

# Online BCI Typing using Language Models by ALS Patients in their Homes

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*Introduction:* The P300 speller is a common brain computer interface system that can provide a means of communication for “locked-in” patients, such as those with amyotrophic lateral sclerosis (ALS) [1]. While this system was initially developed almost 30 years ago, it is not widely used in part because typing speed and accuracy are below those desired by the ALS population [2]. Recent studies have shown that performance using the system can be improved by utilizing knowledge of natural language to improve signal classification [3]. The preliminary results have been promising, but they have largely been tested on healthy volunteers in a laboratory setting. The goal of this study was to demonstrate the functionality of the P300 speller system with language models when used by ALS patients in their homes.

*Material, Methods and Results:* Electroencephalogram (EEG) data was recorded using g.tec amplifiers, active EEG electrodes, and an electrode cap (Guger Technologies, Graz, Austria). The BCI2000 application [4] was used to run the P300 speller experiments with famous faces stimuli [5] and language model integration using a previously published particle filtering algorithm [6]. The hardware was loaded onto a cart, which was then transported to patients’ homes so they could use it in their home environment.

Two ALS patients participated in this study. The first is on a ventilator and uses an eye tracking system for communication, while the second maintains some speaking ability. To form a baseline for comparison, three healthy subjects also participated, using the system in a hospital setting. All subjects consented to participate and the study was approved by the UCLA institutional review board. For each subject, the study consisted of three five-minute calibration phases where the subject would copy a given phrase without feedback. A testing phase followed during which the subjects were instructed to type anything that they chose with the results being displayed in real time. Results were evaluated using selection rate, accuracy, and information transfer rate (ITR).

Both ALS subjects were able to type using the system with 100% accuracy. The first subject typed nine characters in 58.4 seconds for a selection rate of 9.24 characters/minute and an ITR of 47.8 bits/minute. The second subject typed 15 characters in 77.4 seconds, for a selection rate of 11.6 characters/minute and an ITR of 60.1 bits/minute. The three healthy subjects also typed with 100% accuracy, with an average selection rate of 11.7 characters/minute and an average ITR of 60.4 bits/minute.

*Discussion:* Both subjects performed well above the average previously reported using the particle filtering algorithm (37.3 bits/minute), which is likely due to the inclusion of the famous faces stimuli. The second subject had comparable performance to the healthy volunteers, while the first was somewhat lower. This drop could have been due to the fact that his head was supported by a cushion, which could have affected the connection of occipital EEG electrodes. Future work will involve further testing in ALS subjects to determine if there is a consistent pattern between disease progression and P300 performance.

*Significance:* The results of this study indicate that the improvements in performance using language models in the P300 speller translate into the ALS population, which could help to make it a viable assistive device.

*Acknowledgements:* This work was supported by the National Institute of Biomedical Imaging and Bioengineering Award Number K23EB014326 and the UCLA Scholars in Translational Medicine Program.

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