Training the Brain to Behave: Neurofeedback, Mirror Neurons & Autism

Contact Information

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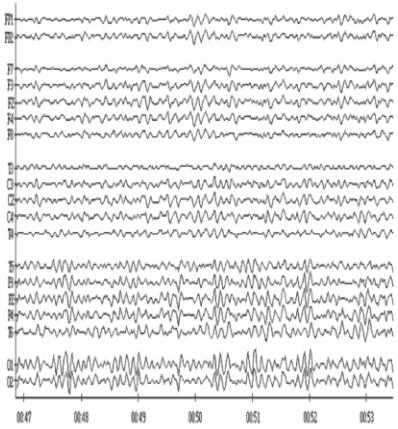
Goal of the Project

- To test the effectiveness of neurofeedback training (NFT) as a means to change behavior in children diagnosed with autism.

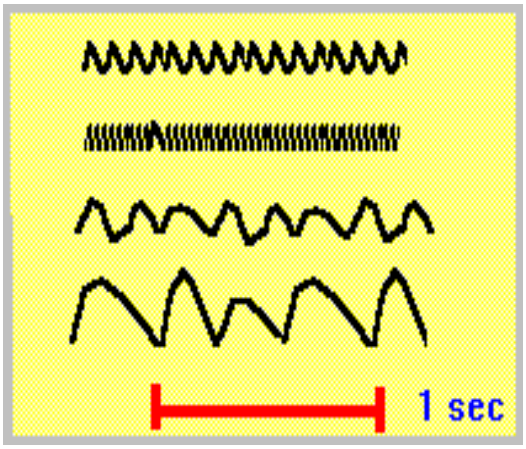
What is Neurofeedback Training?

- The brain generates electrical signals as part of how it processes information
- These signals are measured as the EEG and have a certain amplitude and frequency



EEG Frequencies

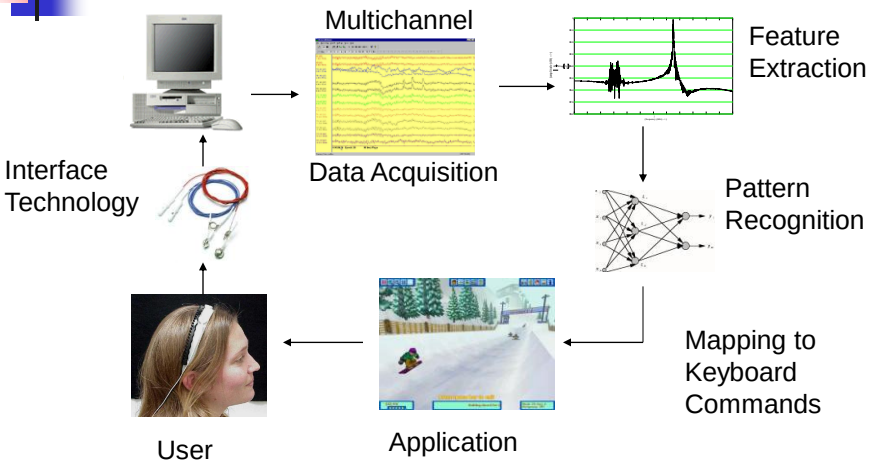
- Alpha
- Beta
- Theta
- Delta



What is Neurofeedback Training?

- Learning to control the amplitude of a specific frequency component of the EEG
  - A type of learning or skill
- This is done by visualizing that frequency component and seeing the effects of changing its amplitude

Neurofeedback System

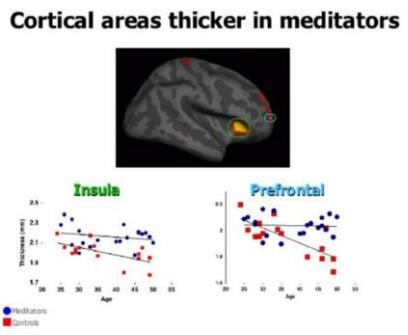


What Does NFT Do?

- It temporarily changes the dynamics of the brain
  - Affects amplitudes and frequencies of EEG components
- Persistent training produces permanent changes in the brain
  - New connections
  - Changes how the brain is organized and wired

Why Does NFT Work?

- Brain is plastic and therefore changeable
- NFT gains access to regulatory mechanisms that control information processing



Why Should It Be Applied to Autism?

- Anatomical irregularities exist in the brains of autistic children
  - Increased cell densities
  - Larger/smaller areas
  - More/less connections between areas
- Changes in anatomy can occur with neurofeedback training
- Changes in anatomy produce changes in behavior

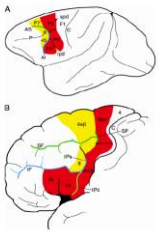
Imitation: Innate Mechanisms

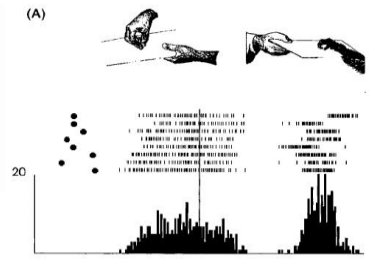
Imitation: The Root of Social Cognition

- Construction of
  - a first-person experience
  - a self different from others
- It's how we understand others

Mirror Neurons in Monkeys

- Monkey see, monkey do cells
- Activated by:
  - Goal directed actions
  - Observation of similar actions
- Found in:
  - Inferior frontal gyrus (F5)
  - Superior temporal sulcus
  - Inferior parietal cortex (7b)





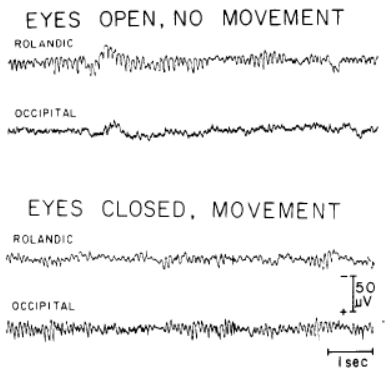
Di Pellegrino et al., Exp. Brain Res., 1992, 91: 176-80

Functional Significance

- Response facilitation
- Mimicry
- Simulation
- Imitation
- Understanding actions
- Understanding intentions
- Empathy
- Theory of Mind
- Language

Human Mu Rhythm (8-13 Hz)

- Maximal over frontal cortex
- Attenuated or blocked by
  - movement and
  - observation of movement
- Not affected by auditory/visual stimulation in the absence of movement



Kuhlman, W.N., Electroenceph. Clin. Neurophys., 1978, 44: 83-93

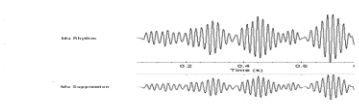
Autism Spectrum Disorders

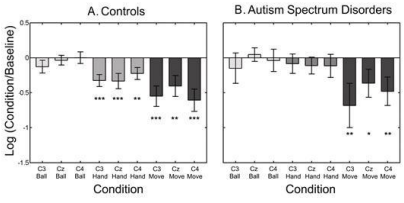
- ASD is characterized by:
  - Impairments in social interaction
  - Delayed/abnormal language development
  - Impaired imagination
  - Repetitive and restricted patterns of behavior
- No common underlying mechanism has been identified
  - Deficits in imitation learning – Rogers and Pennington, 1991
- ASD children should show differences in mu rhythms compared to controls

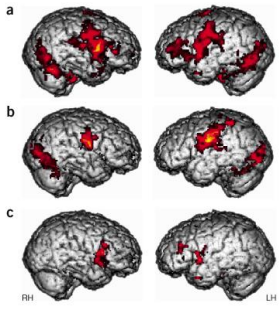
A Dysfunctional MNS?

- Mu suppression for executing actions, but not observing them (Oberman et al., 2005)
- No fMRI activation in IFG during imitation of emotional facial expressions

  (Dapretto et al., 2006)







Study: Changing Cortical Dynamics

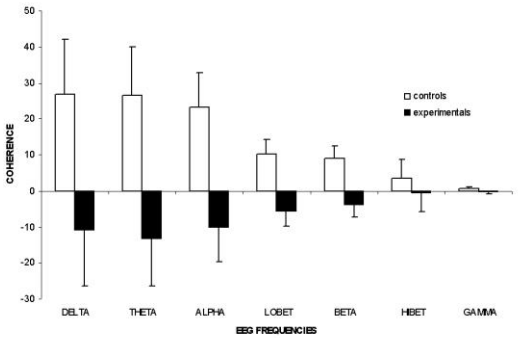
- Operant conditioning of the mu rhythm (7-17 yr olds; n=8)
- Rewarded when
  - Mu activity above threshold (E)
  - EMG activity below threshold (E/C)
- Hypothesis:
  - Functional changes in mu rhythm dynamics produce changes in MNS activity and in behaviors mediated by this system
  - "Reengaging" MNS

Pre/Post Assessments

- Quantitative EEG (qEEG)
- Test of Variable Attention (TOVA)
- Imitation ability (Apraxia imitation test)
- Mu rhythm suppression index
- Autism Treatment Evaluation Checklist (ATEC - parental assessment)

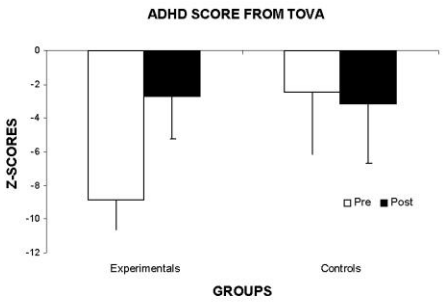
QEEG

- Decreased coherence in experimental group relative to controls

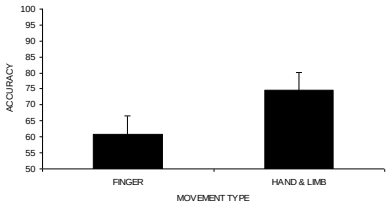


TOVA

- Sustained attention
  - Reduction in ADHD score for experimental group

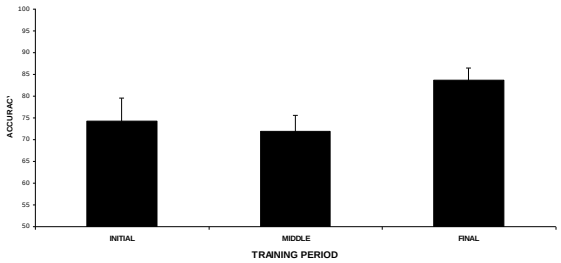


Imitation Test



Improvement in both E/C groups

Better at hand & limb imitation



Conclusions

- ASD children learn to change cortical dynamics via operant conditioning
- Training produces effects on:
  - EEG spectral power
  - Cognitive and behavioral assessments
  - Parental assessments
- Some changes are specific to manipulating EEG dynamics
  - EEG coherence
- Other effects are due to non-specific (EMG/attentional) changes