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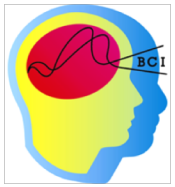


Beyond Eye Gaze: Alternative Access for Adults with Severe Speech and Physical Impairments

Betts Peters

The Problem:

- People with severe physical impairments may be unable to use commonly available AAC and computer access methods.
  - Minimal movement
  - Inconsistent movement
- Can design help?
- How about math?

Shuffle Speller

- Typing interface
- Can be used with various access methods
- Adapts to user input characteristics
- Aggregates evidence from multiple queries

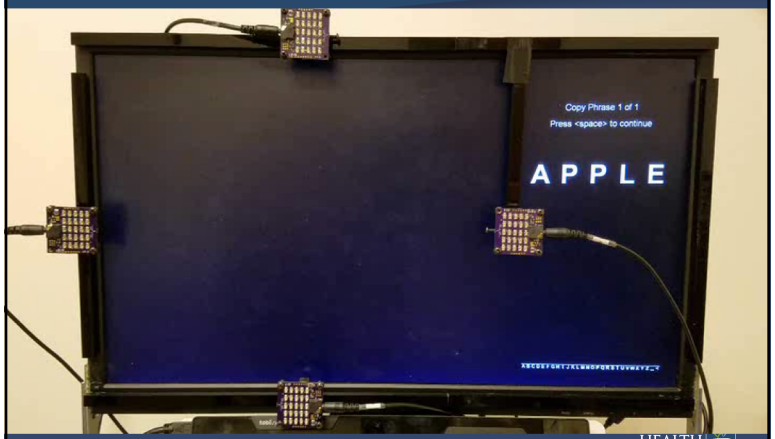
Adaptation to the user

- Character presentation
  - Based on:
    - Language model probabilities
    - User-specific calibration data
  - Uses boxes that will get the most information from a user
- Multiple queries
  - Keeps asking “smart” questions until confidence threshold is reached

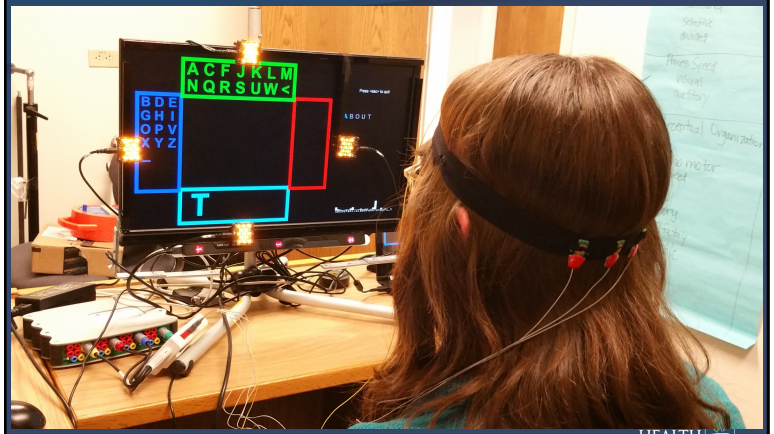
Access methods

- So far:
  - Eye tracking
  - SSVEP brain-computer interface
- Potential:
  - Switches
  - Joystick
  - Headmouse
  - Trackball
  - Etc.

User Interface



Electrode setup



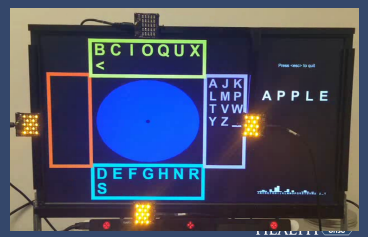
Experiment 1: SSVEP BCI Typing with Simulated Visual Impairments

Participants

- Healthy controls
- Ages 21-80
- Normal or corrected-to-normal hearing and vision
- Passing score on Telephone Interview for Cognitive Status

Variables

- Independent variable: condition
  - Unimpaired
  - Simulated visual acuity impairment (VAI)
  - Simulated ocular motility impairment (OMI)



Variables

- Dependent variables
  1. Typing accuracy (correct selections/total selections)
  2. Typing speed (characters per minute)
  3. User experience
     1. Comfort
     2. Workload
     3. Satisfaction

Tasks

- Copy-spelling
  - 10 words per session (different each time)
  - 5-7 letters each
  - Balanced for language model support
- Stoppage criteria (for motility condition)
  - Stop if no letter selections within 5 minutes
  - Stop after 20 minutes regardless of performance

Analysis

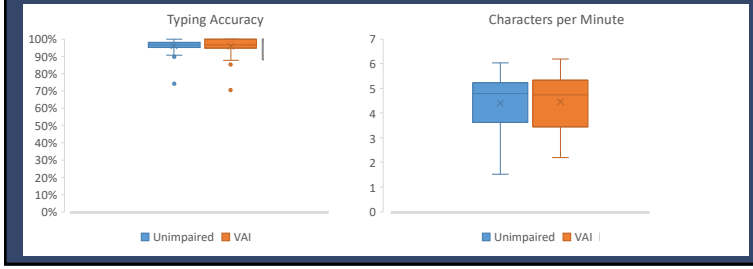
- Unimpaired vs. VAI
  - paired *t* test of mean equivalence
- Descriptive statistics for OMI

Results

- 38 participants
  - Aged 37.2 ± 15.47 years
  - 26 women
  - 17.3 ± 2.41 years of education
  - Mostly 20/20 vision both near (n=35) and distance (n=31)

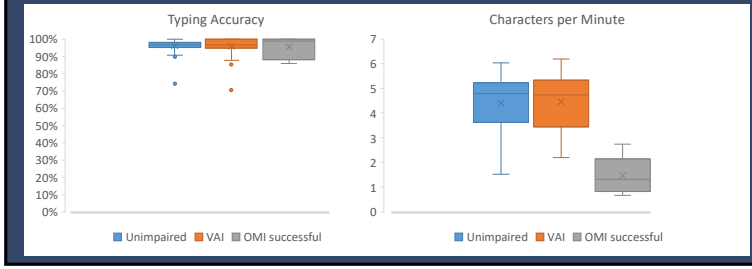
Results: unimpaired and VAI

- All participants could spell under unimpaired and VAI conditions
  - VAI performance was not inferior for either accuracy or speed



Results: OMI

- 6/37 spelled word(s) under OMI condition
  - Accuracy comparable to other conditions, speed greatly reduced
  - Longer trial lengths
- 31/37 could not spell under OMI condition



Results: unimpaired and VAI outliers

- 6 participants had low accuracy (<80%) and/or failed to complete 10 words under unimpaired or VAI conditions
  - Color blindness (difficulty seeing correct & incorrect selections)
  - Fatigue
  - Confusion about backspace character
  - Misreading of target word

Results: UX

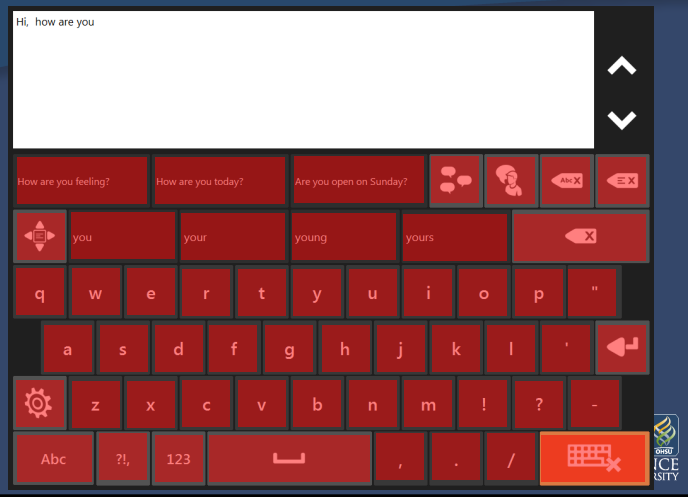
- Unimpaired and VAI
  - Low ratings for workload and discomfort
  - High ratings for overall satisfaction
- OMI
  - Higher ratings for workload
  - Similar ratings for discomfort
  - Lower ratings for overall satisfaction

Discussion

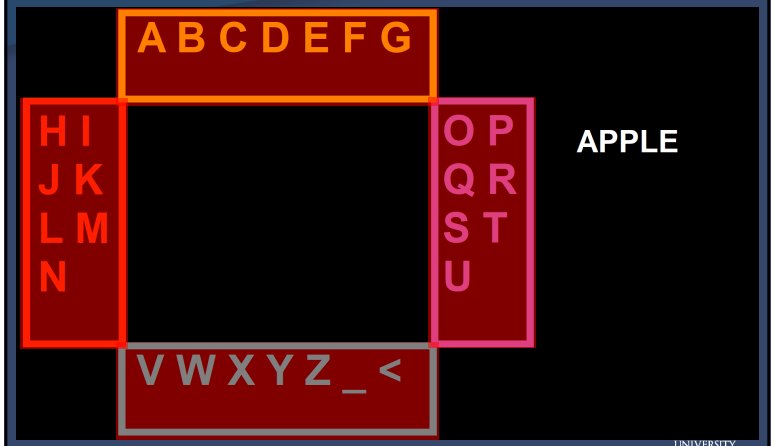
- 20/200 acuity impairment (legal blindness) is not an obstacle to Shuffle use
- Some people may be able to use Shuffle with reduced motility
- High user satisfaction (unimpaired and VAI)
- Adaptive trial length
  - May support accurate typing

Experiment 2: Eyegaze and EEG Access for Participants with SSPI

Typical Eyegaze SGD Interface



Shuffle Interface



Research Questions

- Is the Shuffle Speller interface, accessed with eyegaze or SSVEP-BCI, a viable option for people who have difficulty with traditional grid-based eyegaze systems?
- How do eyegaze access and SSVEP-BCI access compare?

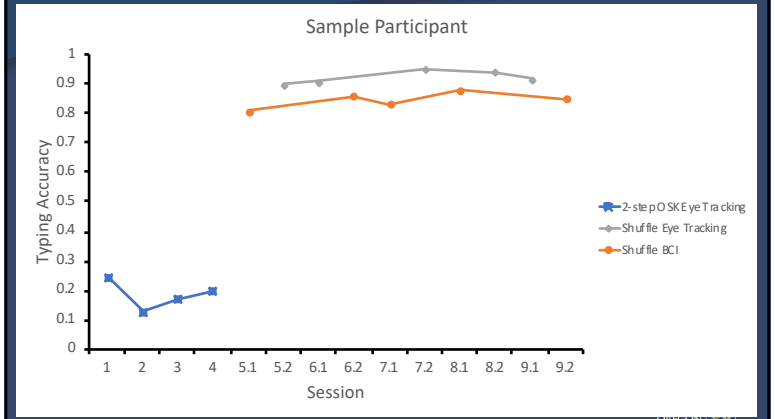
Participants

- 3 adults with SSPI who have difficulty with commercially-available eyegaze systems

Design

- Single-case alternating-treatments research design
- Baseline: Two-step keyboard in Communicator 5 (similar to existing multi-step, large-button keyboards)
- Alternating treatments:
  - Shuffle Speller BCI
  - Shuffle Speller eyegaze
- 6 boxes used for all conditions

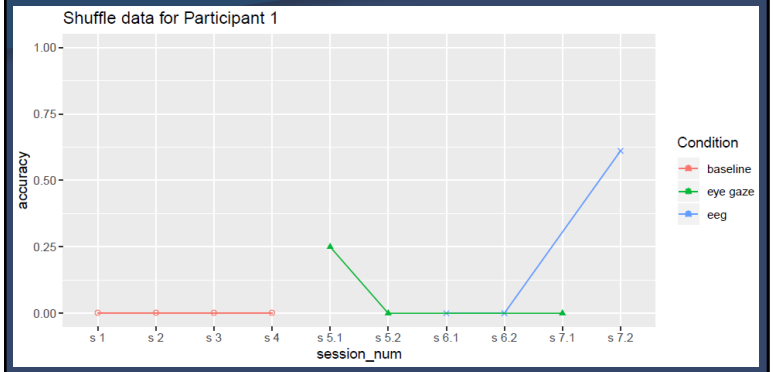
Design



First attempt…

First attempt…

What we learned



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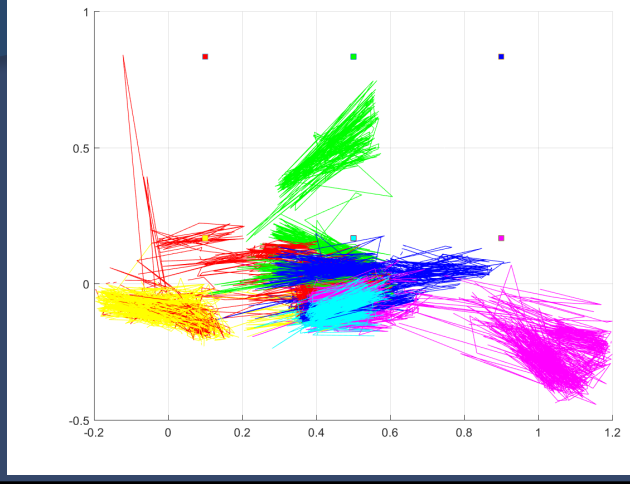
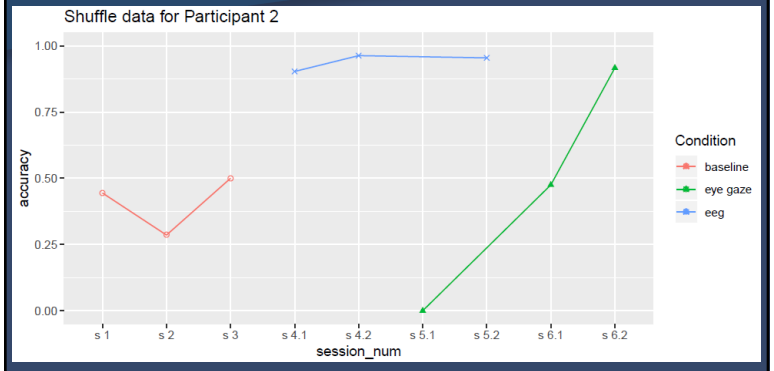
What we learned



What we learned



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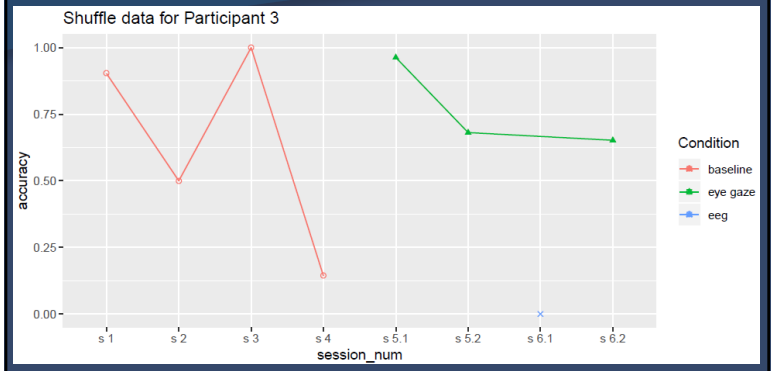
What we learned



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Second attempt

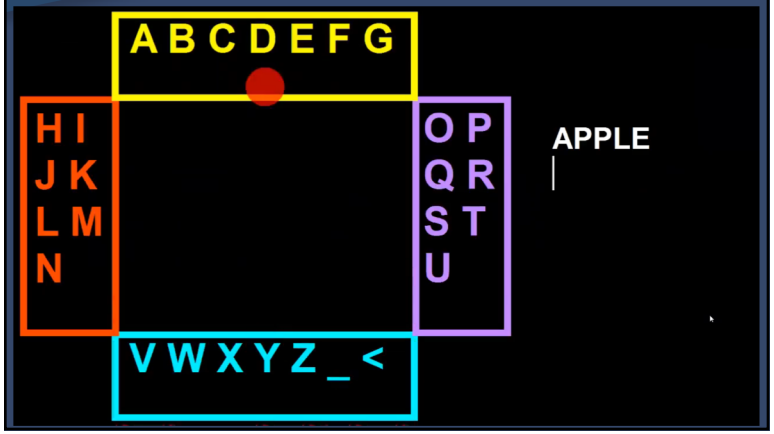
- Switch from 6 boxes to 4 for all conditions
  - Equipment failure
  - Possible easier for some participants
- Baseline: Three-step keyboard in Communicator 5 (1.2 second dwell)
- Alternating treatments:
  - Shuffle Speller BCI
  - Shuffle Speller eyegaze: New algorithm!
  - Three-step keyboard in Communicator 5 (2.5 second dwell)

Alternating treatments conditions: Potential advantages

- Shuffle Speller (Eyegaze or SSVEP BCI)
  - Smart querying
  - Aggregated evidence
  - Adapted to user input characteristics
  - Modified eye tracking is more forgiving
  - BCI option may work for some users when eye tracking won't
- Multi-step Communicator keyboard with 2.5 second dwell
  - Longer dwell allows more time to move

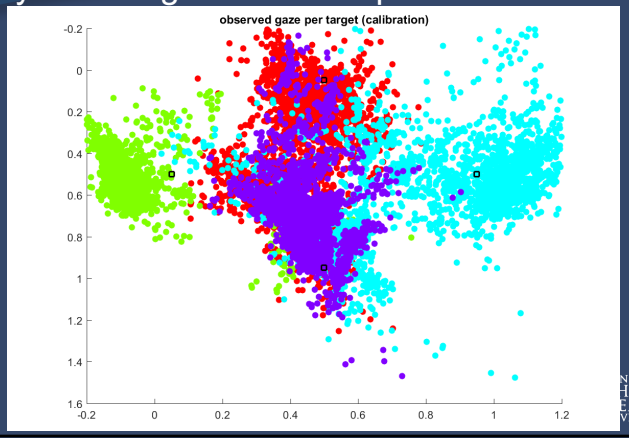
Baseline condition

- 3-step eyegaze spelling in Communicator



Shuffle conditions

- Eye tracking for Shuffle Speller



Tasks

- Copy-spelling
  - 5 words per session
  - 5 letters each
  - Balanced for language model support

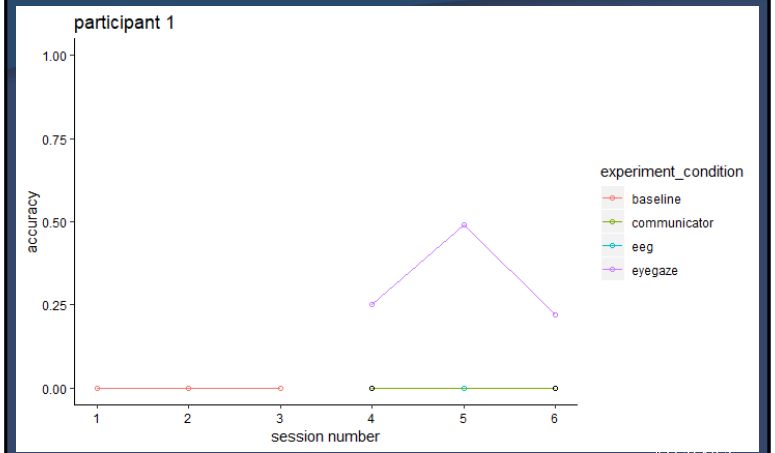
Variables

- Independent variable: condition
  - Baseline: 3-step Communicator keyboard
  - Alternating treatments:
    - Shuffle Speller eyegaze
    - Shuffle Speller BCI

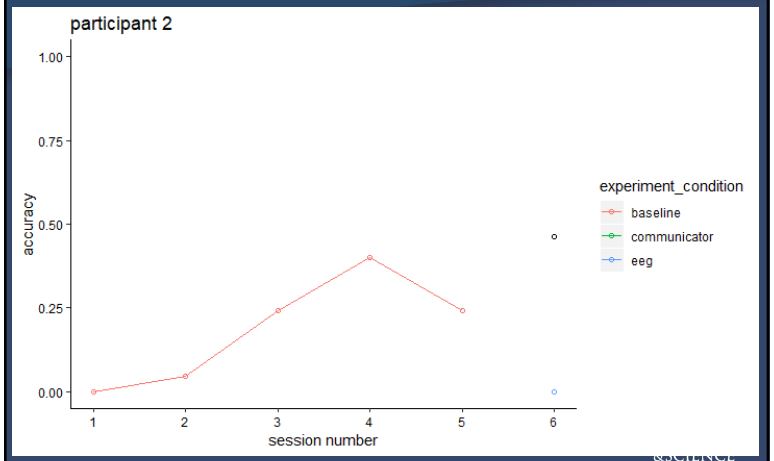
Variables

- Dependent variables
  1. Typing accuracy (correct selections/total selections)
  2. Typing speed (characters per minute)
  3. User experience
     1. Comfort
     2. Workload
     3. Satisfaction

Preliminary results



Preliminary results



Next steps

- Finish data collection
  - 5+ sessions with each condition
- Bonus round!

Research Challenges

Well, it didn't work. Now what?

What are some obstacles to adopting a new access method, and what can we do about them?

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