BRAIN-COMPUTER INTERFACE FOR PEOPLE WITH ALS: LONG-TERM DAILY USE IN THE HOME ENVIRONMENT

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INTRODUCTION

A noninvasive brain-computer interface (BCI) records brain activity from the scalp and uses the signals to convey intent.

Five users have been provided with portable P300-based BCI systems that they use to perform a variety of tasks on a daily basis. Caregivers have been trained to apply electrode caps and start the systems. Each day's data are electronically transferred to the lab. Classification coefficients are updated remotely as needed. Users are presented with a matrix of items, each emulates a keyboard command. The users operate the system by attending to a desired matrix item while all items flash rapidly. The attended item produces a P300 response and the unattended items do not. The system operates by detecting which item elicits the largest P300 for a given series of flashes. The system selects that matrix item, and then activates a keyboard command.
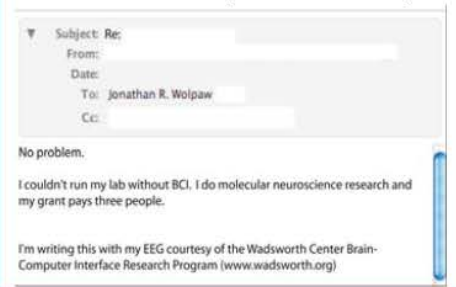
EXAMPLE OF FREE SPELLING
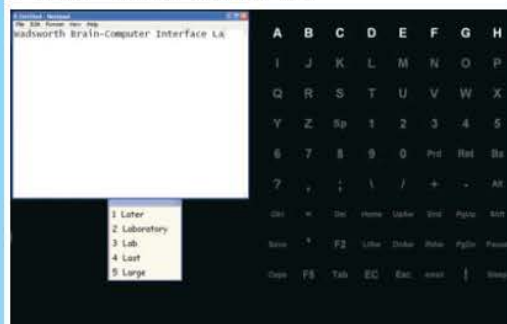
Free Spelling - Allows the user to produce messages of their own volition.
Copy Spelling - The user selects specific characters (i.e., spells words) to provide calibration data.
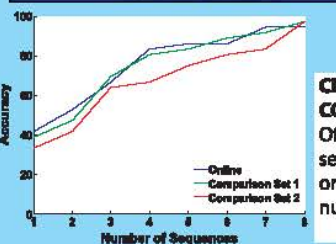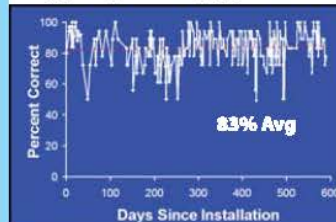
User A

- 49 y/o man
- Totally paralyzed except for eye movements
- System Installed February 2006
- Immediately stopped using eye-gaze system
- Primary tasks include email and word processing

Asked to describe BCI impact on his life he replied:

No problem.

I couldn't run my lab without BCI. I do molecular neuroscience research and my grant pays three people.

I'm writing this with my EEG courtesy of the Wadsworth Center Brain-Computer Interface Research Program (www.wadsworth.org)

COPY SPELLING SUMMARY

83% Avg

A BCI USER IN HIS HOME

Close-up of the flashing matrix and predictive speller

BCI user accessing a computer via his EEG

CLASSIFICATION COEFFICIENT COMPARISON

Offline comparisons are made among several sets of coefficients to optimize online performance and adjust the number of sequences (flashes).

STEPWISE LINEAR DISCRIMINANT ANALYSIS

- 800 ms window
- 128 Features sampled at 20 Hz
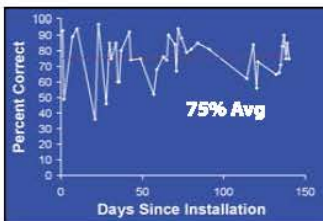- Up to 60 features control online selection

Electrode Montage

COPY SPELLING SUMMARY

User B

- 62 y/o man
- Has limited head, mouth, and finger movement
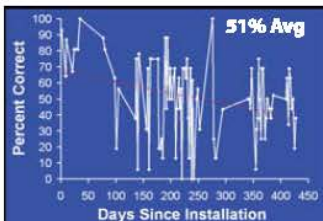- No speech
- Currently not using system

75% Avg

User C

- 60 y/o woman
- Has eye movement only

51% Avg

User D

- 36 y/o woman
- Has limited head and mouth movement
- Inaudible speech

83% Avg

User E

- 49 y/o woman
- Has limited hand movement
- No speech

67% Avg
(uses system with lab members present)
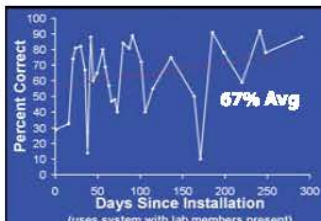
INITIAL FINDINGS

1) Severely disabled people can and do use a BCI in their daily lives without close technical oversight.
2) The BCI improves communication ability.
3) Performance has been stable for up to 20 months.
4) The P300 response is relatively stable over time.
5) Quality of life is improved (self report).
6) Caregivers find the system easy to operate.

CONCLUSIONS

1) BCI technology is a feasible assistive technology for severely disabled people.
2) Subjects report improved quality of life and independence.
3) Future research will focus on optimizing speed and accuracy, automating processes, simplifying caregiver procedures, and measuring changes in quality of life.