Principles of Multichannel Neurofeedback

Thomas F. Collura, Ph.D., P.E., BCN
Multichannel Neurofeedback

- Goals
- Methods
- General Approaches
- Specific Approaches
Multichannel NF Goals

• Address L & R Brain, A & P Brain, or Whole Brain
• Train 2+ locations at one time
• Increase/reduce intersite coupling
• Increase/reduce intersite communication
• Achieve brain balance
• Achieve brain asymmetry
Multichannel EEG - General Approach

- Combine EEG signals
- Process EEG signals
- Combine processed values
- Present feedback to trainee
Two-channel vs. Bipolar I

- Bipolar takes difference between two sites
- E.g. F7 – O1 measures across left hemisphere
- Any difference in EEG produces measurable signal
- Cannot (generally) train direction, only difference
Two-channel vs. Bipolar II

• Two-channel allows specific relationships to be measured, fed back, trained
• E.g. specific states or events in each channel
• Can train asymmetry specifically
• Can train coherence, phase between sites
Multichannel NF - Examples

• Channel Summation
• Two-channel protocol
• Multi-channel feedback
• Coherence Training
• Synchrony Training
• Asymmetry Training
Channel Summation

- Adds raw EEG signals in time domain
- Analog or Digital implementation
- Peaks and valleys reinforce or cancel
- Synchrony produces larger signals
- Sensitive to phase relationships
- Process as a new EEG signal
Values vs. raw EEG

- Combining raw eeg combines waveforms
- Combining values combines numerical results of filtering or spectral analysis
- Values typically always “positive”
- Can set thresholds independently
- Can set for specific asymmetries
Two-channel protocol

- Extend protocol processor to 2+ channels
- Define criteria separately for each channel
- Reward using either or both sets
- E.g. C3 beta high AND C4 smr high
- Can provide simple feedback signal
- Brain learns multiple tasks at one time
Multi-channel feedback

- Each channel has own feedback method(s)
- Feedbacks are combined (audio or video)
- Provides multiplicity of information
- Stereo sounds, multiple boxes, etc.
- Brain discerns multiple states or events
- Secondary benefits: coherence, symmetry, etc.
Coherence Training

• Process 2 channels to measure coherence
• Sensitive to spectral similarity
• Reflects amount of common frequency
• Reduced by presence of incoherent “noise”
• Can provide a simple feedback signal
• Encourages amount of common signal
• Downtraining encourages independence
Coherence Training – Bipolar I

• E.g. F7-F8 versus P5-P6
• Large signal in either channel implies L-R asymmetry in brain (either direction)
• Large coherence implies coordination front-to-back
• Single task engenders complex brain response
Coherence Training – Bipolar II

• E.g. FPz-Oz versus T3-T4
• Large signals imply difference front-to-back or left-to-right
• Large Coherence implies coordination across and between hemispheres
• Can alternate uptraining and downtraining for flexibility, awareness
Synchrony Training

- Process 2 channels to measure synchrony
- Sensitive to phase (signals lined up)
- Reflects amount of common timing
- Reduced by phase “jitter”
- Absolute or relative phase possible
- Encourages speed of information transfer
Asymmetry Training

• Use processed values in an equation or algorithm
• Can train ratios, differences, combinations
• Can provide a simple feedback signal
• Results similar to two-channel protocol with uptraining vs. downtraining
• Benefit of simplicity and directness
Summary

• Various ways to combine channel information
• Various ways to present information
• Combining complex brain state/event information into comprehensible form
• Can train inter- and intra-hemispheric properties, some simultaneously