEEG studies revealed consistent findings among different diagnostic groups, suggesting there should be a strong positive recommendation for using EEG as a diagnostic tool to support assessment and treatment of a range of clients including, for example, those with attention disorders for whom QEEG evaluation improves the rate of clinical success (Wright & Gunkelman, 1998; Hughes & John, 1999).

EEG Phenotypes

- EEG phenotypes may be recognised at semi-stable states of neurophysiological function observable in common psychopathologies (Johnstone, Gunkelman & Lunt 2005).
- These findings may contribute to predictions of treatment response, for example, to either medication and/or non-invasive interventions such as neuro or psychotherapies.

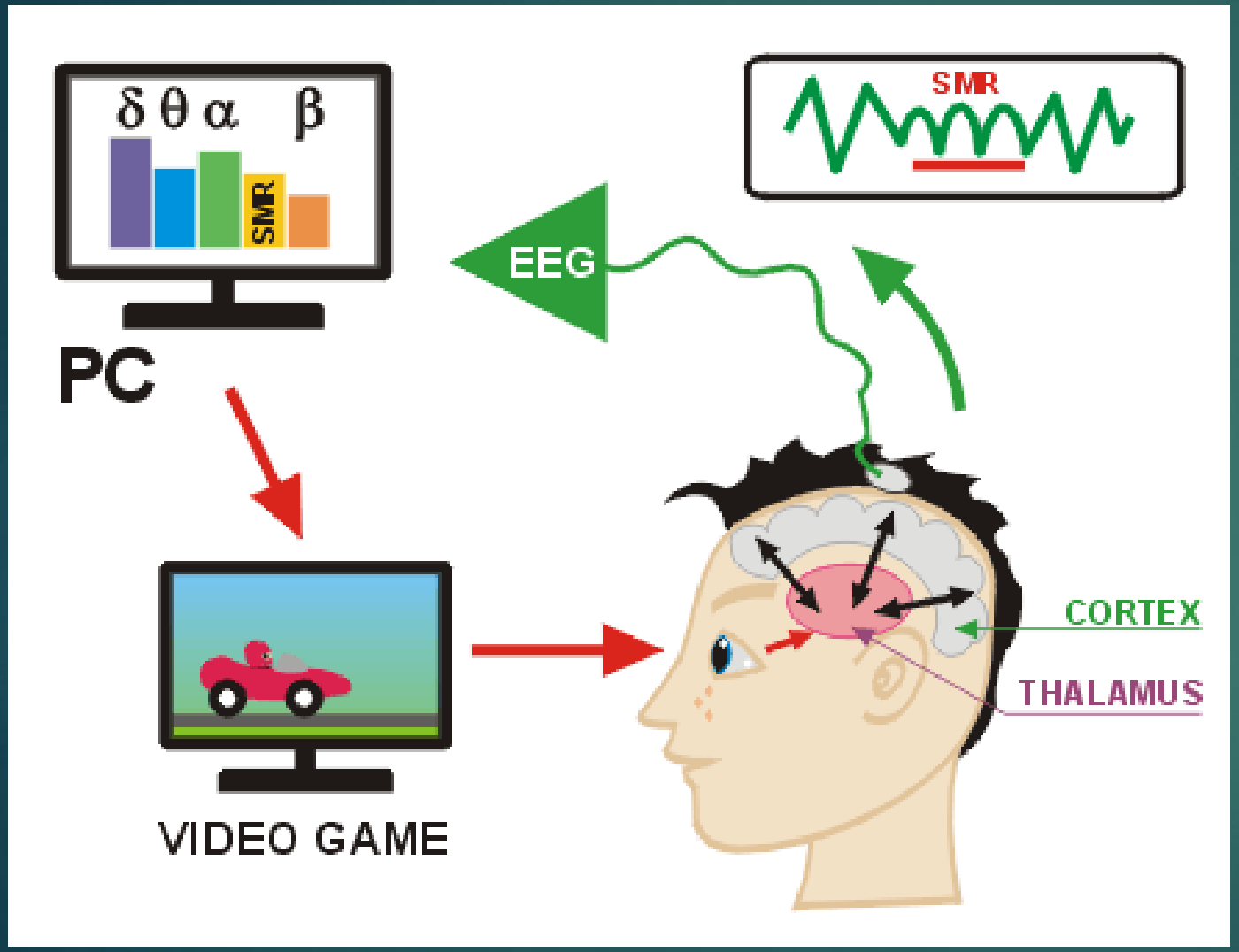
In the diseased brain, normal mechanisms of EEG rhythms may be impaired and the rhythm may:

- become slower in frequency (EEG slowing);
- appear in unusual places (e.g. alpha rhythms in temporal areas);
- become higher in amplitude (hypersynchronization) and in more synchronicity with other areas (hypercoherence) indicating poor differentiation of brain structures and functioning;
- in some cases, a separate slow rhythm in delta frequency may appear (e.g. disconnection of cortical areas from sub-cortical structures due to stroke, trauma or tumour); and
- in some cases, normal synchronization may be enhanced and spike or spike/slow patterns appear indicating a so-called focus in the human brain (e.g. clinical or sub-clinical seizure).

What is Neurofeedback?

- NFB is a non-invasive intervention which moves away from medical models of treatment to a learning model.
- The trainee receives moment-to-moment visual & audio feedback relative to their EEG parameters and clinically determined training goals
- Brain functioning is conditioned over time

Image by Prof. Josef Faber, accessed 29/5/10 at mentis.ie/images/smr1_en.gif



With regular neurofeedback therapy and practice, significant improvements seem to occur 75 to 80% of the time (Hammond, 2011).

Learning through operant conditioning

- EEG can be operantly conditioned e.g., an individual receives feedback about their EEG activity, increasing their capacity to self-regulate the frequency, amplitude and other characteristics of the EEG, creating a feedback loop.
- Sterman, et al., (1972) trained cats by EEG operant conditioning, using food reward, to produce 11-15 Hz "alpha spindle" electrical activity.

Key Principles

Sherlin, Arns, Lubar, Heinrich, Kerson, Strehl & Sterman (2011) exhort adherence to 7 principles of learning theory in neurofeedback (NF):

- Speed of Reinforcement – delayed reinforcement decreases the strength of the conditioning;
- Type of Reinforcement - a *response–reinforcer association* is developed in operant learning.
- Shaping – learning depends upon the feedback context.
- Specificity –learning is promoted when characteristics of the target behaviour can be specified and discriminately reinforced.
- Artifacts – treatment efficacy may be compromised by reinforcing artifacts in the EEG.
- Secondary Reinforcement – rewards must be rewarding!
- Generalisation – learning must be generalised beyond the clinic to the context of daily living in order for neurofeedback training to have any ecological validity.

NFB Definition

Neurofeedback is employed to modify the electrical activity of the Central Nervous System including:

- electroencephalography (EEG),
- event related potentials (ERPs),
- slow cortical potentials (SCPs,) and
- other electrical activity either of subcortical or cortical origin.

Neurofeedback is a specialized application of biofeedback of brainwave data in an operant conditioning paradigm. The method may serve as the basis for treatment of a clinical disorder or enhancement of normal functioning.

NFB Research

- A growing body of research suggests the efficacy of NFB for a variety of disorders related to brainwave activity.
- A special issue of Child and Adolescent Psychiatric Clinics of North America featured neurofeedback in seven of its ten chapters, concluding:

"EEG biofeedback meets the American Academy of Child and Adolescent Psychiatry clinical guidelines for treatment of ADHD, seizure disorders, anxiety (OCD, GAD, PTSD, phobias), depression, reading disabilities, and addictive disorders. This suggests that EEG biofeedback should always be considered as an intervention for these disorders."

Hirshberg, L. M., et al. (2005). *Emerging Interventions. Child and Adolescent Psychiatric Clinics of North America. 14*(1): xiii-xvii.

Research support for NFB

- Although a non-invasive treatment modality, NFB resembles pharmacotherapy given its capacity to stimulate neurotransmission (Butnik, 2005) but in (a) an informed targeted way, and (b) with long term rather than temporary changes.
- NFB offers a viable alternative and/or complementary treatment to the traditional medical model and is also considered to be the treatment of choice where ***"medication is ineffective, only partially effective, has unacceptable side effects, or where medication compliance is low"*** (Rossiter & La Vaque, 1995, p. 11).
- In an independent review, Duffy (2000) found that ***"the literature, which lacks any negative study of substance, suggests that …EEG biofeedback… 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."***

Schoenberg and David (2014) review of biofeedback in a range of disorders: anxiety, autistic spectrum disorders, depression, dissociation, eating disorders, schizophrenia and psychoses.

- EEG biofeedback was employed in 31.7% (n = 20) of studies.
- Fourteen studies (70.0%) reported statistically significant clinical amelioration following NFB:
  - 14 of the NFB studies (70.0 %) included a comparison treatment (sham/placebo), a differing EEG parameter for feedback, another clinical intervention, or no treatment/wait-list control);
  - 7 interventions (35.0 %) were randomized, four (20.0 %) nonrandomized, and for the remaining 9 (45.0 %) randomization was not feasible; and
  - 23.7 was the mean number of sessions per study (range 5–69), with BF exposure lasting 28.7 min (range 14.6–60 min) on average per session.

- Multi-modal biofeedback appeared most effective in significantly ameliorating symptoms, suggesting that using more than one physiological modality for bio-regulation increases therapeutic efficacy.
- Of all the biofeedback modes, NFB seems particularly promising for disorders where inducing particular states of conscious experience (through the alteration or regulation of cortical oscillatory activity) is a driving mechanism in alleviating symptomatology (Shoenberg & David, p. 125).

Benefits of NFB

- In the treatment of at least one disorder, Attention-Deficit/Hyperactivity (ADHD), neurofeedback is *considered to be the only type of treatment demonstrating sustained improvement of the central* symptoms of pathology in the absence of stimulant therapy (Monastra, et al., 2002; Rossiter & La Vaque, 1995).
- NFB treatment is a cost effective alternative to longterm use of medication, for example, only 60-70% of individuals with ADHD do not outgrow symptoms and will therefore require some form of ongoing treatment (Rossiter & La Vaque).
- Niv (2013) reviews the effectiveness of neurofeedback in ADHD, autism spectrum disorders, substance use, PTSD, and learning difficulties and found that neurofeedback emerged as superior or equivalent to either alternative or no treatment in many of the examined studies.

Evidence of Efficacy

A special issue of *Child and Adolescent Psychiatric Clinics of North America* featured neurofeedback in seven of ten chapters. About neurofeedback Hirshberg, et al., (2005) concluded, that ***"EEG biofeedback meets the American Academy of Child and Adolescent Psychiatry (AACAP) 'Clinical Guidelines' criteria for treatment of ADHD, seizure disorders, anxiety (OCD, GAD, PTSD, phobias), depression, reading disabilities, and addictive disorders".*** AACAP's 4 level scale is:

- *Minimal Standard* (MS) backed up by rigorous empirical evidence, and/or an overwhelming clinical consensus;
- *Clinical Guidelines* (CG) recommendations based on strong empirical evidence and/or strong clinical consensus;
- *Option* (OP) emerging empirical evidence or clinical opinion, but lack strong empirical evidence and/or clinical consensus;
- *Not Endorsed* (NE)

Methodological and Statistical Criteria for Research Evidence

- AAPB & iSNR collaborated to evaluate the NF research and to provide a template for scientific review of the evidence base for neurotherapies.
- According to this *Task Force* (La Vaque, et al., 2002), NF applications achieved *Probably Efficacious (Level 3)*.
- To achieve '*Efficacious and Specific*' (see Table 4), studies were recommended that could demonstrate NF to be ''statistically superior to credible sham therapy, pill, or alternative bona fide treatment in at least two independent research settings''.
- A meta-analysis of the ADHD research has since claimed Level 5 efficacy, demonstrating a large effect size for inattention and impulsivity (Arns, et al., 2009).

- While not conclusive, there is sound evidence that warrants neurofeedback, at least as an adjunct therapy, for conditions such as ADHD, Seizure Disorders, Addictive Disorders, Anxiety and PTSD, particularly where clients are non-responsive to pharmaceuticals or experiencing abreaction to other treatment options.

Quality research is needed to further examine the efficacy and effectiveness of neurofeedback for treatment of the following conditions, although preliminary findings are promising for:

- Depression
- Obsessive-Compulsive Disorder
- Traumatic Brain Injury
- Autism Spectrum Disorders
- Learning Difficulties
- Migraines
- Bipolar Disorder

Publications

Extensive bibliographies of NFB are available e.g.,

- Brain Science International, http://www.brainsinternational.com/default/assets/File/NFB%20Biblio.pdf
- ISNR, http://noviancounseling.wix.com/bibliography
- AAPB, http://www.aapb.org/i4a/pages/index.cfm?pageid=3443
- EEG Spectrum, http://www.eegspectrum.com/articles/
- BCIA, http://www.bcia.org/i4a/pages/index.cfm?pageid=3664

Certification in Neurofeedback

For BCIA Certification, didactic education must include:

- A human anatomy, human physiology, or human biology course covering the organization of the human body and all 11 systems or a biological psychology or neuroscience course from a regionally-accredited academic institution.
- A 36-hour didactic education program specifically covering all topics as listed in the BCIA Blueprint of Knowledge taken from either a regionally-accredited academic institution or a BCIA-accredited training program.

In Closing…

- EEG Neurofeedback may have a short history and limited research-base however "unlike other biological treatment modalities, neurofeedback is steeped in the history and ethos of psychology…and shows promise as a therapeutic option" (Masterpasqua et al, 2003).

- While efficacy for other disorders is yet to be strongly demonstrated in the literature, the APA has endorsed NFB as a treatment option for ADHD for suitably qualified practitioners.

Useful links & resources:

- Getting started in Neurofeedback
- www.appliedneuroscience.org.au
- www.eegspectrum.com
- www.isnr.org
- www.aapb.org
- www.bfe.org
- www.bcia.org
- www.neurofeedbackfoundation.org