



Connectome

Connecting Minds

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Advisor



Stakeholder



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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



OVERVIEW

- 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?

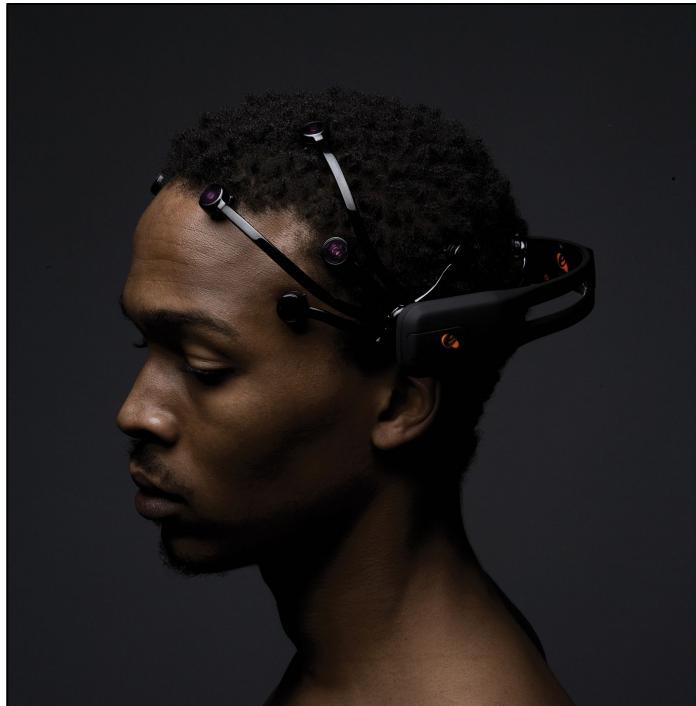
Emotiv EPOC+



OVERVIEW

Hardware:

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



Connectome



OVERVIEW

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



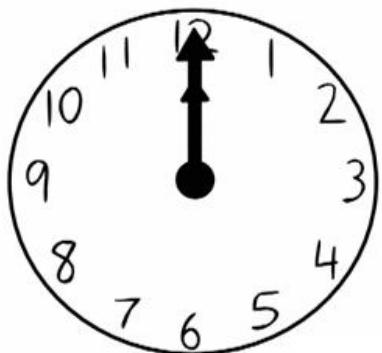
USER TRAINING

Adaptive Learning

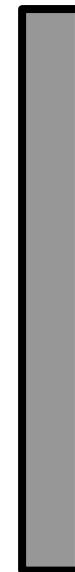


USER TRAINING

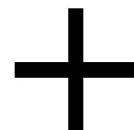
DURATION



POWER



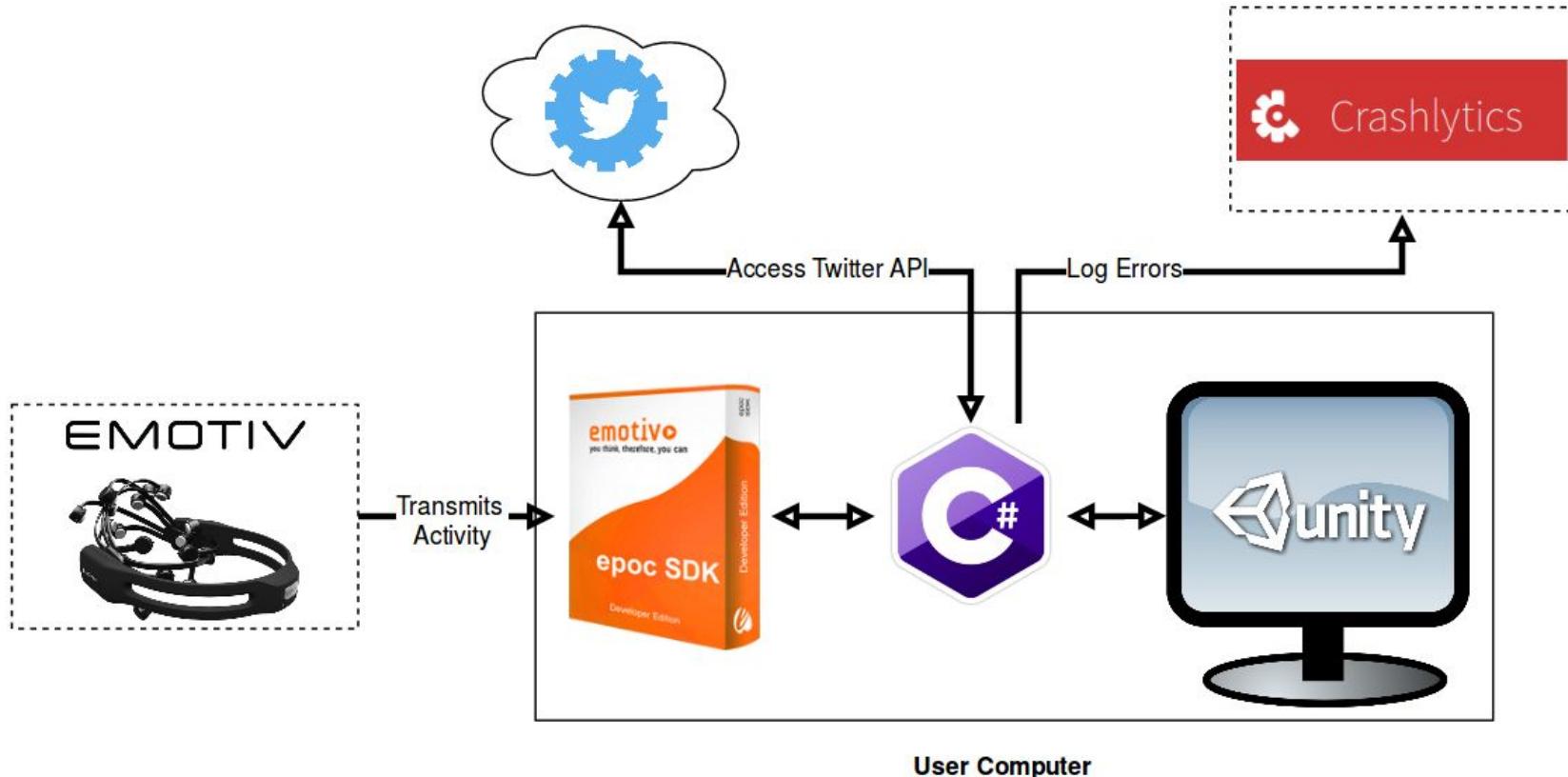
ACCURACY



Technologies



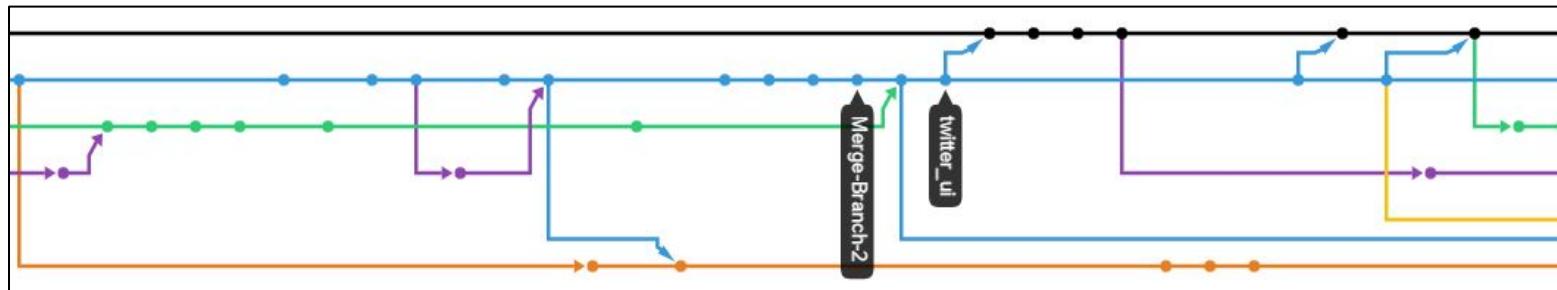
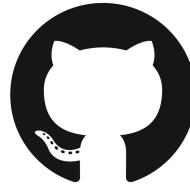
IMPLEMENTATION



Development Tools



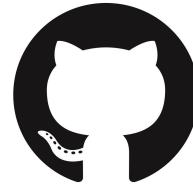
IMPLEMENTATION



Development Tools



IMPLEMENTATION



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

Development Tools



IMPLEMENTATION

The screenshot shows the Asana interface for the 'Senior Design ALS' project. The left sidebar shows 'MY TASKS' and 'INBOX' with a plus sign. The main area displays a list of tasks categorized by week:

- Winter Week 6:**
 - Refactor Twitter API Backend (Feb 20, SH)
 - Calibration - Power (Feb 20, JS)
 - Fix Build Issues (Feb 20, KM)
 - Keyboard Updates (Feb 20, KM)
 - Calibration Testing/Training (Feb 20, BV)
 - Twitter - DM Functionality (Feb 20, NB)
 - User Settings Window (Feb 20, KG)
- Winter Term 7:**
 - Refactor Twitter Controller (Feb 27, SH)
 - Twitter DM (Feb 27, NB)
 - Refactor Keyboard Functions (Feb 27, KM)
 - Fix build errors (Feb 27, KM)
 - Update Calibrations to meet requirements (Feb 27, JS)
 - Work on Presentation (Feb 27, BV)
 - Create Keyboard Demo (Feb 27, KG)
- Winter Term 8:** (No tasks listed)

At the top right, there are sections for 'Personal Projects' and a link to 'Public to anyone with the link'. The Asana logo is located in the bottom right corner of the slide.



Standards



IMPLEMENTATION

- **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



IMPLEMENTATION

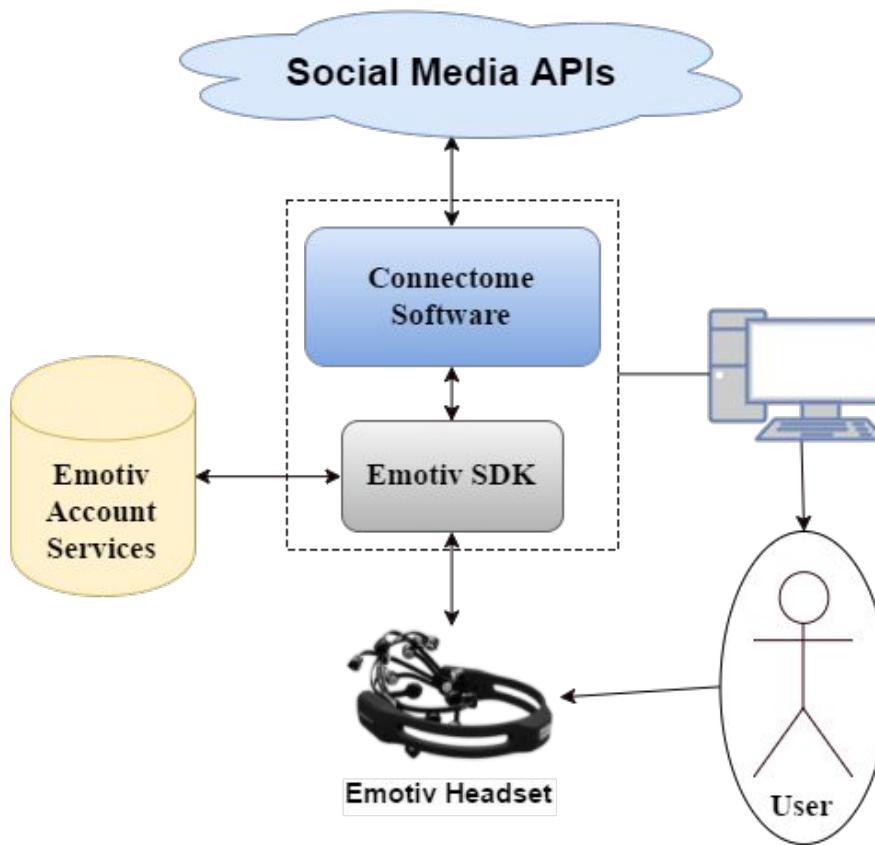
- Variable Naming Conventions
- **Decentralized Version Control**
- Exception Handling
- Paired Programming
- **Develop Iteratively**
- **Component Architectures**
- **Design Patterns**



System Architecture



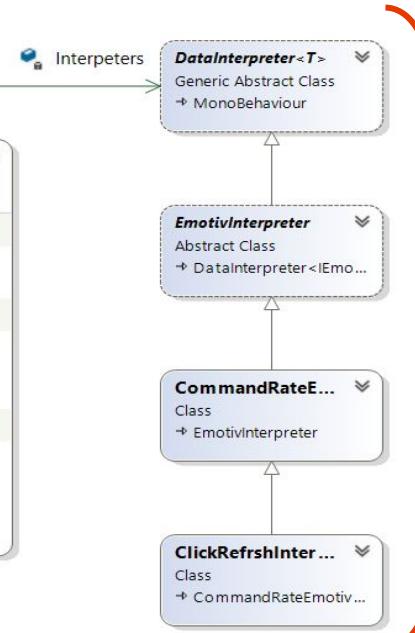
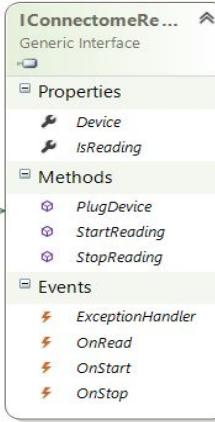
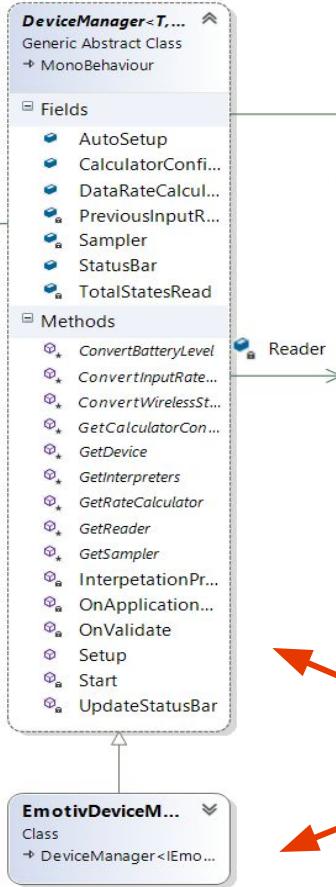
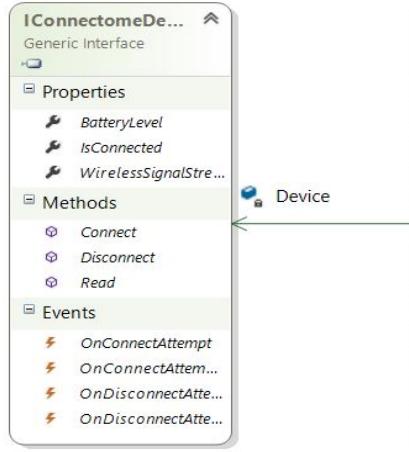
IMPLEMENTATION



Design Patterns



IMPLEMENTATION



Mediator

Builder

Keyboard



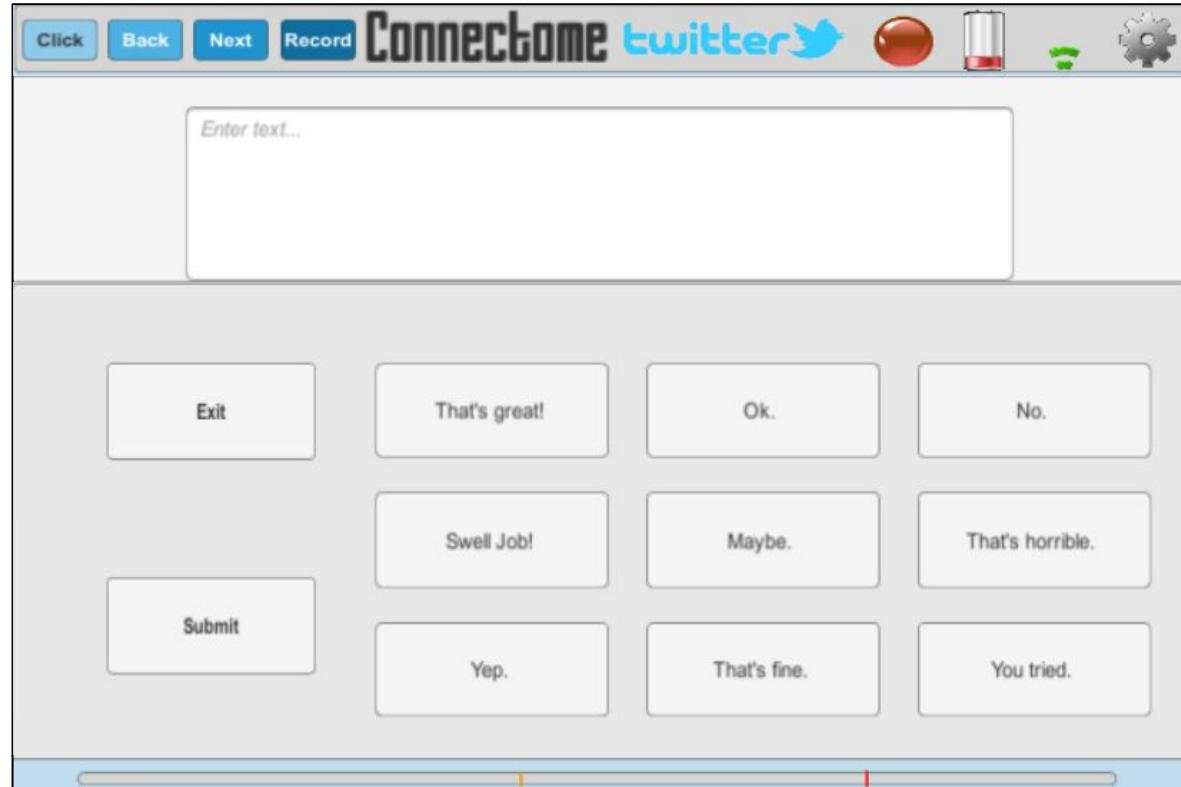
IMPLEMENTATION

Configurable :

- JSON

Interchangeable :

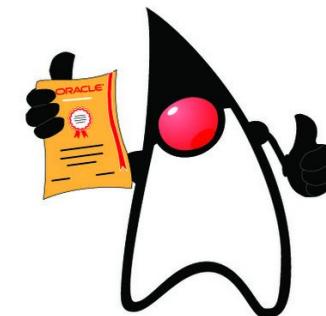
- Grid
- QWERTY
- Phrases



Alternative Designs



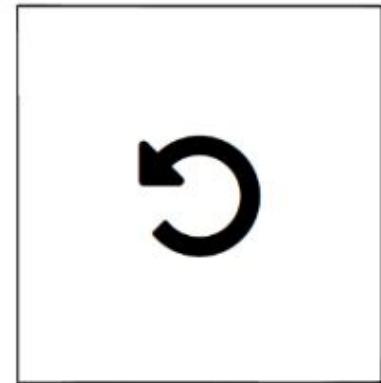
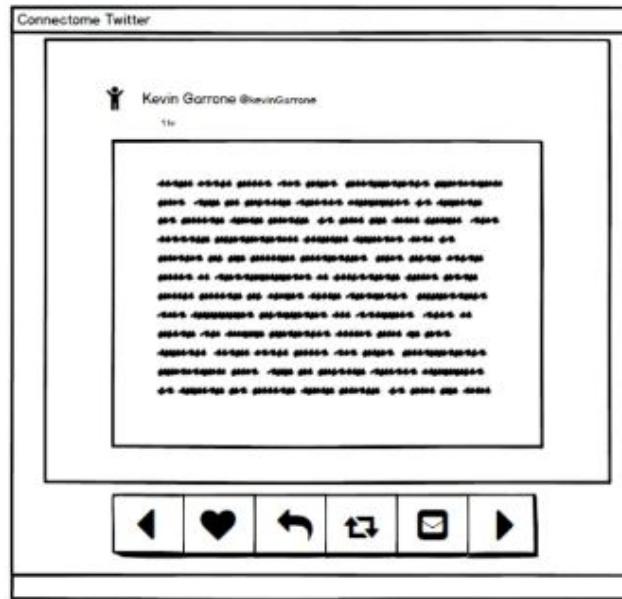
- **Web Application**
 - Pros: Social Media APIs, ease of impl.
 - Cons: Send Emotiv data over connection
- **Desktop Application with JS/HTML**
 - Pros: Social Media APIs
 - Cons: Emotiv SDK, Arch. technologies
- **Java Desktop Application with Swing**
 - Pros: Emotiv SDK, ease of implementation
 -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



Alternative Designs



IMPLEMENTATION



Alternative Designs



IMPLEMENTATION

Click

twitter

Connectome

Timeline

Connectome Bci
BCI_Connectome

That's Great!

5/21/2017 8:27:44 PM +00:00

< (2) newer Home Reply Retweet Message (98) >

Alternative Designs



IMPLEMENTATION

Click Back Next Record Connectome

TED Talks @TEDTalks "Waking a teenager up at 6am is the biological equivalent of waking an adult up at 4am." @wendytroxel <https://t.co/74gvTYkdEW> 15 hours ago

Yiliang Peng @TSMDoublelift we are in line for X2 <https://t.co/4L8HL4BaBD> 15 hours ago

Yiliang Peng @TSMDoublelift why am I at six flags <https://t.co/SYT62mrTBT> 15 hours ago

TED Talks @TEDTalks "Waking a teenager up at 6am is the biological equivalent of waking an adult up at 4am." <https://t.co/21FKCMFn> 15 hours ago

Back Select Tweet Older Tweets

22/32

Alternative Designs



IMPLEMENTATION

Click Back Next Record **Connectome**    

DW (دويتشه فيله)
@dw_arabic
لوجتنجتون تايمز 2017 - 2016 جميع الحقوق محفوظة
عنوان: لوجتنجتون تايمز
<https://t.co/rPe180ZRH>
<https://t.co/N3QUMdSx1H>



15 hours ago

SEPTA
@SEPTA
Rte 101: Trolley service will not operate b/w Orange and Jackson Street until further notice due to police/fire activity blocking the rails.

15 hours ago

Historical Pics
@OttomanArchive
Istanbul, 19th Century
<https://t.co/bMCd8Kcjyx>



15 hours ago

POLITICO
@politico
.@GovChristie: "If I were president-elect of the United States, I wouldn't let Gen. Flynn in the White House" <https://t.co/Wkzz50MbBO>



15 hours ago

Newer Tweets Back Select Tweet Older Tweets

Testing



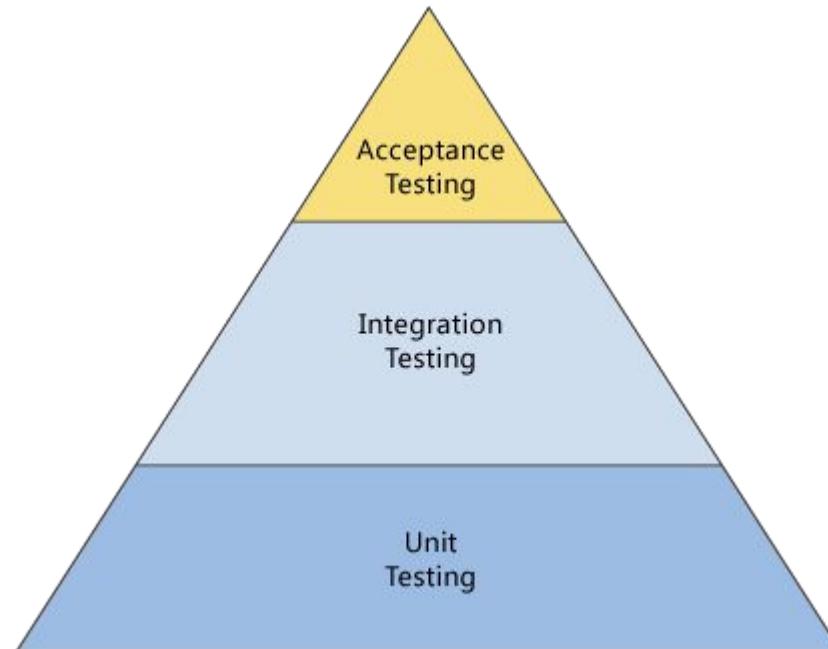
TESTING

- **Software:**

- Unit
- Integration
- Performance
- Acceptance

- **User:**

- Internal
- Patient



Testing - Procedure



TESTING

- 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



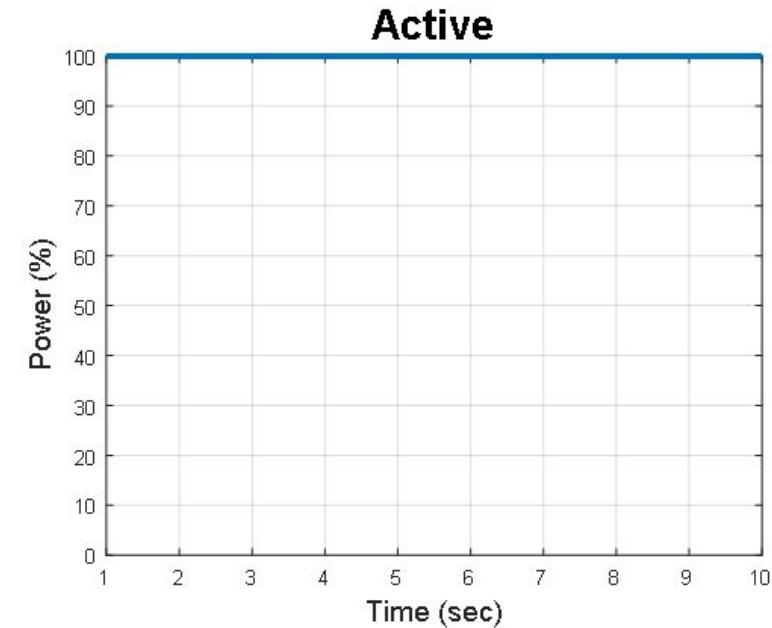
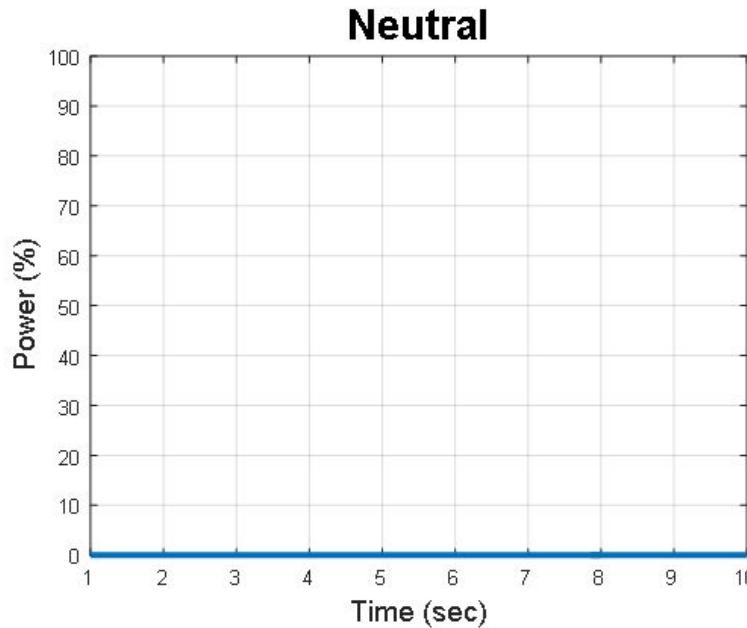
TESTING



Results - Ideal



TESTING



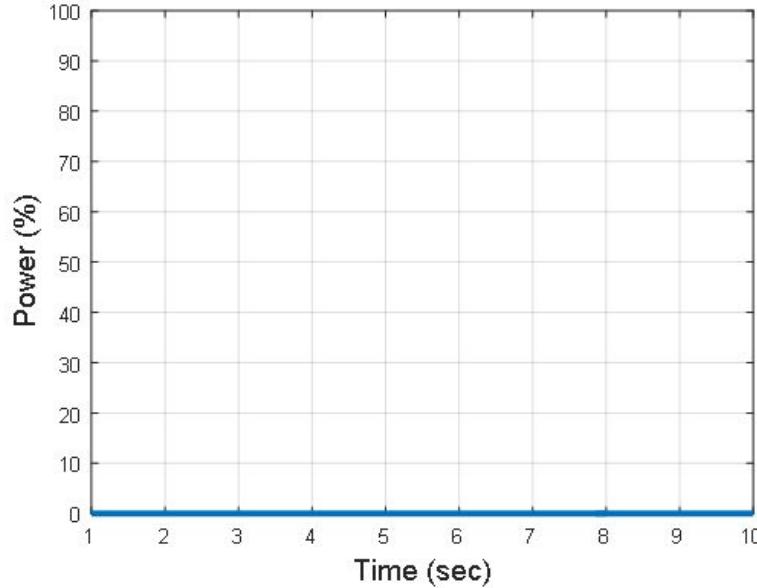
No false positives in either Neutral or Active states

Results - Type A

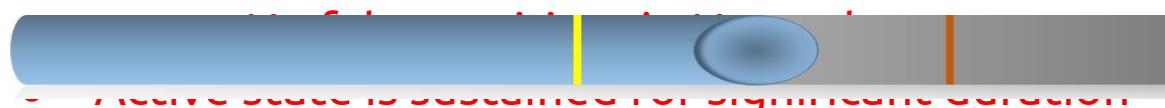
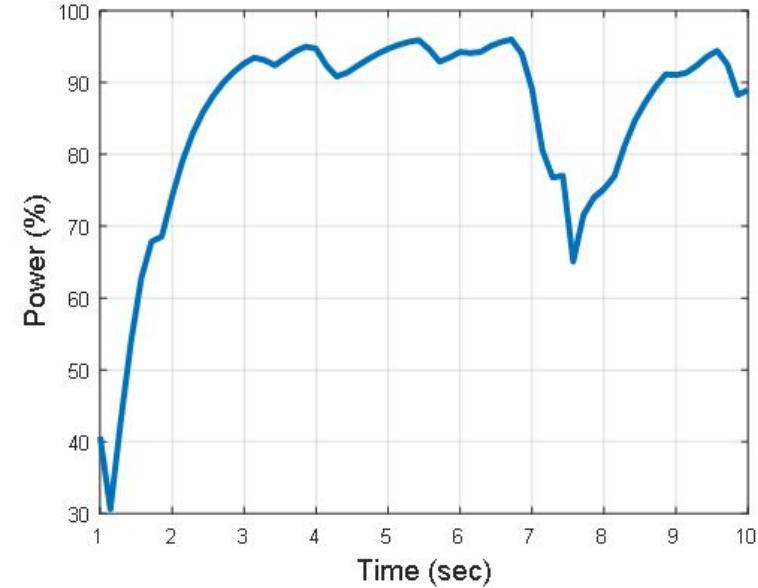


TESTING

Neutral



Active

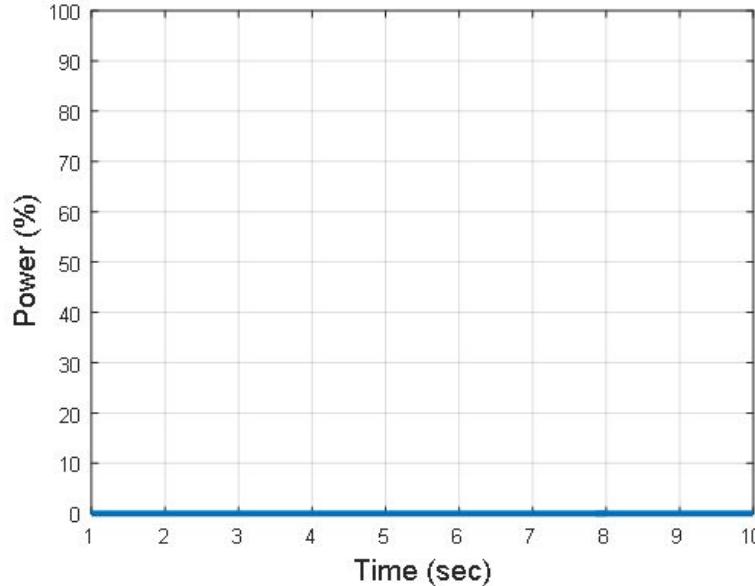


Results - Type B

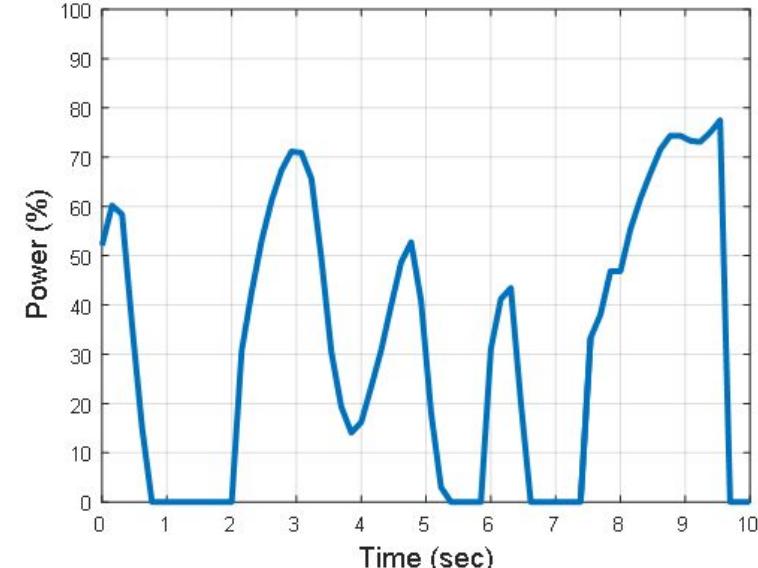


TESTING

Neutral



Active

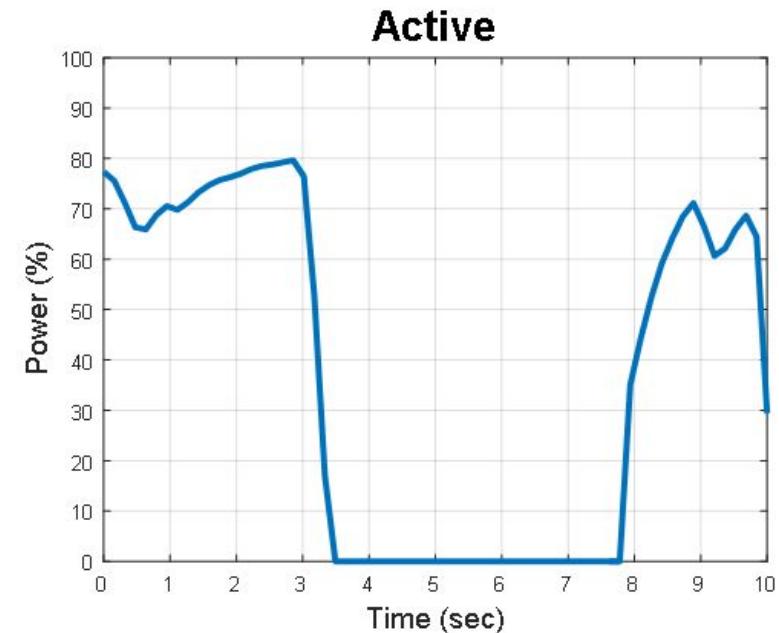
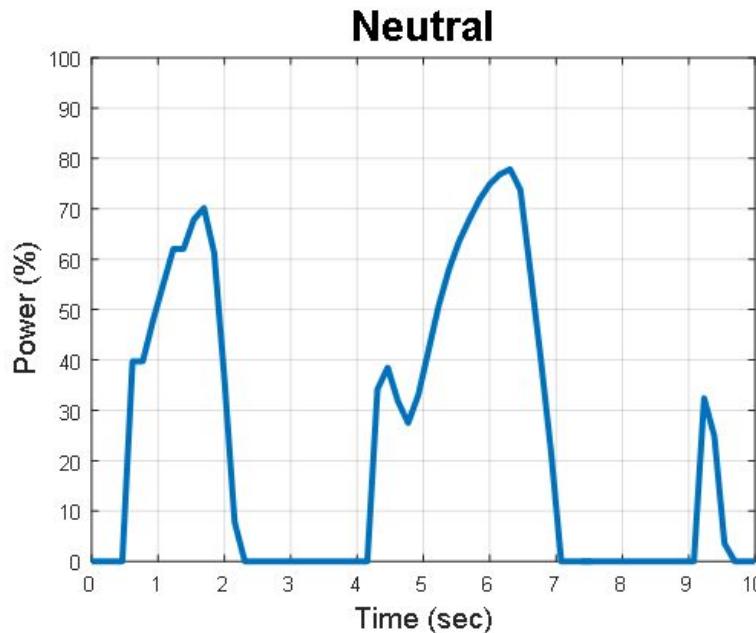


- Active state is maintained, but with intermediate false positives

Results - Type C



TESTING



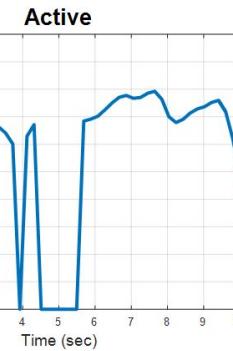
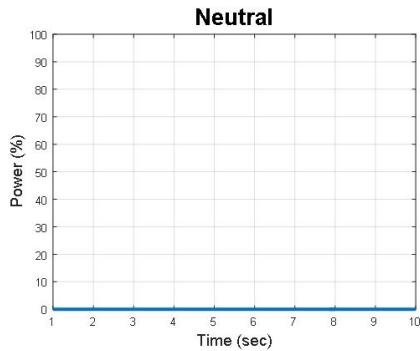
Many false positives in both Neutral and Active states

Results - ALS Patients



TESTING

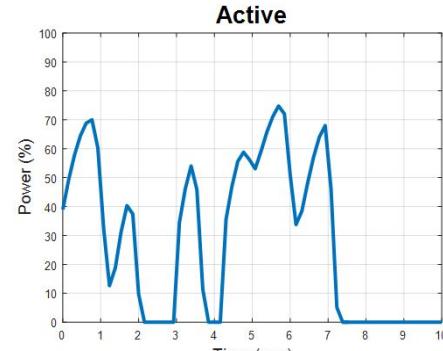
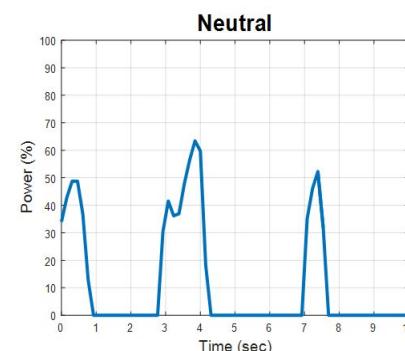
Subject 1



TYPE B



Subject 2



TYPE C

Further Training Necessary

Questions?



BACKUP



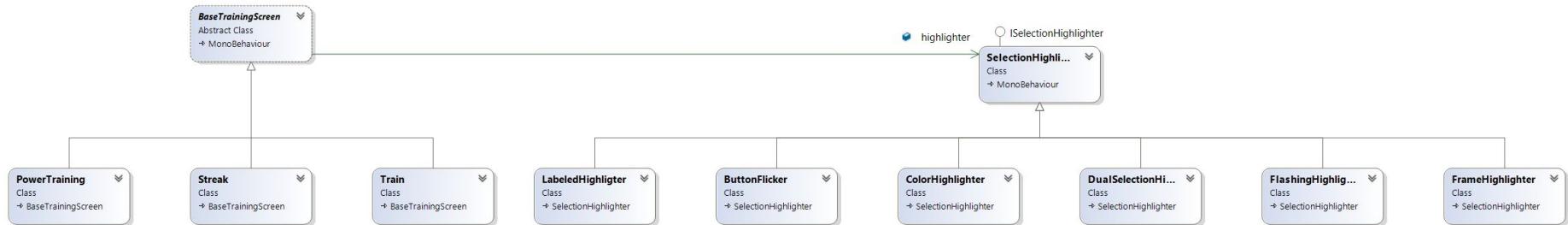
QUESTIONS

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

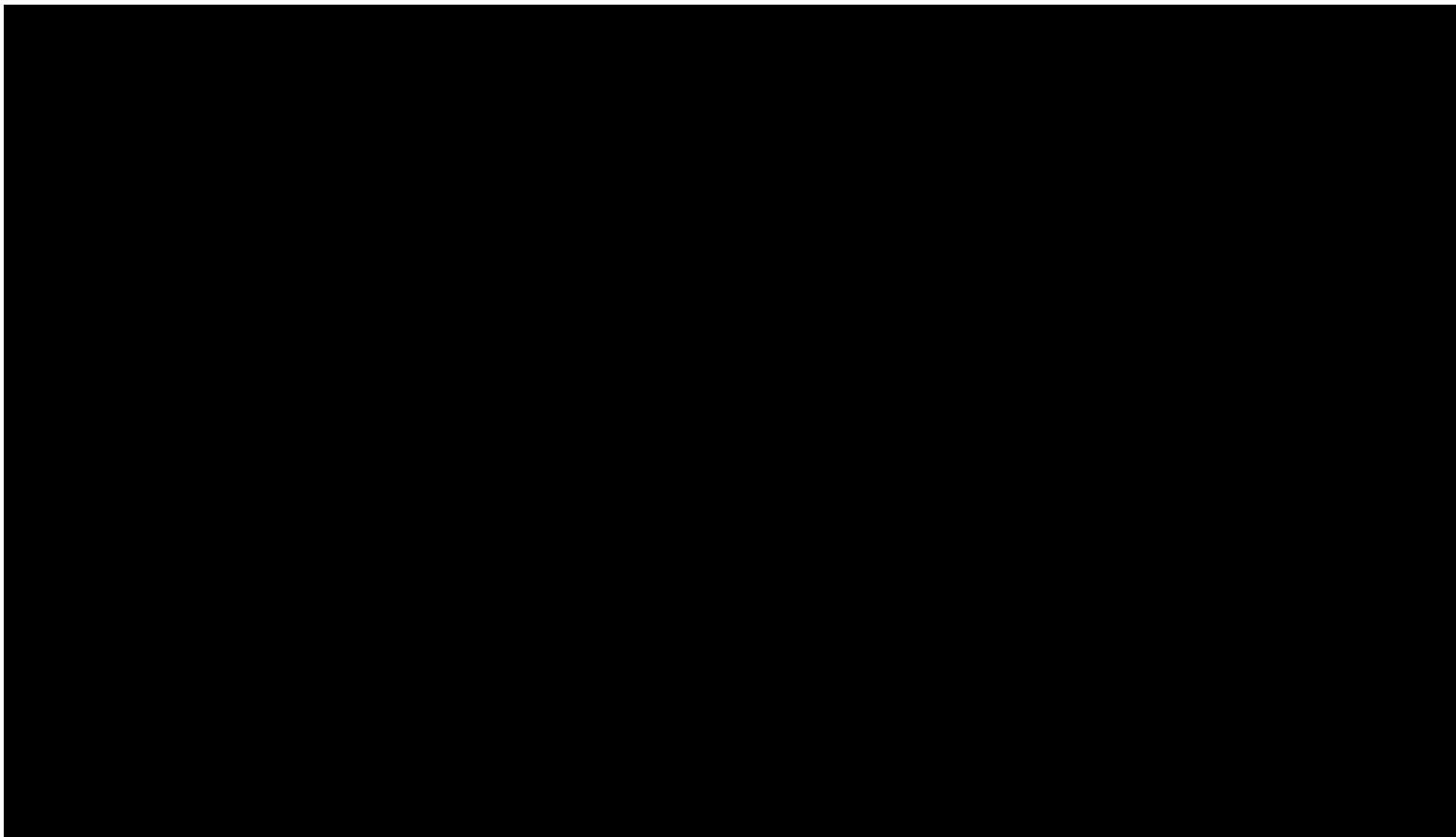


TESTING

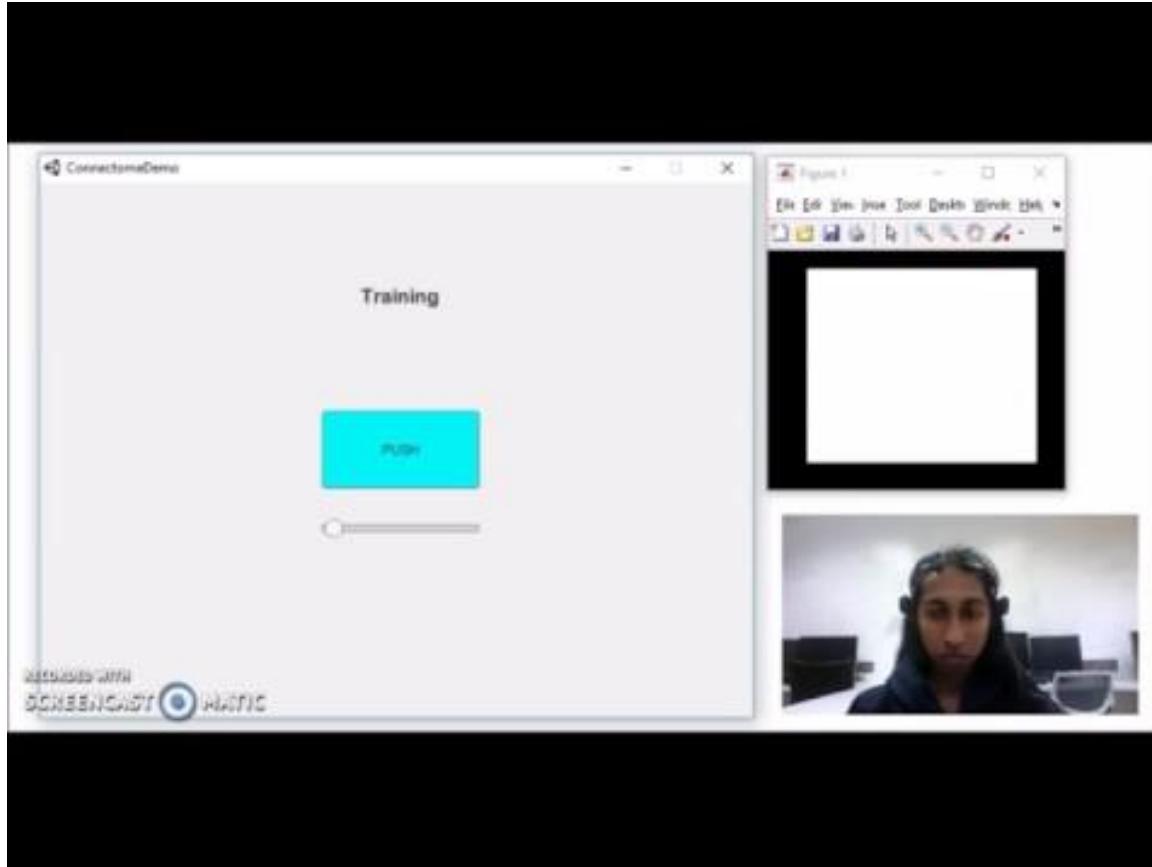
- Conduct more testing across a wider subject pool
- Collect raw EEG data
- Test different data interpreters to robustly create slider thresholds
- Dynamic User Settings
- Improved Keyboard
- Adaptive Training Improvements
- Additional Social Media Implementations



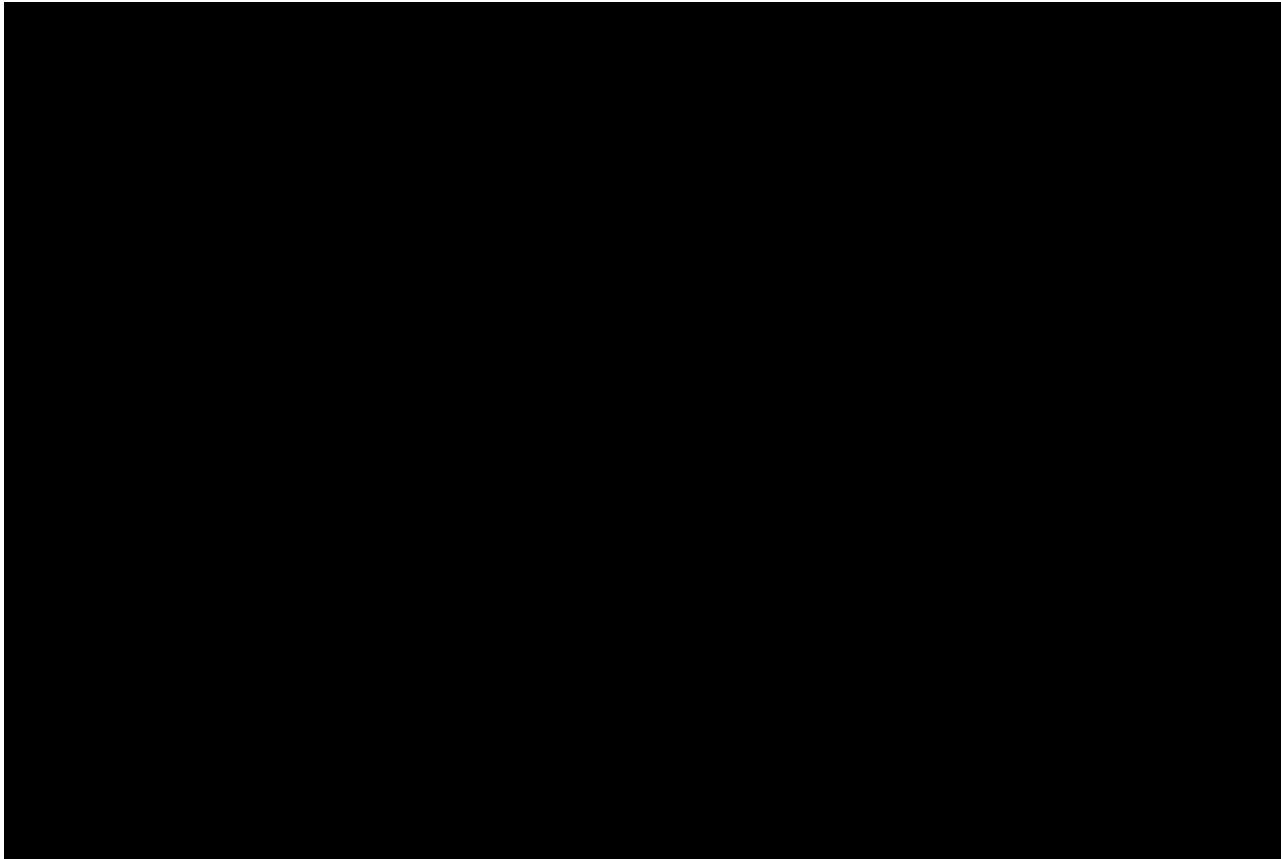
Twitter Demo



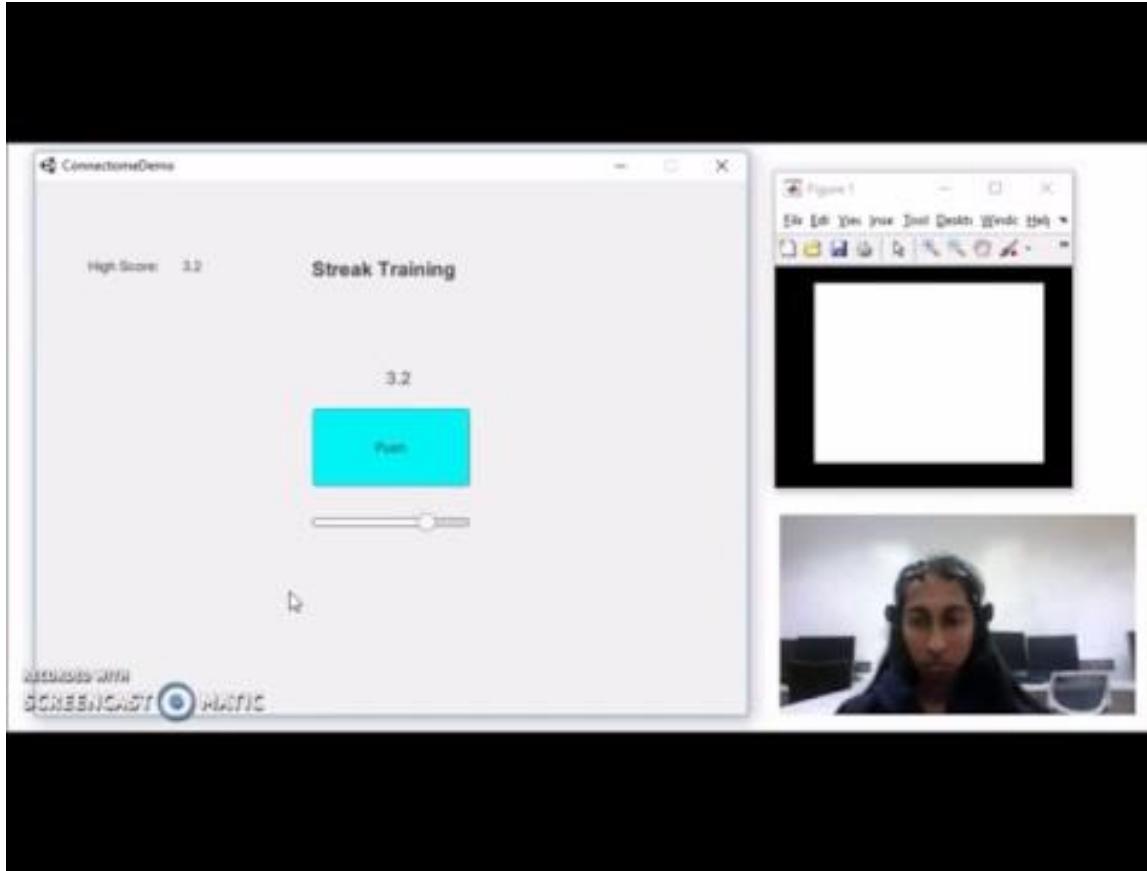
Adaptive Training - Accuracy



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