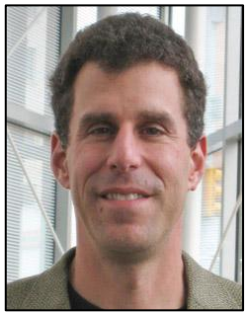
Connectome

Connecting Minds

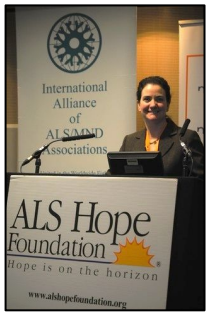
Khaled Alhendi, Nate Bender, Kevin Garrone, Sheik Hassan, Kennan Meyer, Jon Schuck, Bairavi Venkatesh

Advisor



Jeff Salvage

Stakeholder



Sara Feldman

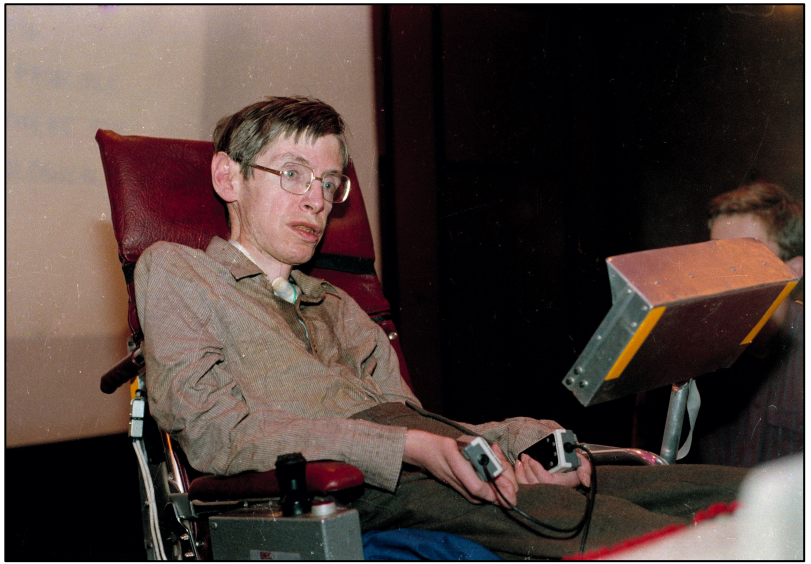
Imagine not being able to tell your family that you love them...

Targeted Users

- ALS patients
- Patients with limited mobility
- Initial symptoms include loss/impairment of:

  -Speech
  -Swallowing
  -Movement of arms
  -Extremities

- Patients have an ever declining quality of life



Existing Solutions

- Assistive technologies:
  - Eye Tracking
  - Sip and Puff System
  - Brain Computer Interface (BCI)
- Research grade BCIs are:
  - Expensive ($20,000+)
  - Time consuming to set up

Is there a cost-effective BCI option for recreational applications?

Emotiv EPOC+

Hardware:

- 14-channel wireless EEG
- Designed for contextualized research and advanced brain computer interface applications
- $800 and widely available

Connectome

A hardware/software solution specifically designed to allow a person with ALS to communicate with friends and family using social media - specifically Twitter

Connectome Demo

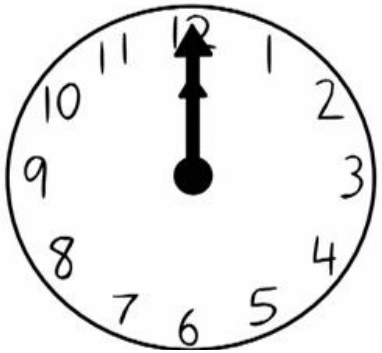
Live Demo

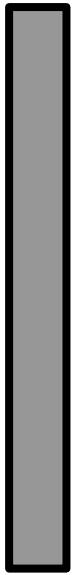
Training Paradigms

USER TRAINING

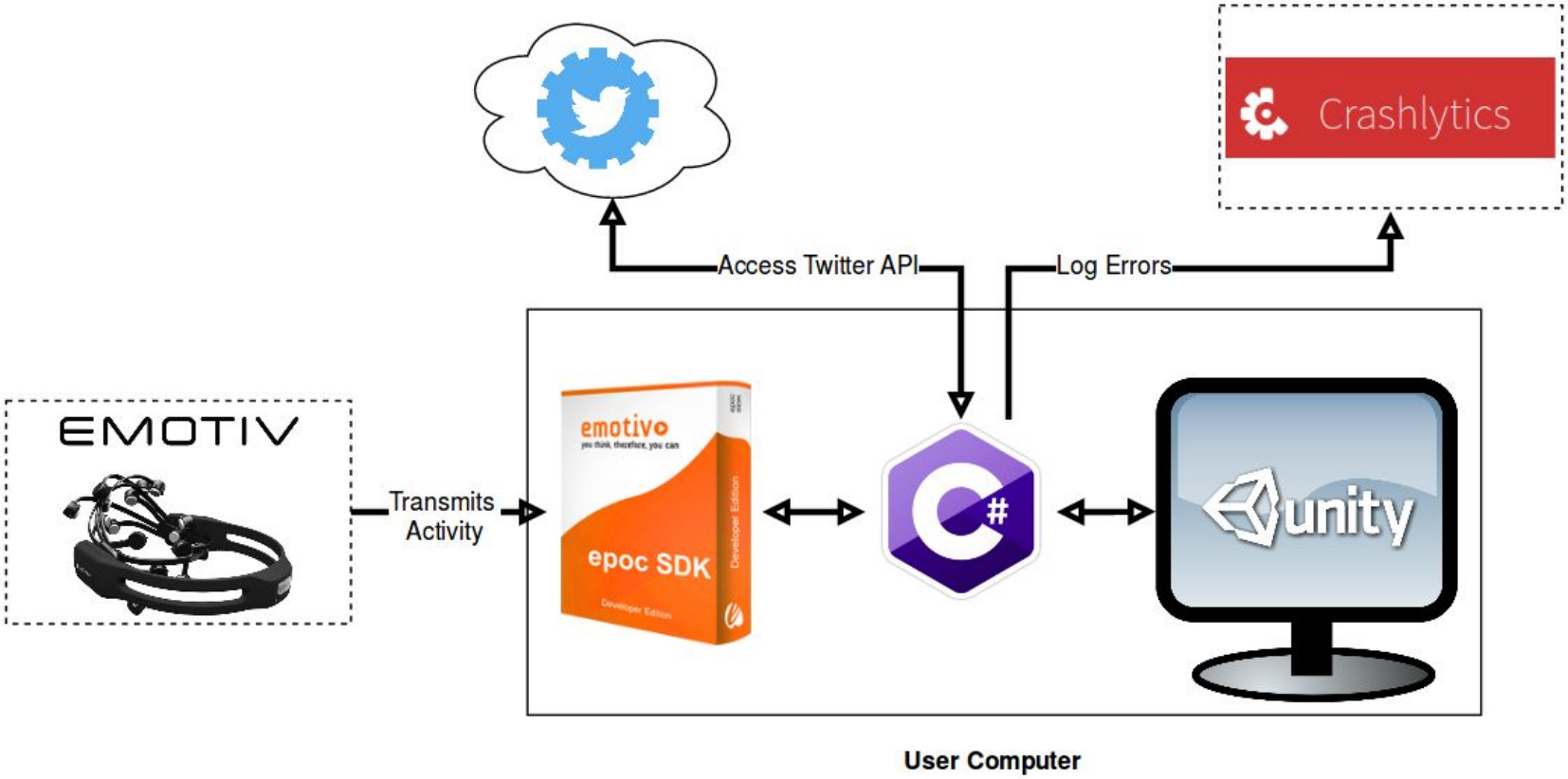
Adaptive Learning

DURATION + **POWER** + **ACCURACY**



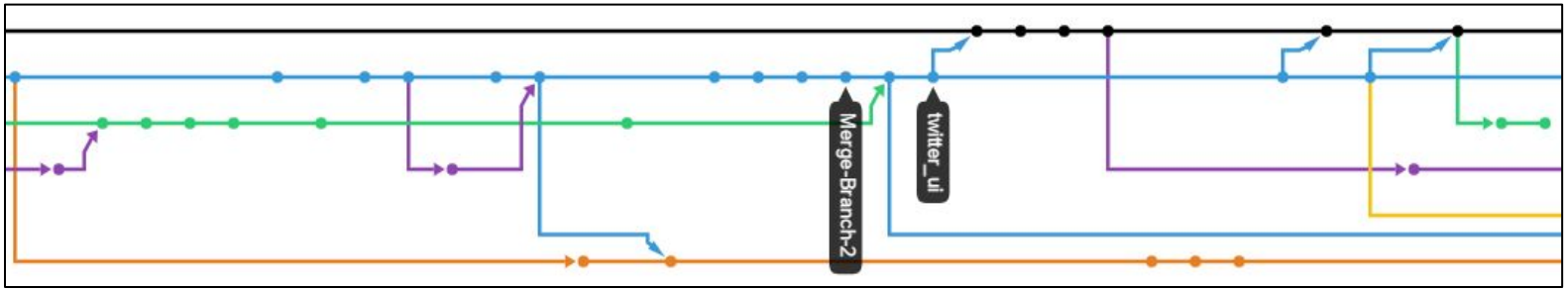


Technologies



Development Tools

IMPLEMENTATION



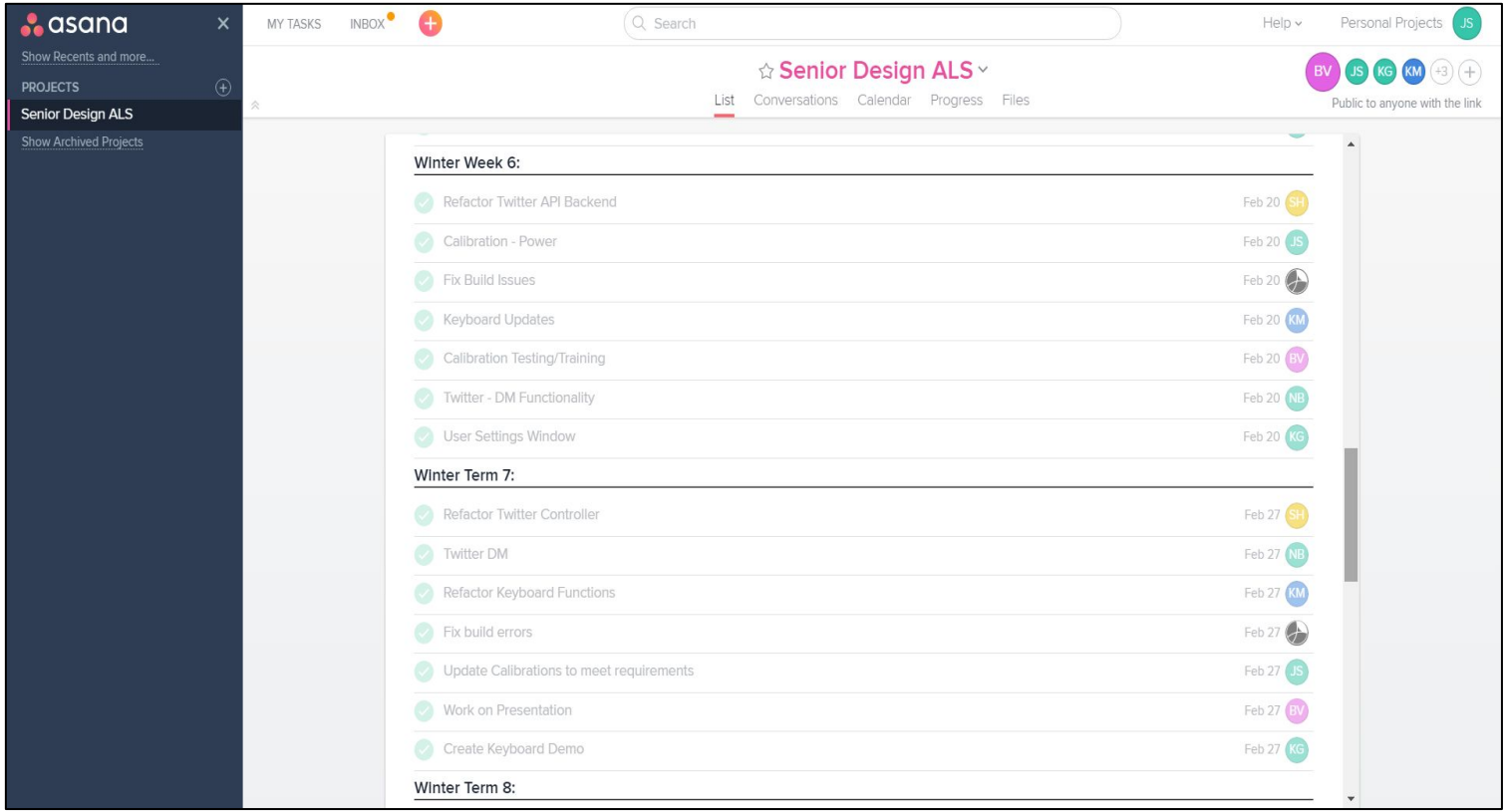
Development Tools

IMPLEMENTATION

	32 Open	20 Closed	Author	Labels	Projects	Milestones	Assignee	Sort
	Tweet information not displayed after clicking older tweets #63 opened 4 days ago by hassanNS						
	Don't allow users to message people that aren't their friends. #62 opened 5 days ago by TheBenderman						
	Selection manager doesn't deactivate when logging out #61 opened 5 days ago by TheBenderman						2
	Twitter Profile Issue - Tweets menu, some buttons don't work, others don't do anything #56 opened 8 days ago by TheBenderman						
	Twitter Conversations Issue - Back button bad behaviour #55 opened 8 days ago by TheBenderman						1

Development Tools

IMPLEMENTATION



asana

Standards

- **Software:**
- UML 2.0 Standard
- Microsoft C# Coding Conventions
- Nielsen's Ten Heuristic Principles
- Shneiderman’s Eight Golden Rules

- **Clinical:**
- 21 Code of Federal Regulations
  - Protection of Human Subjects

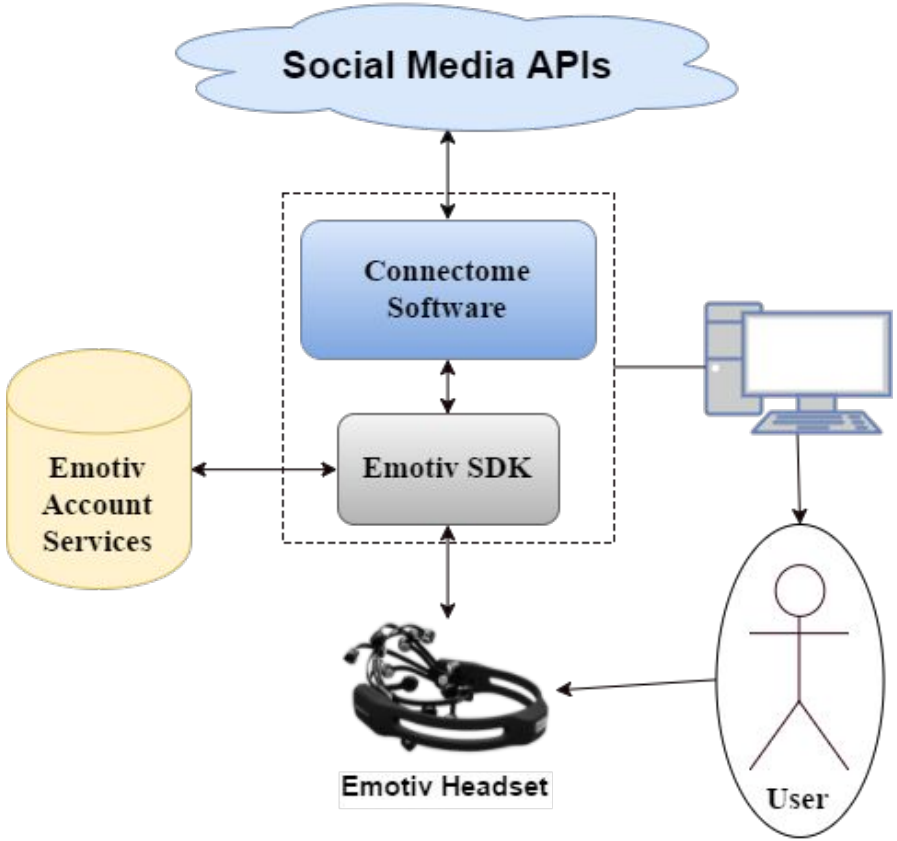
Software Engineering Institute

Best Practices

- Variable Naming Conventions
- **Decentralized Version Control**
- Exception Handling
- Paired Programming
- **Develop Iteratively**
- **Component Architectures**
- **Design Patterns**

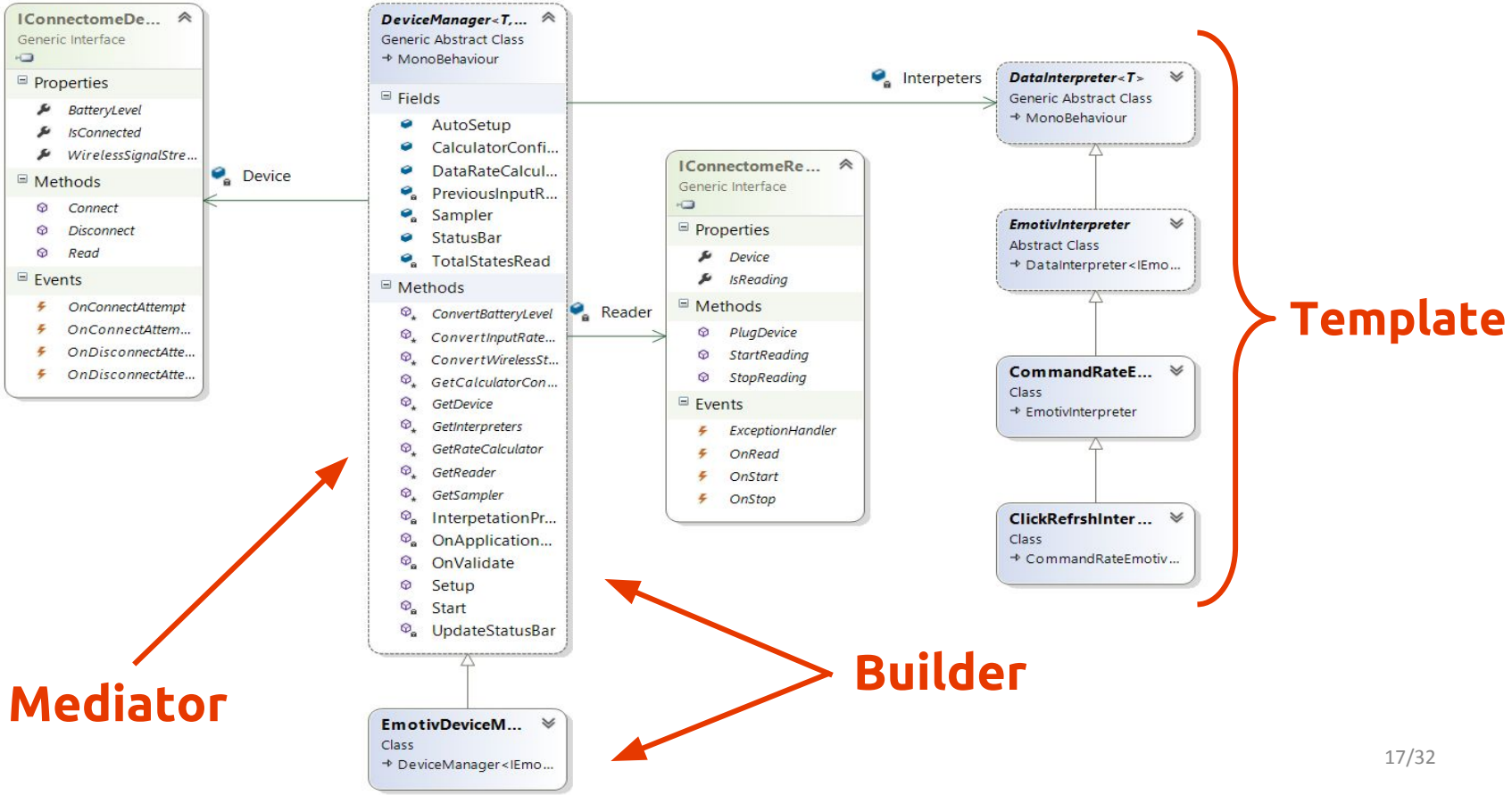
System Architecture

IMPLEMENTATION



Design Patterns

IMPLEMENTATION



Keyboard

Configurable **:**

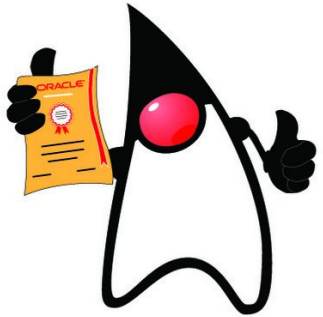
- JSON

Interchangeable **:**

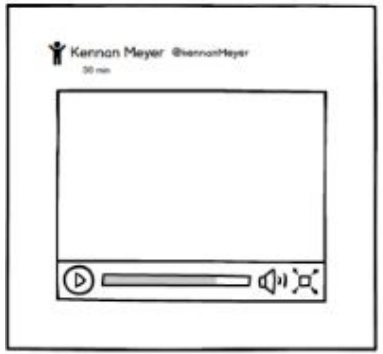
- Grid
- QWERTY
- Phrases

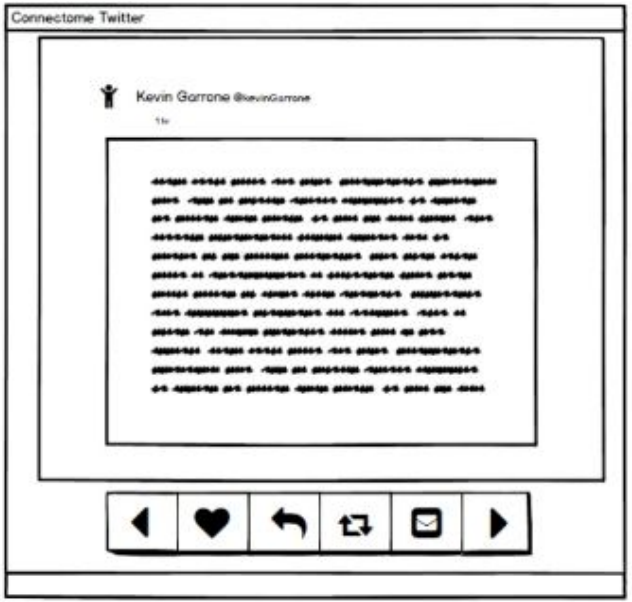
Alternative Designs

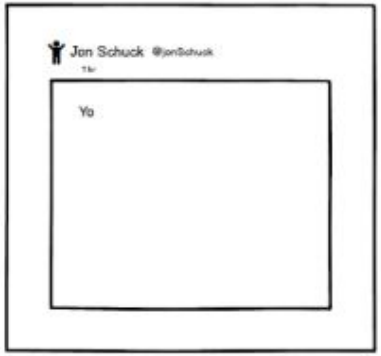
- **Web Application**
  - Pros: Social Media APIs, ease of impl.
  - Cons: Send Emotiv data over connection
- **Desktop Application with JS/HTML**
  - Pros: Social Media APIs
  - Cons: Emotiv SDK, Arch. technologies
- **Java Desktop Application with Swing**
  - Pros: Emotiv SDK, ease of implementation
  - Cons: UI Development, Social Media APIs

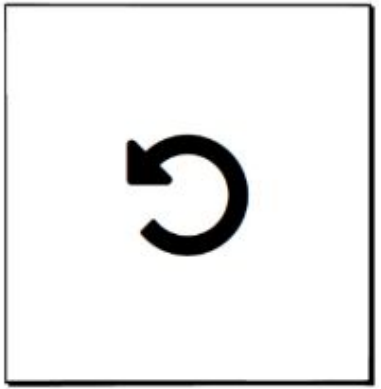


Alternative Designs



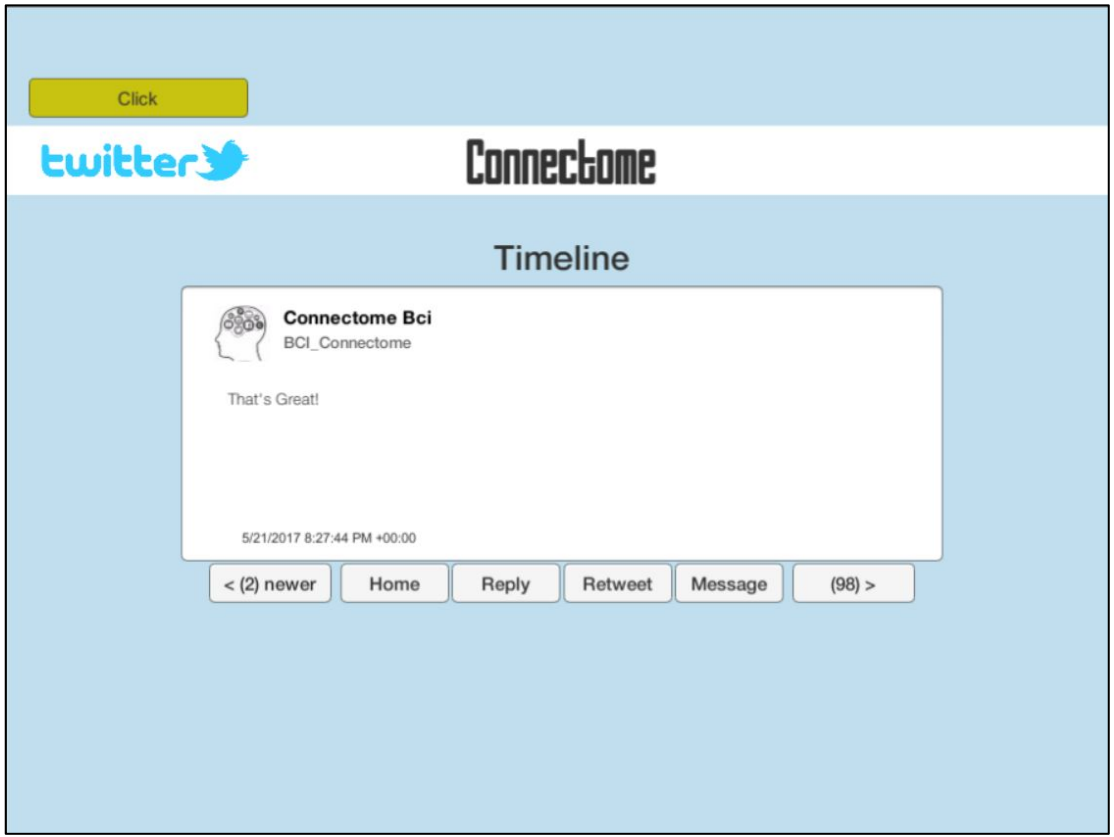






Alternative Designs

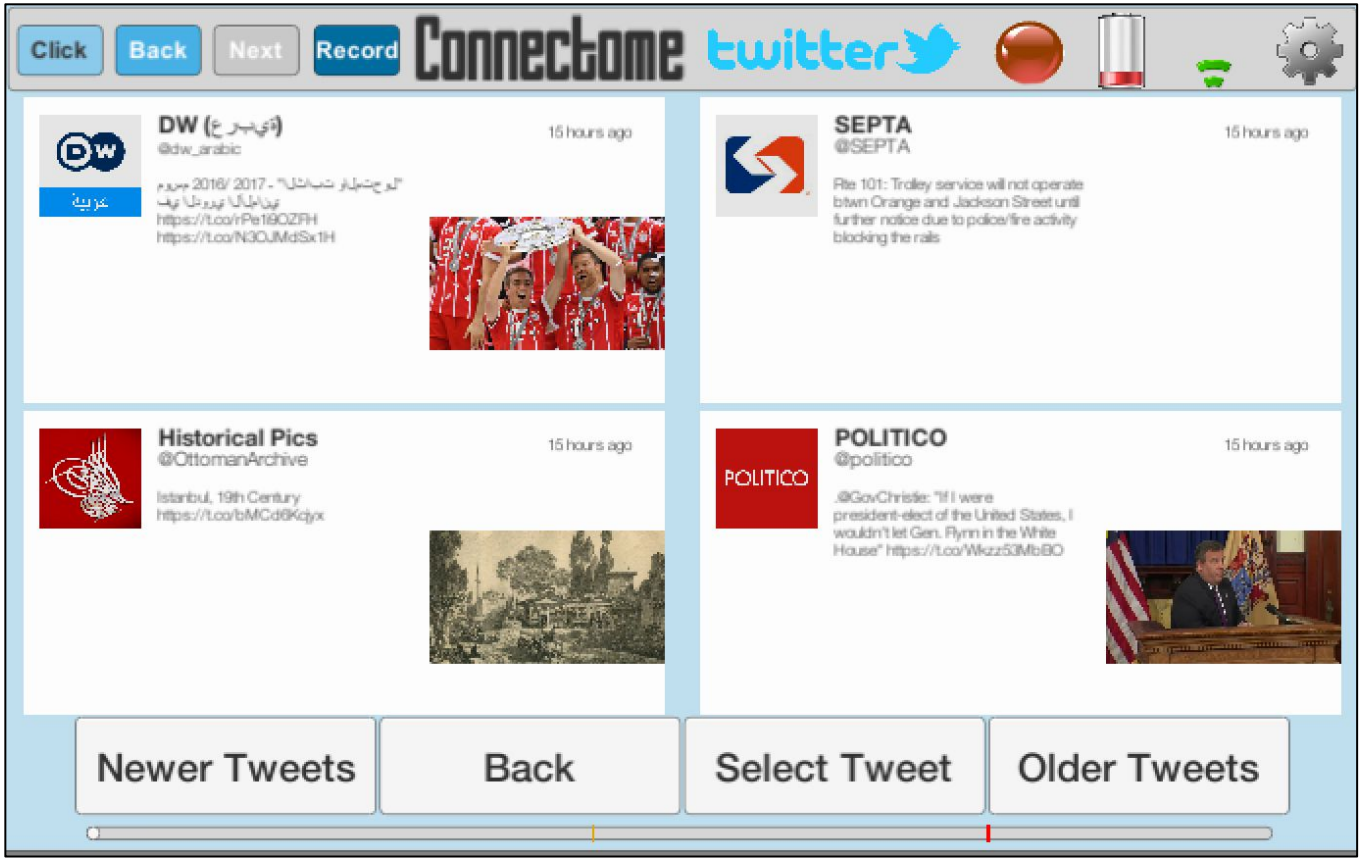
IMPLEMENTATION



Alternative Designs

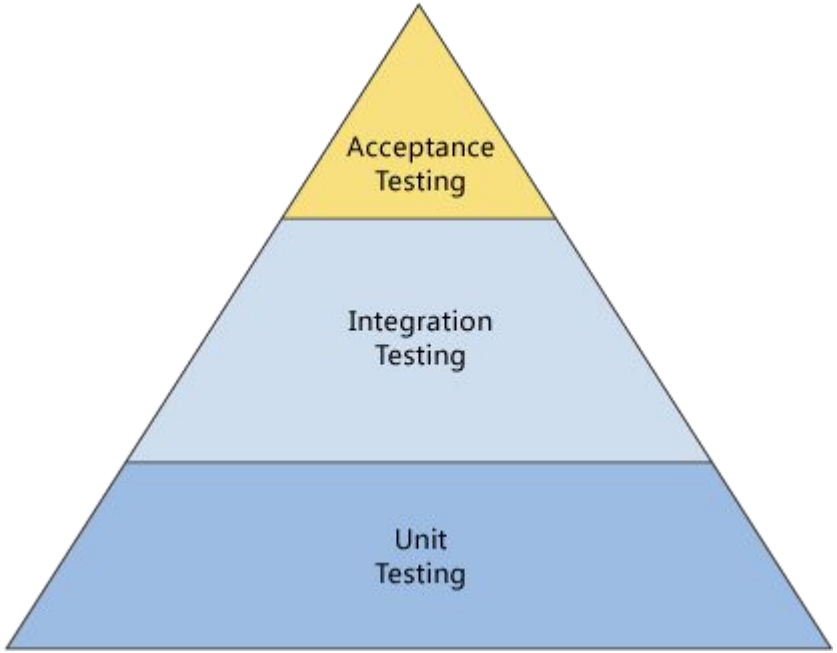
Alternative Designs

IMPLEMENTATION



Testing

- **Software**:
  - Unit
  - Integration
  - Performance
  - Acceptance
- **User:**
  - Internal
  - Patient



Testing - Procedure

- Subjects
  - 6 Connectome Team Members
  - 2 ALS Patients
- Objectives
  - Standardized Approach
  - Comfort Patient
  - Test Multiple Paradigms
- Format

  1) Equipment and Software Setup

  2) Create Emotiv Profile

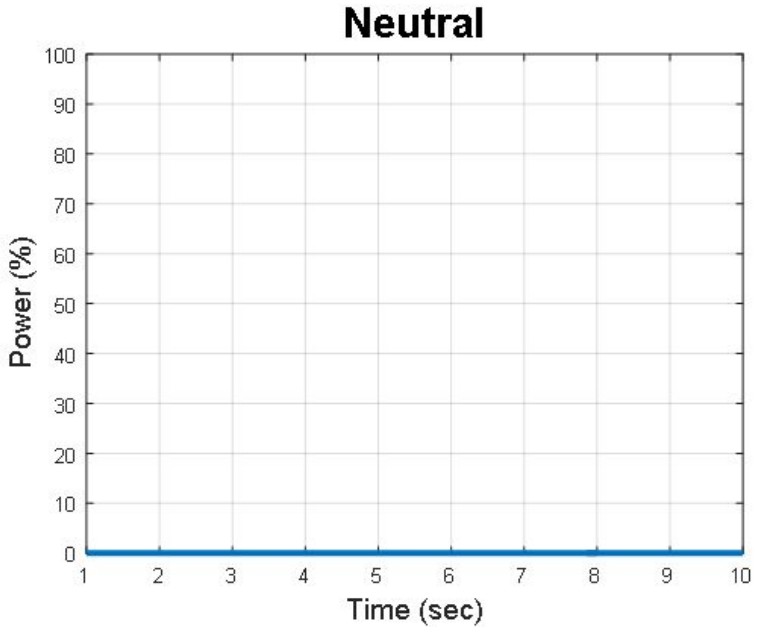
  3) Complete Adaptive Training

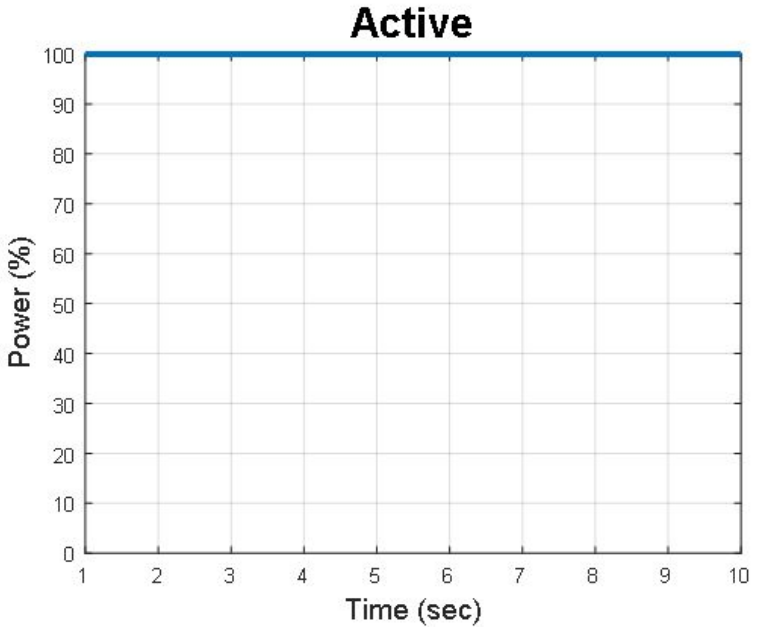
  4) Attempt Twitter

Testing

Results - Ideal

TESTING

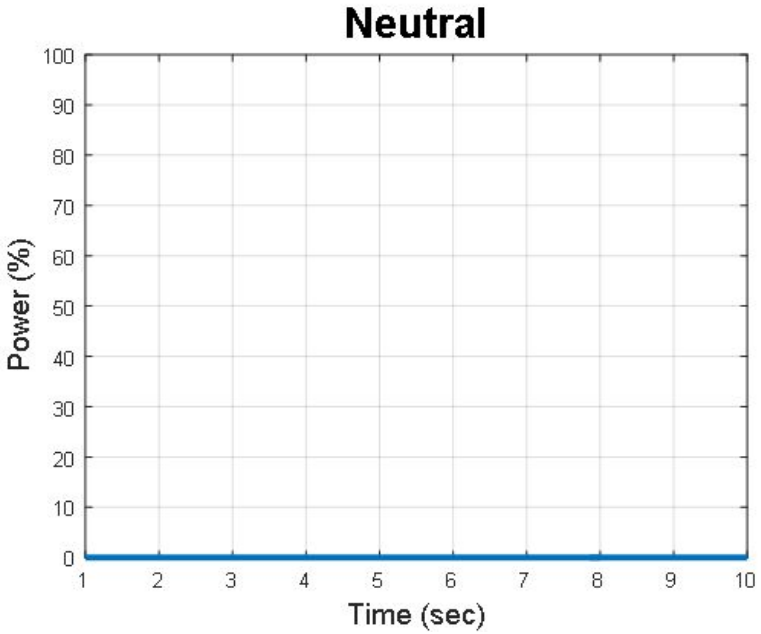


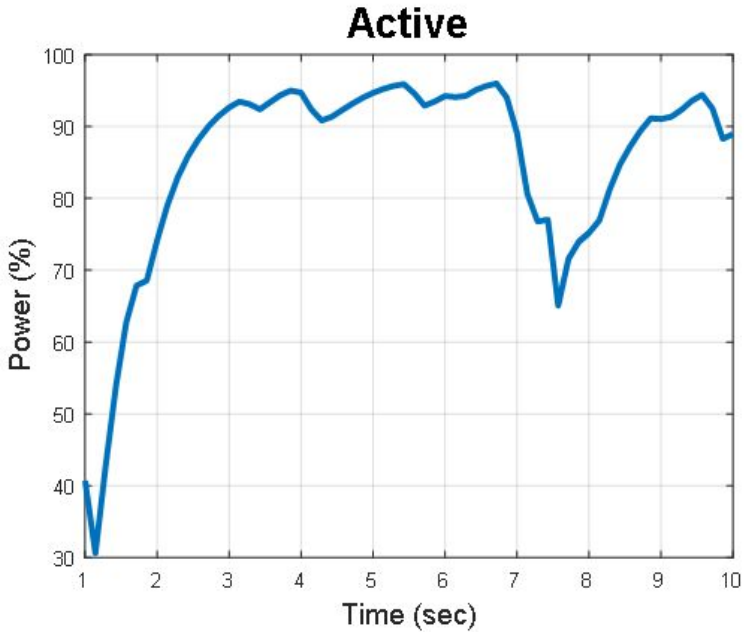


No false positives in either Neutral or Active states

Results - Type A

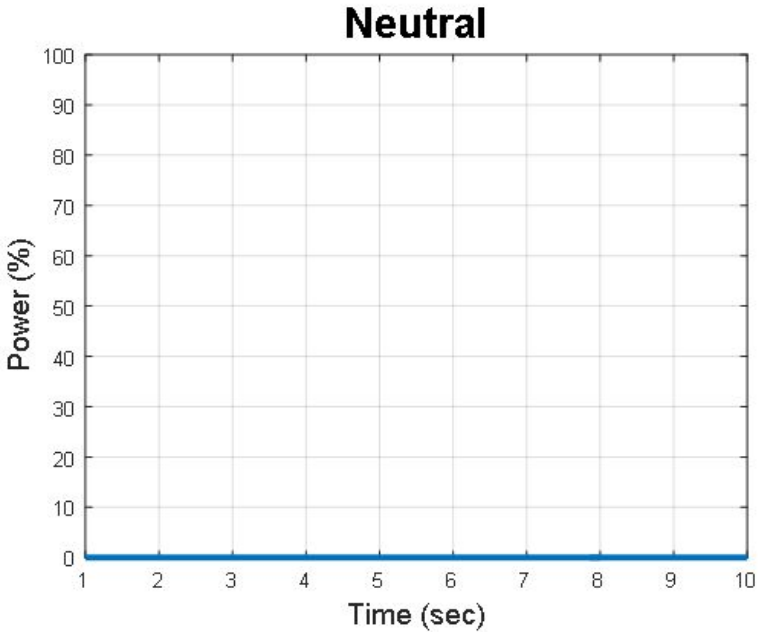
TESTING

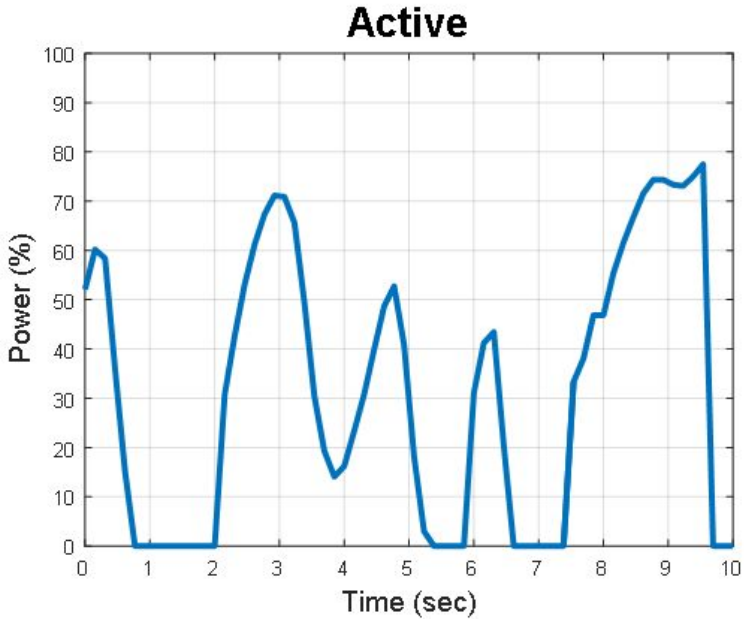




Results - Type B

TESTING

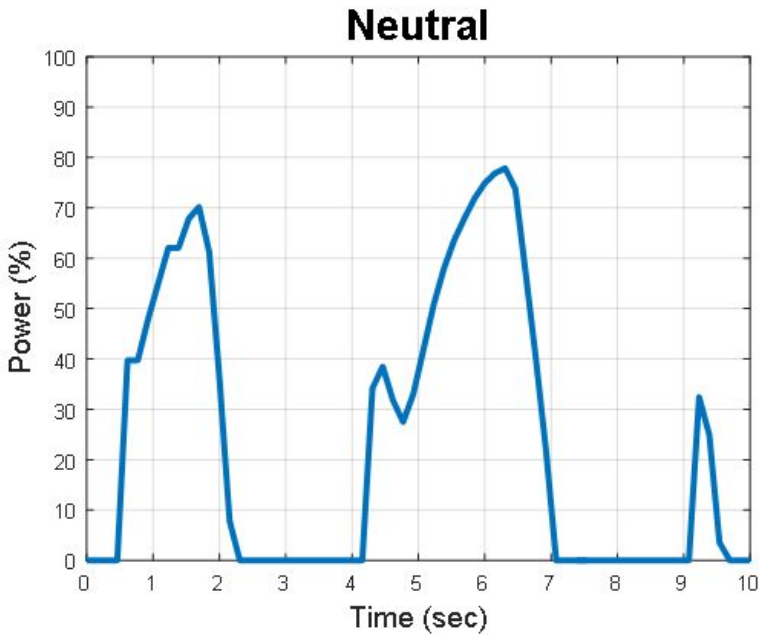


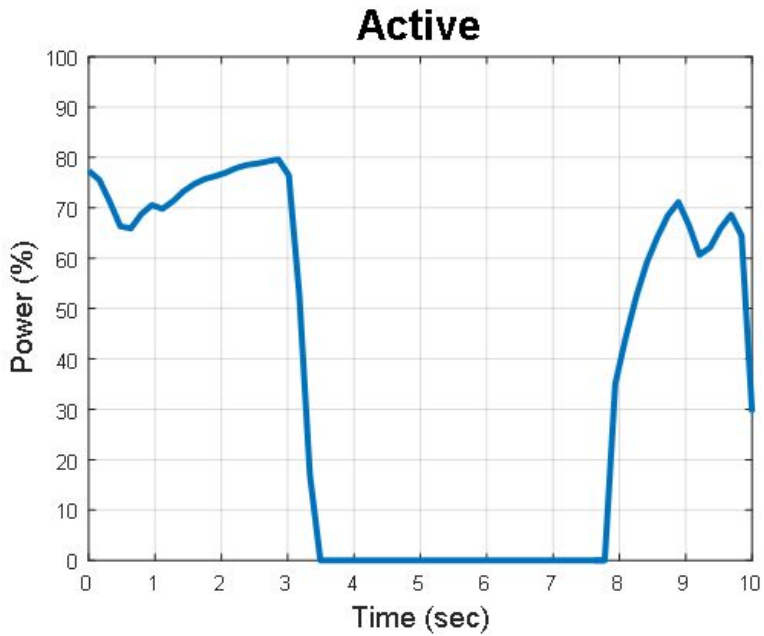


- Active state is maintained, but with intermittent false positives

Results - Type C

TESTING



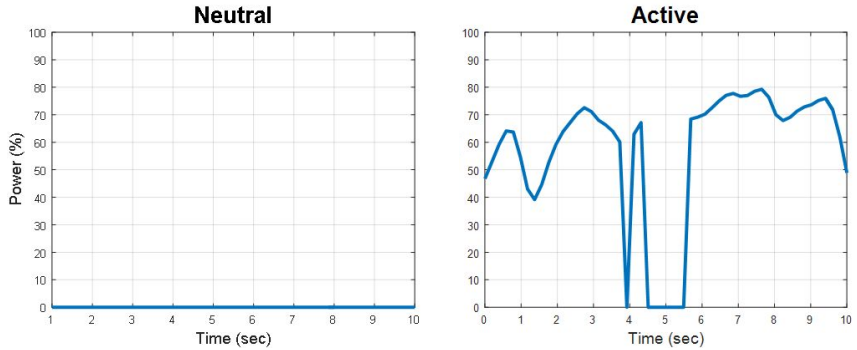


Many false positives in both Neutral and Active states

Results - ALS Patients

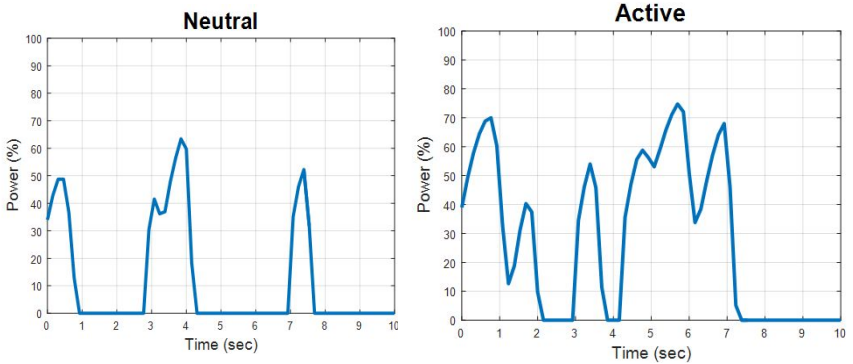
TESTING

Subject 1



TYPE B

Subject 2



TYPE C

Further Training Necessary

Questions?

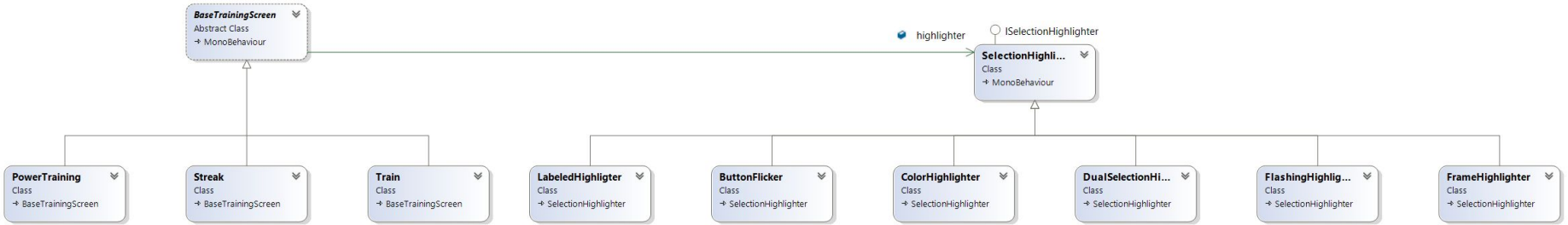
BACKUP

QUESTIONS

Design Patterns

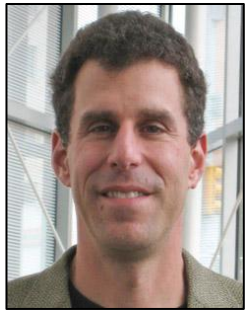
IMPLEMENTATION

Bridge



Use Cases

USER TRAINING



User 1:

Training Results:

- High Accuracy Score
- Low Power Score

User 2:

Training Results:

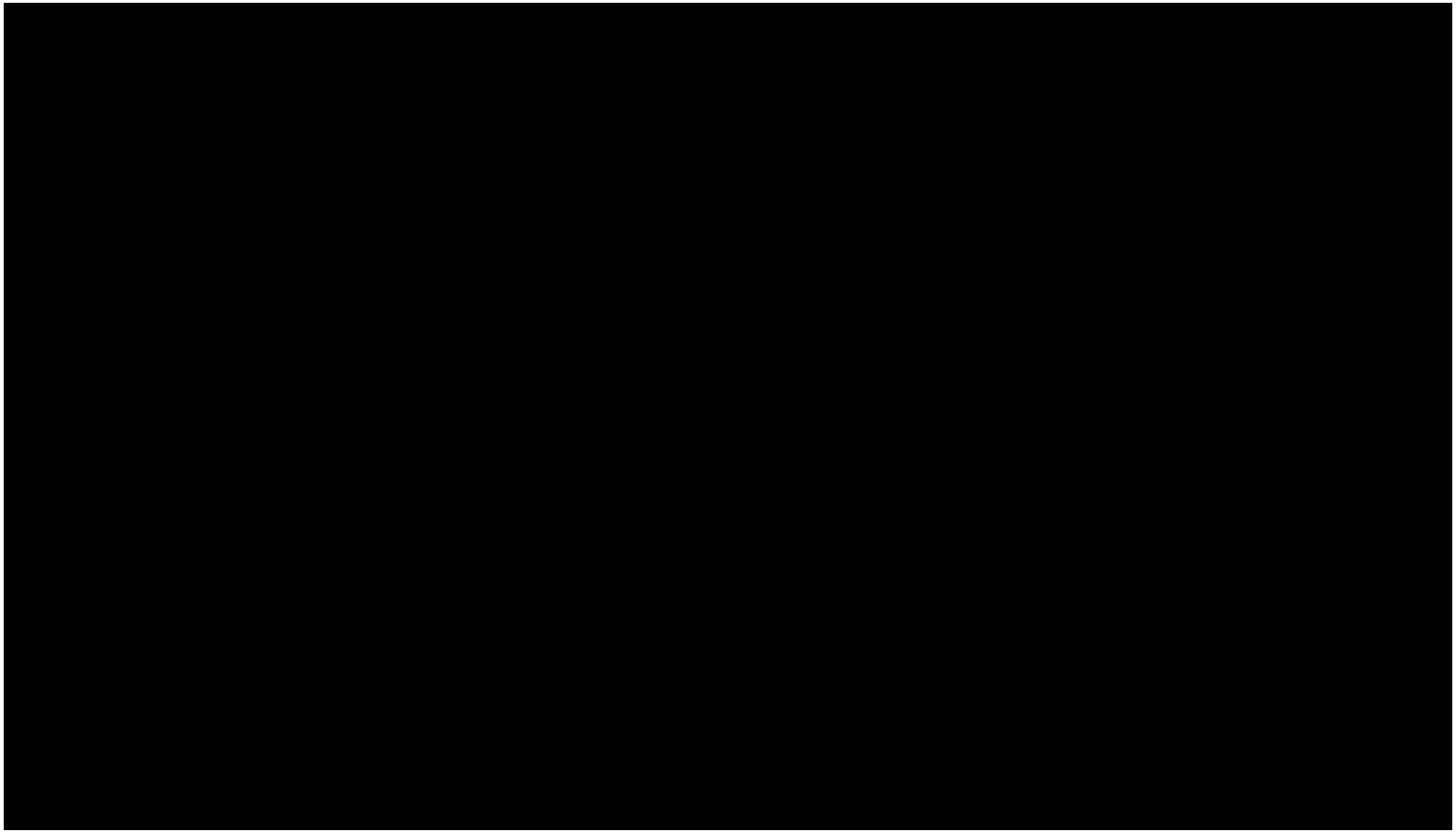
- Low Accuracy Score
- High Power Score

Future Directions

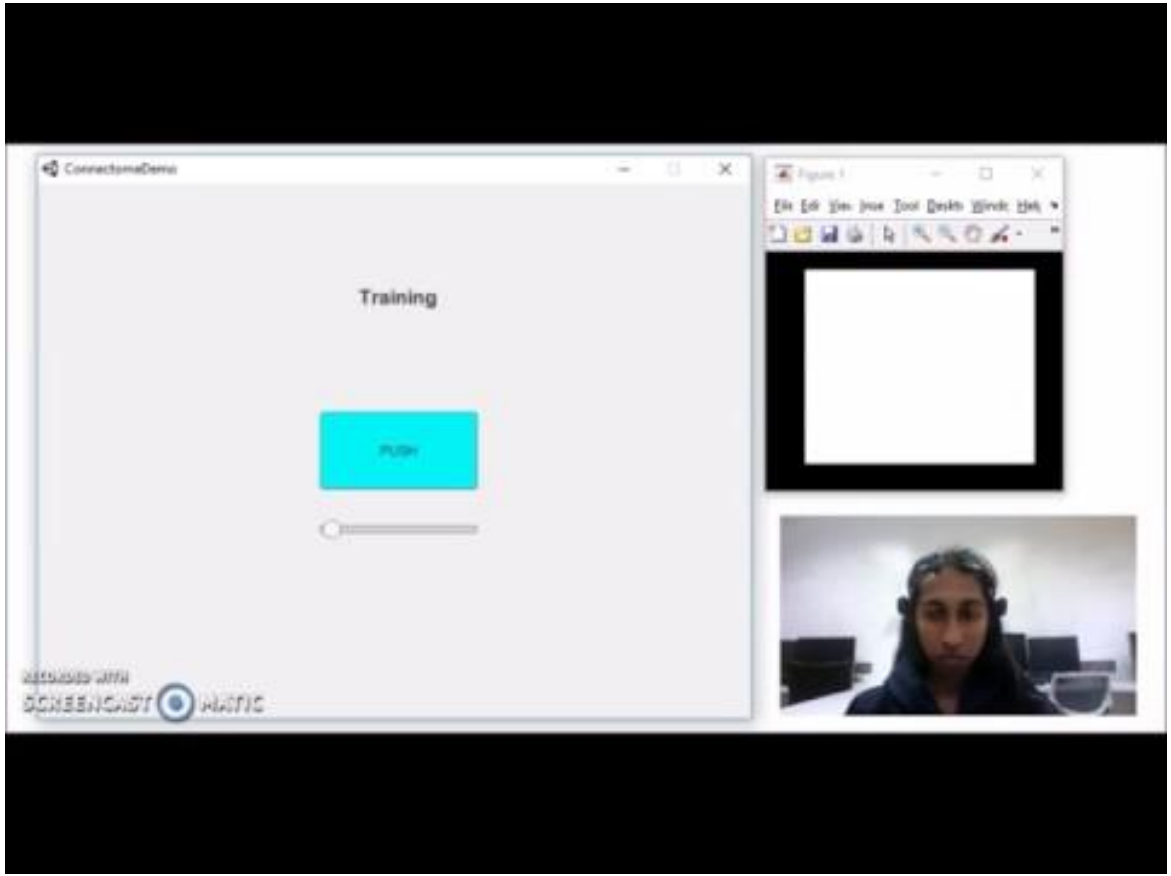
TESTING

- Conduct more testing across a wider subject pool
- Collect raw EEG data
- Test different data interpreters to robustly create slider thresholds
- Dynamic User Settings
- Improved Keyboard
- Adaptive Training Improvements
- Additional Social Media Implementations

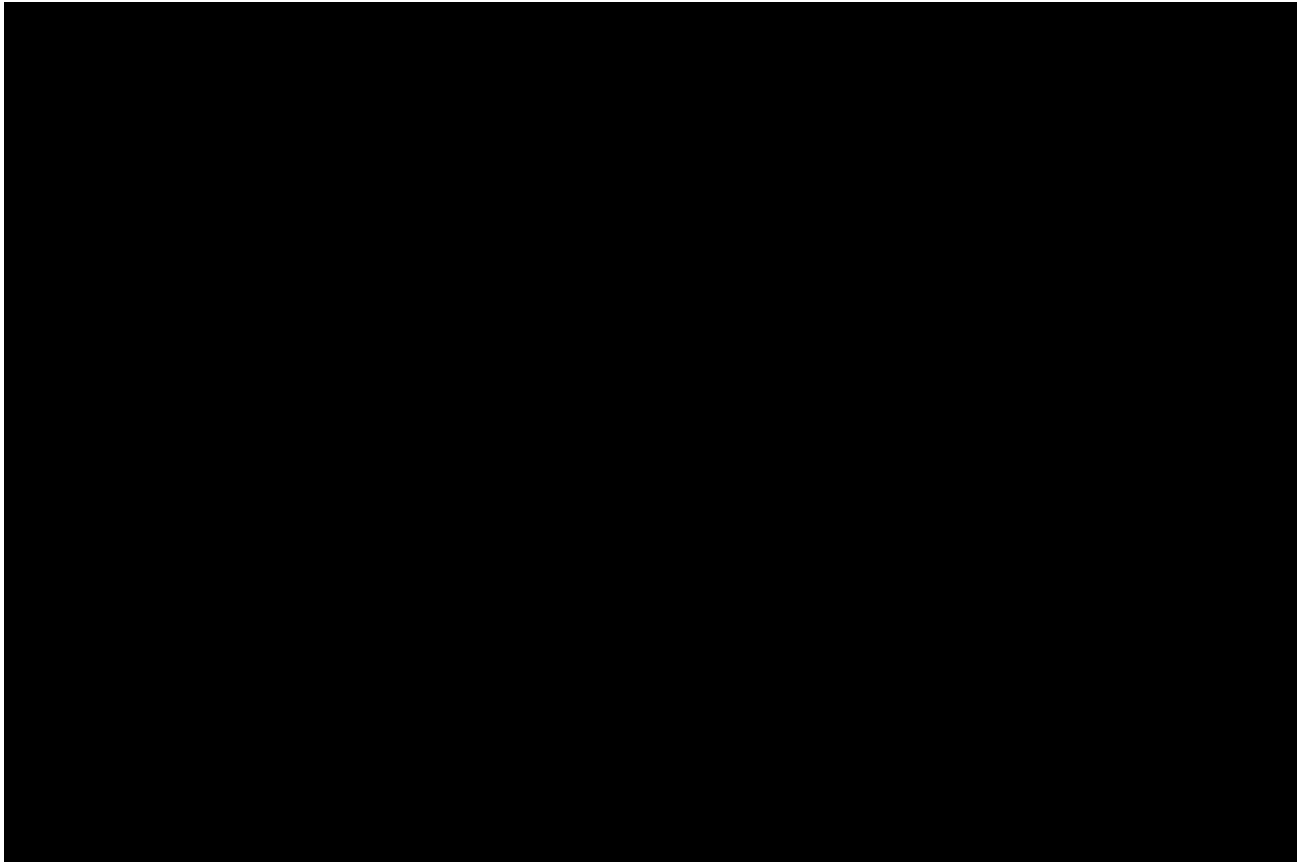
Twitter Demo



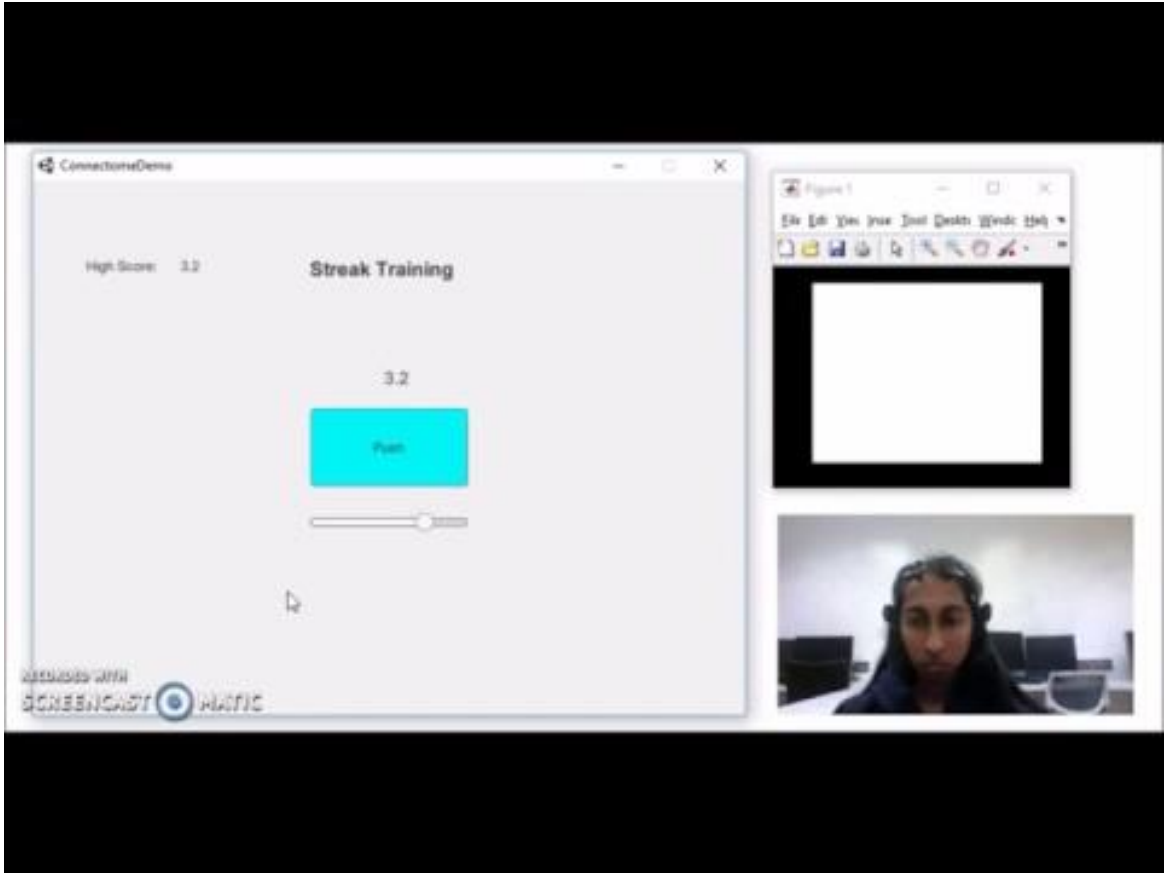
Adaptive Training - Accuracy



Adaptive Training - Power



Adaptive Training - Streak



ALS Patient Testing

- **Sample Size** = ~ 1
- **Testing Location** = Patient's home or Temple University Clinic
- **Duration** = 2 to 4 hours
- **Paradigms** = 1 to 2
- **Procedure**
  - Equipment and Software Setup
  - User Profile Creation
  - Adaptive Training Within Connectome
  - Twitter

Metrics

- Upon command, how many Tweets can a trained user send out in a span of X minutes?
- Is there any improvement in Adaptive Training scores pre and post testing?
- Usability and HCI Concepts for Connectome Application

Hardware Challenges

- Reliability
  -Consistency of commands
  -Signal strength and clarity
  -Sampling rate
  -Noise from EMG electrodes
- Compatibility
  -No cross-device implementation