Principles of Science

- Measurements must be repeatable
- Hypothesis falsifiable
- Rational associations and inferences
- Tools are imperfect
- Communications are honest and transparent
- Clean up mistakes, especially our own
- Cite sources accurately, preferably original sources

Science is a set of rules to keep us from lying to each other

Evidence-Based Practice Policy Statements

- “Evidence-based practice is the integration of best research evidence with clinical expertise and patient values.” Sackett, 2000 (IOM) = APA statement

- Evidence-based neurotherapy promotes effective practice of neuromodulation by relying on empirically-supported principles of neurotherapeutic assessment, case formulation, therapeutic relationship, and intervention for specific and nonspecific issues and symptoms.

Why evidence-based practices matter

- FACTS:
  - Widespread practice variation
  - Unknown clinical effectiveness for all but a handful of protocols and symptoms

- GOALS
  - Evaluate protocol effectiveness for symptoms
  - Improve quality and accountability of care
  - Shared vocabulary and concepts
PROTOCOL SEQUENCING PRIORITY PARADIGMS

Hierarchy of Needs (Maslow) priorities
1. Physiological – Stabilize Rhythms (ANS)
2. Safety – Stabilize Arousal (CNS)
3. Belonging 1 – Stabilize Attention (Posterior cortex)
4. Belonging 2 – Stabilize Emotions (Limbic)
5. Esteem – Stabilize Self-Directed (Frontal lobe)

Psychosexual (Freudian) EEG priorities
1. Lingual
2. Orbital frontal
3. Temporal pole
4. Auditory cortices

Default Network Training
1. PCC
2. DMN hubs and PCC connections (D.C., C.)
3. BA 38, 39, 40, beta/gamma deficits
4. Posterior to anterior

Converting raw EEG spectral parameters to statistical probabilities

Shared alpha activity

database

FP1 client

F2 0.97
F3 0.00
F4 0.00
Fz 0.00
Cz 0.00
O1 0.17
O2 0.00

Mean =+4.2

r = 0.5 means different things depending on frequency and site.
Criticisms of Neurometrics

- Too many statistical tests (inflates Type I errors)
- Some normals appear abnormal to controls
- Sensitive to artifact
- More removed from the data, the more errors that can creep in
- Cautions: Methodology differences between client and database recordings (montage and artifactoring differences, calculation of parameters)
Normalization, montage issues with correlative indices

FISHER Z: Distribution normalization (on one half) of comodulation and coherence using the Fisher transformation. The transformation accounts for change in a correlation parameter as it approaches perfect coupling. In other words, it accounts for the fact that more order is required to move the same distance away from 1.0 correlation than disorder is needed to reach the same distance away from.

MONTAGE: Radial and tangential components of electrical activity spread activity across multiple electrodes with reference montage. Laplacian techniques correct it but corrupt correlational analyses such as coh and comod. Degree of coupling is overestimated with referential montage but underestimated with Laplacians, so we must decide whether source locality is more important than coupling strength and vice versa.

Z-scores

<table>
<thead>
<tr>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Omega</th>
<th>Beta1</th>
<th>Beta2</th>
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<td>0.4</td>
<td>0.3</td>
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<td>0.4</td>
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<td>0.8</td>
<td>-0.7</td>
</tr>
<tr>
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<td>-0.5</td>
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<td>-0.7</td>
<td>-0.7</td>
<td>-0.4</td>
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</tr>
</tbody>
</table>

With a 5% p-level, approximately 2 standard deviations, we expect 5% of the comparisons to be significant by random chance. In 14 comparisons, 5 are likely fake. Which ones? Which are accurate?

Normative EEG analysis
replications required due to multiple comparisons
Replication across challenge levels (conditions) test internal and alternate-form reliability of EEG

Reliability of Raw EEG

2009

left temporal alpha and theta transients

2010

Reliability of EEG

Age 28

Age 45
Multiple Parameters – which is correct?

Periodicity Table

<table>
<thead>
<tr>
<th>FREQUENCY</th>
<th>1 Low Sb.</th>
<th>1 High Sb.</th>
<th>2 Low Sb.</th>
<th>2 High Sb.</th>
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<td>Acute</td>
<td>Chronic</td>
<td>Acute</td>
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</tbody>
</table>

4 replications of Comod, 9 bands for 1.5 hrs

4 replications of Coh, 9 bands for 1.5 hrs
1.5 hours apart, 4 replications

Verify recording condition is being performed (e.g., non-processing EC3)

Without intervention, brain habits an individual considers most rewarding are maintained, even if maladaptive to adult challenges

(EC3 remember the sadness experience of your life)
Scale-invariant, Complexity, Resistant to External Influences

Energy distribution by Frequency

Human brain "gives the finger" to universe's 1/f rule

Pink to bell-shaped curve
WHAT CREATES SPINDLES?

Inhibition and its Time Out
Alpha Rhythm and Its Generators

Alpha rhythm is of cortical origin, but the theory of a thalamic pacemaker function has frequently surfaced since the work of Berger (1939a), who presumed cortical genesis but thalamic governance of the alpha phenomenon.

Evolution of brain waves
Phylogenetically
Reptiles: δ
no REM sleep (Kostov 1981)
dorsal cortex is 0.5–4 Hz (Lemmo 1999)

Primitive mammals (echidna): θ
Sleeping state non-REM/REM (Engel 1993)
EEG power at hippocampus and cortex in 1.5–7 Hz

Modern mammals: α
Basic rhythm at cortex is α (10 Hz)

Evolution of peak frequency deviation from 1/f
Acetylcholine waves at different stages

* Remark: Alzheimer: γ, β & α decrease, θ & δ increase
The PDR (posterior dominant rhythm) is our fundamental visual (and auditory) sampling rate of the world. Most adults sample the world ten times a second (10.25 Hz) when they are relaxed. Medication that slows PDR slows the CFFF (critical flicker-fusion frequency).

EEG rhythms as information gating rates

1989 2013 2014 2014 cigarette
Stability of PDR prior to neurofeedback PDR at 7 Hz. After 10 sessions increased to 8-9 Hz.
Thalamocortical spindles quiet amygdala and hippocampus

Neurogenesis

Intra-hemispheric tracts
- Arcuate fasciculus
- Unilateral cortico-cortical fiber bundle

Inter-hemispheric bundles
- Corpus callosum (splenium)
- Anterior commissure

Rewarding Subcortical Blood Flow
Corticothalamic Systems

The TRN is a thin shell of GABAergic neurons surrounding the entire thalamus (Scheibel and Scheibel, 1966).
Attachment networks emerge early in life
“Autorelating” – Idling within our Default Network

Damaged Default Network = Broken Attachment Capacity

Also severe depression, excessive focus on self actions

Neuomarker for Psychotic Risk

PrePost DNT Tortured by Talban
• Russian orphan adopted in US focused on absent mother, distant past for many years, unattached to adoptive parents

• Brain training results, now attached to adoptive parents

10-10  
DNT  
44 Electrode Sites

19 Frontal Brain Areas

19 Frontal Brain Areas

Pre BrainTraining 18 Months Training

Default Network Brain Areas
Extensive Mental Effort slows neural connectivity

Neuromarkers: fMRI and EEG

Neuromarkers
Fails twice: 1) trait and 2) electrode placement assistance

Abreactions or Journey

If CP1=CP2 abreacts, CP1<>CP2 x2 sessions or more

Impacted symptom-network => adjust direction, frequency

End of Today's Journey