BCI Research at the Wadsworth Center: Developments in Noninvasive Communication and Control

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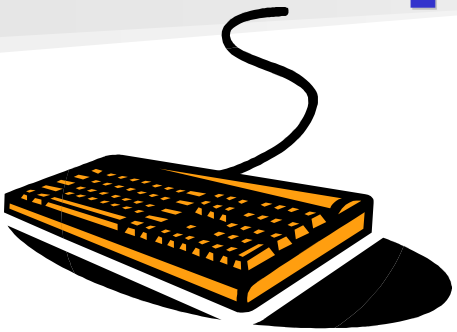
The Wadsworth BCI Lab

- Located in Albany, NY
- Part of the New York State Dept. of Health
- Lab Chief: Jonathan Wolpaw
- ~20 Research Scientists, Postdocs, Technicians, & Students
- Mission: To research and develop BCI technology for helping severely disabled individuals communicate and interact with their environments.

Wadsworth BCI Milestones

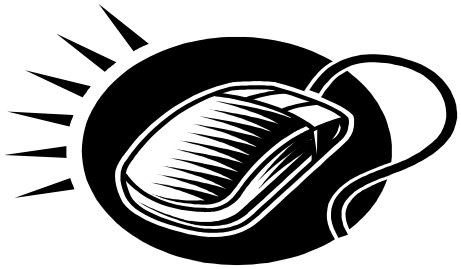
- 1986: Preliminary BCI studies supported by IBM
- 1991: First demonstration of EEG-based 1d cursor control in humans
- 1994: First demonstration of EEG-based 2d cursor control in humans
- 2004: First demonstration of an ECoG-based BCI in humans
- 2004: Demonstration of refined 2d cursor control in humans
- 2006: Home System – first demonstration of long-term, everyday BCI use by a disabled individual in his home
- 2009: First demonstration of EEG-based 3d cursor control in humans (to appear)
- Present: Large-scale BCI testing and dissemination to disabled populations

Wadsworth's Approach

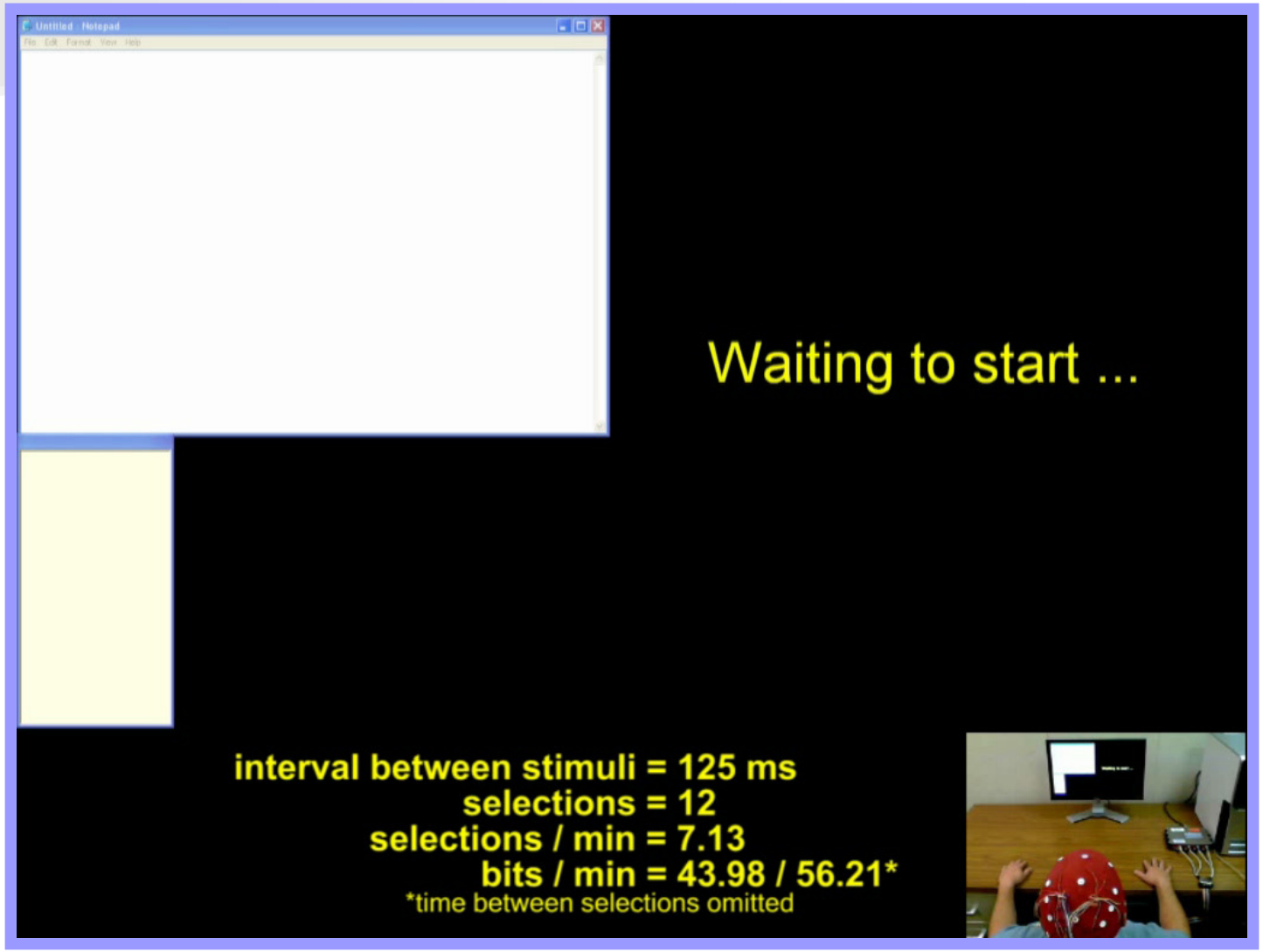


- P300 Evoked Potentials
  - Special interface designed to exploit discrete responses for symbol selection
  - Innate, no training required
  - Low SNR: Typically require averaging of multiple responses
  - Applications: discrete symbol selection for word processing or environmental control

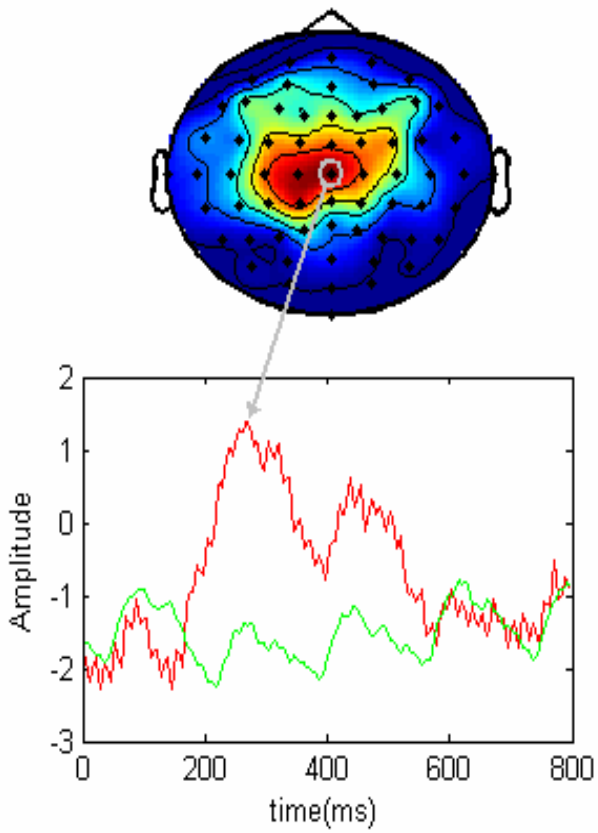
- Sensorimotor Rhythms (SMR)
  - Users can be trained to accurately modulate amplitudes of rhythms for real-time, continuous dimensional control
  - Applications: continuous cursor control, navigation, robotic/prosthesis control

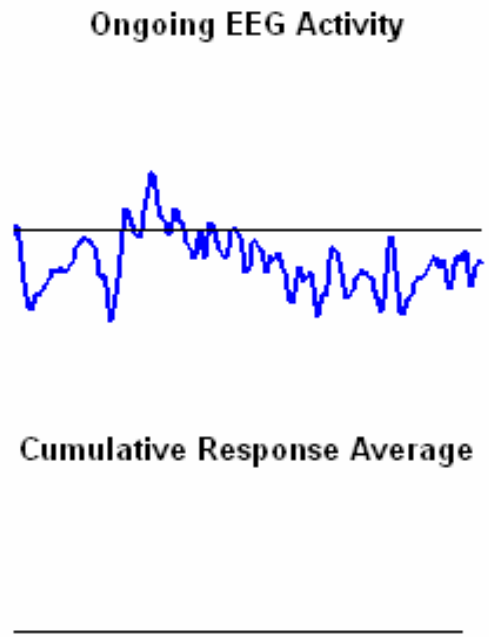


P300 Matrix Speller

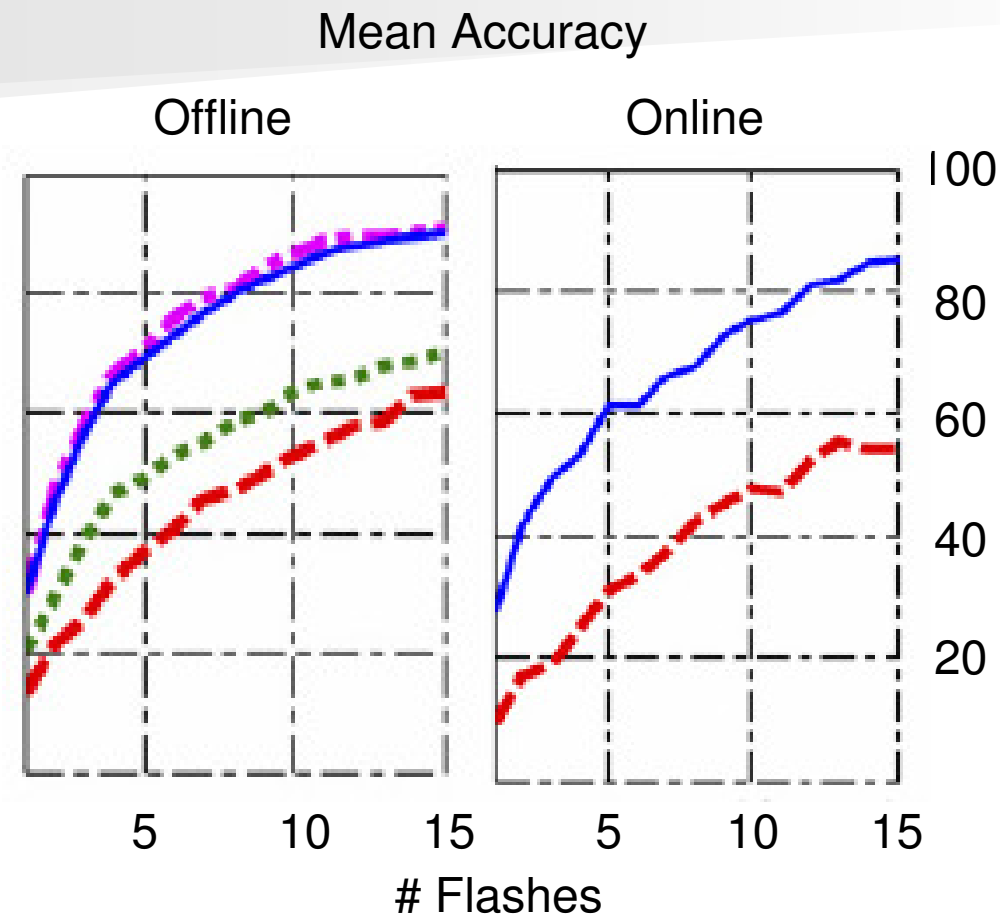


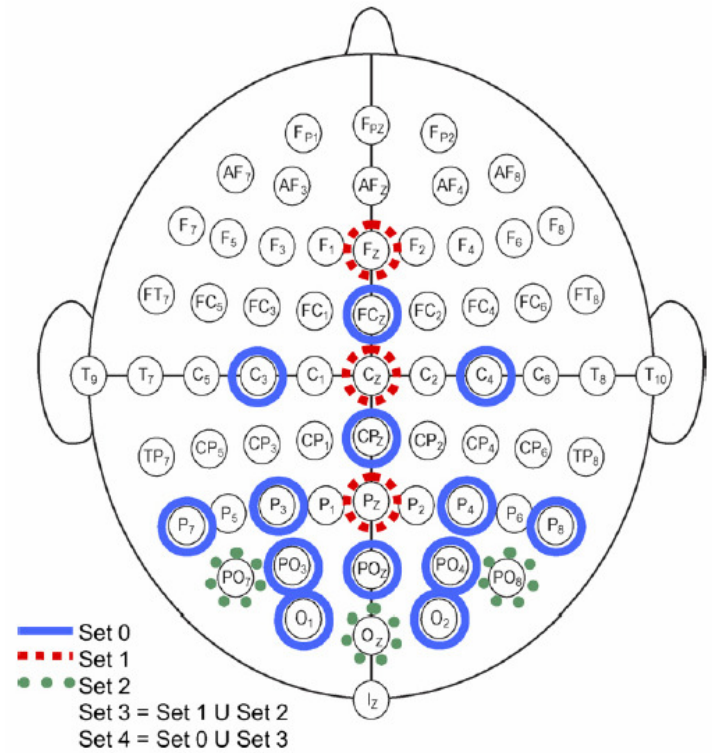
P300 Evoked Potential





P300 Processing





Krusienski et al, J Neuro Meth 2008

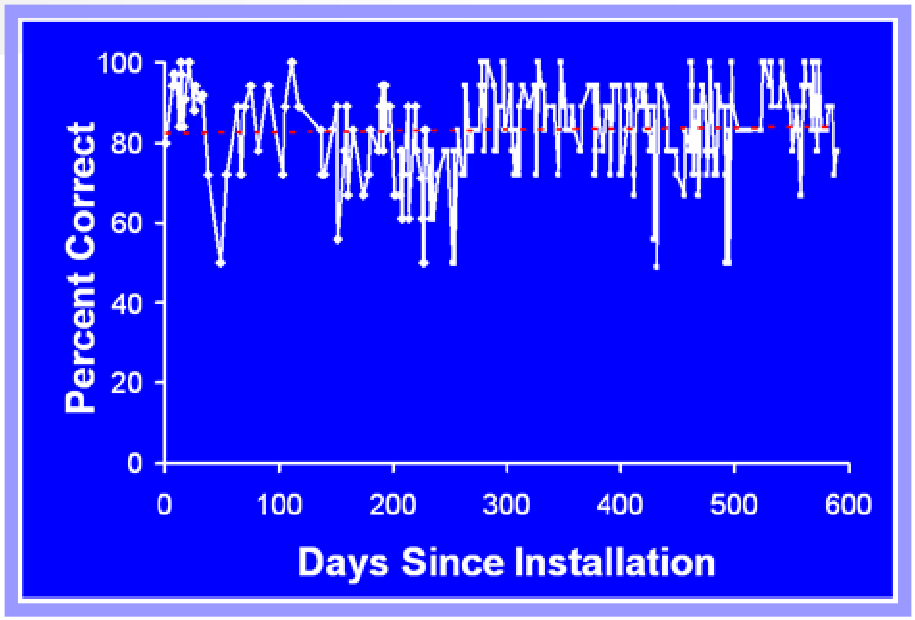
P300 Processing

- 800ms Responses
- Smooth and Decimate to 20Hz
- Stepwise Linear Discriminant Analysis

$$\text{predicted row} = \underset{\text{rows}}{\arg\max} \left[\sum_{i_{\text{row}}} w \cdot f(x_{i_{\text{row}}}) \right]$$

$$\text{predicted column} = \underset{\text{columns}}{\arg\max} \left[\sum_{i_{\text{column}}} w \cdot f(x_{i_{\text{column}}}) \right]$$

P300 Home System



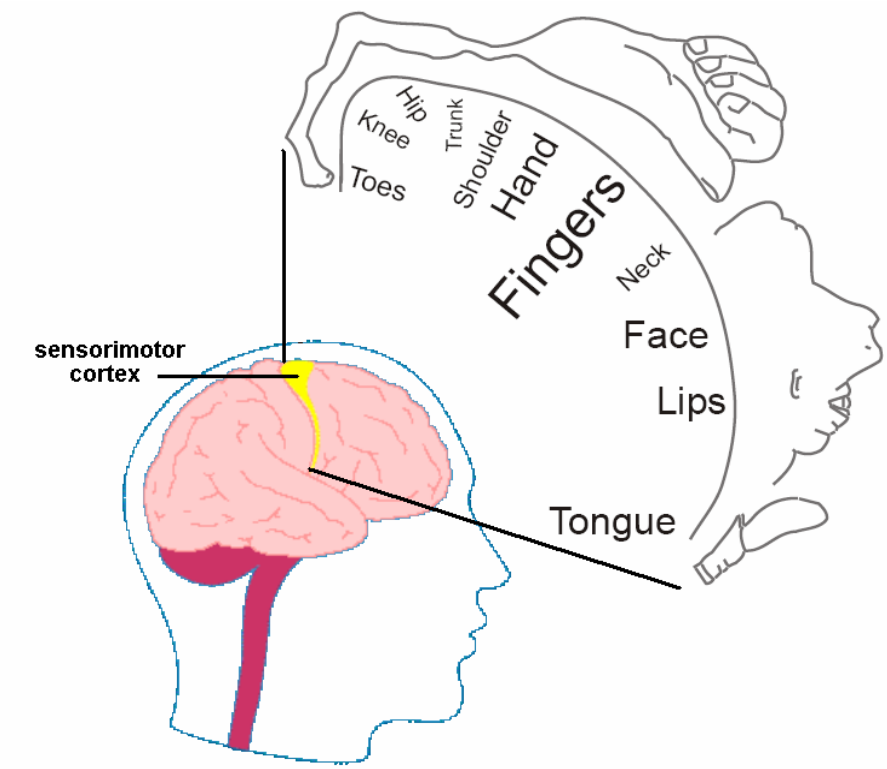
Scott Mackler MD, PhD

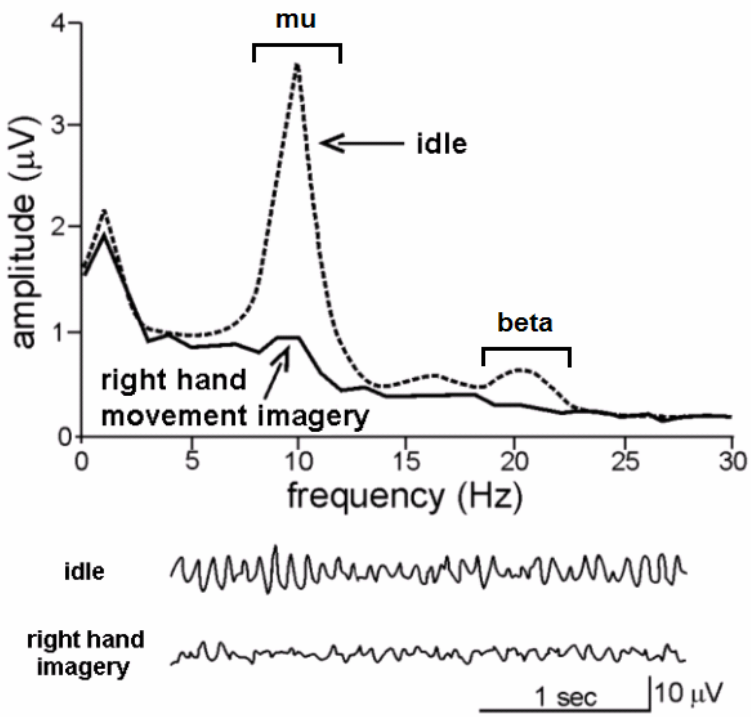
University of Pennsylvania

School of Medicine

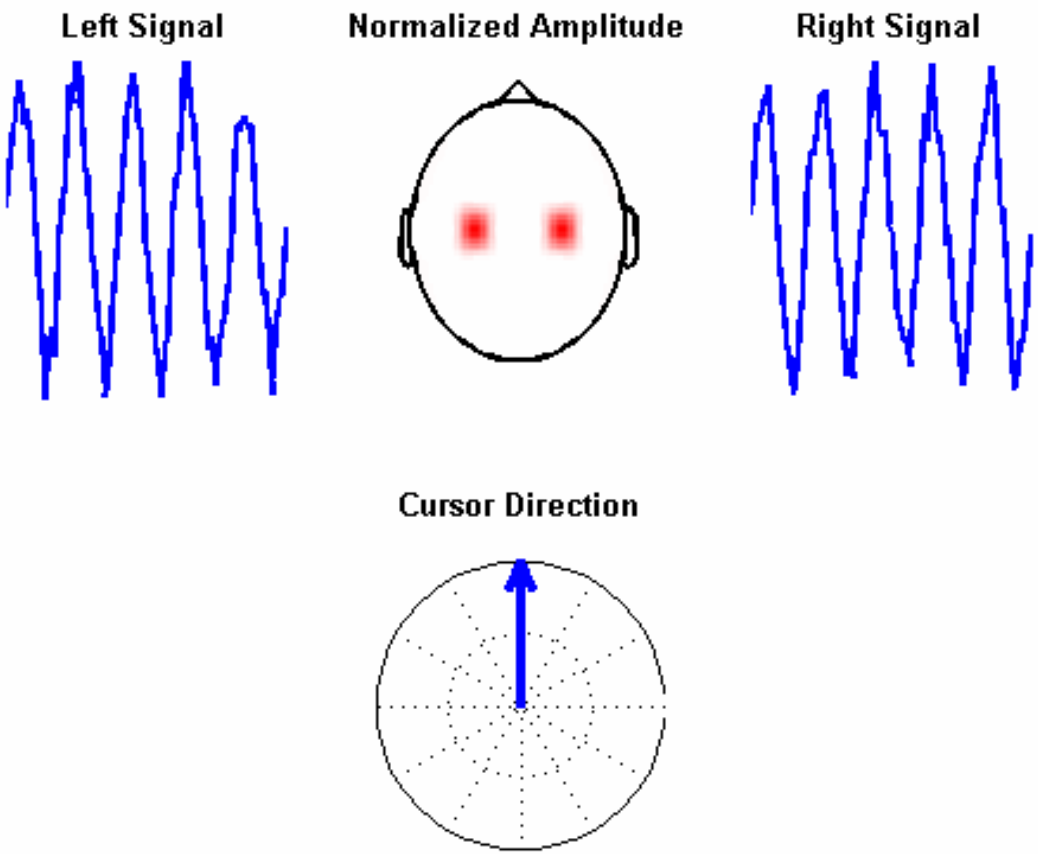
SMR: 2D Cursor Control

Sensorimotor Rhythms



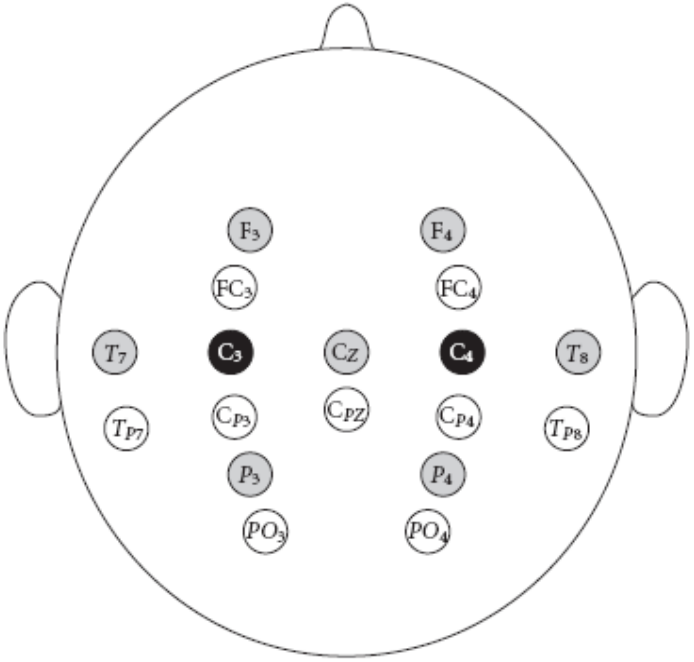


SMR Processing



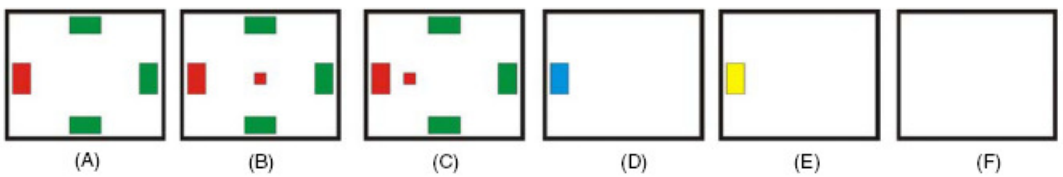
SMR Processing

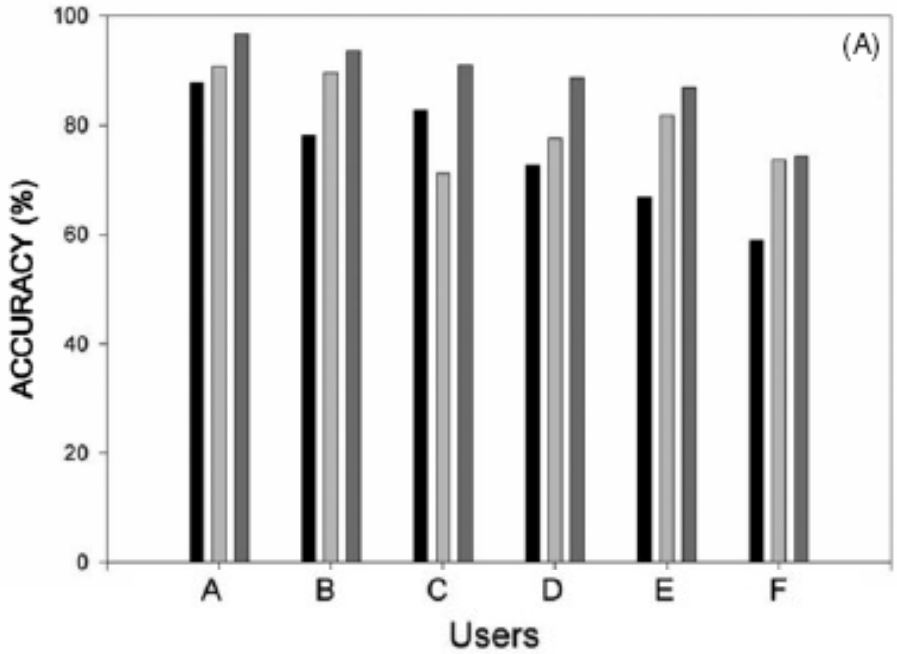
- Large Laplacian Spatial Filter
- 16th Order Autoregressive Spectrum Estimation
- LMS Adaptation of Feature Weights

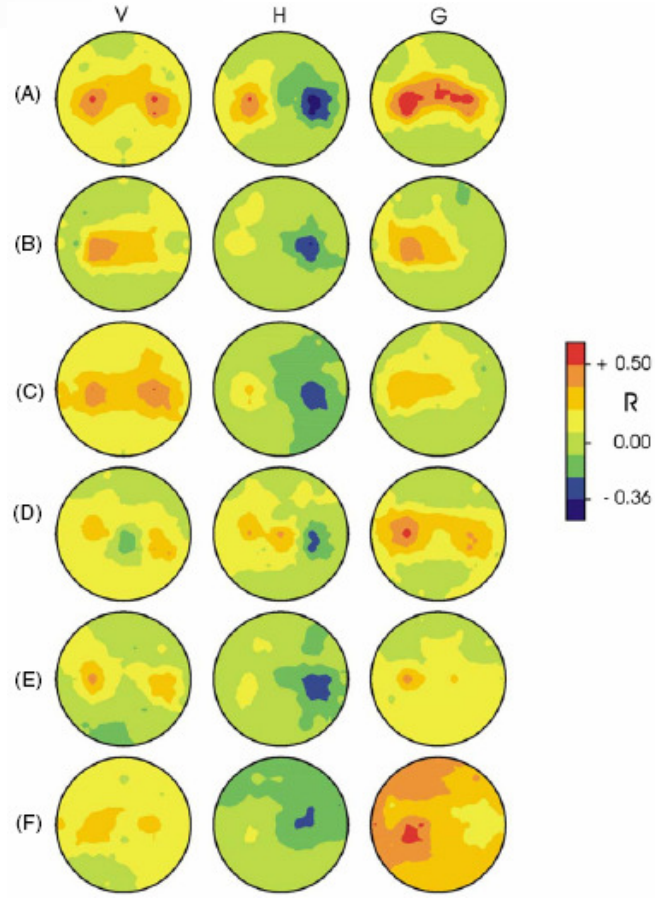


$$\Delta_{xy} = K\left(\sum_{f_L} w_L^f A_L^f + \sum_{f_R} w_R^f A_R^f + b \right)$$

Mouse Emulation

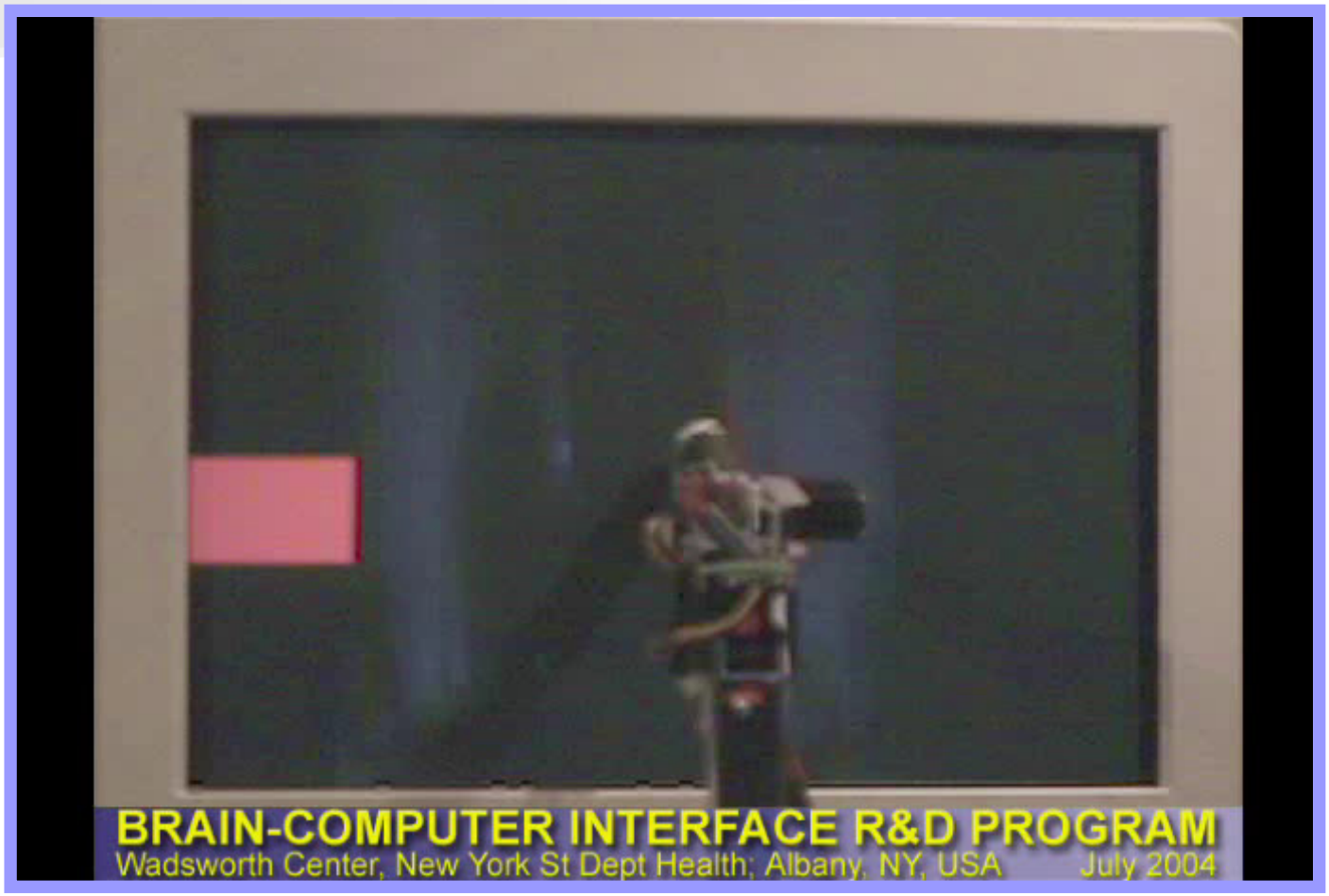






McFarland et al, J Neural Eng 2008

Robotic Arm


BRAIN-COMPUTER INTERFACE R&D PROGRAM
Wadsworth Center, New York St Dept Health; Albany, NY, USA
July 2004

Present and Future

- Refine P300 & SMR Control
- Home System
  - Practical Considerations: Software & Maintenance
- 3-D/N-D EEG-Based Control
- ECoG
  - Attention
  - Speech
  - Motor Activity

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