ERP Responses of the Elderly for Bisyllabic Word Stimuli

**Atieh Bamdadian[1]*, Simone Denzer[1], Mariacristina Musso[2], Michael Tangermann[1]**

[1]Brain State Decoding Lab, Cluster of Excellence BrainLinks-BrainTools, Dept. Computer Science, University Freiburg, Germany; [2]Dept. Neurology, University Medical Center Freiburg, Germany

*Albertstraße 23, 79104 Freiburg, Germany. E-mail: atieh.bamdadian@blbt.uni-freiburg.de

Introduction: Brain-computer interface (BCI) based on auditory event-related potentials (ERPs) are investigated to establish communication for patients with motor impairments [1]. ERPs of the electroencephalogram (EEG) evoked by external stimuli provide information about a subject's attentional state. Most auditory-BCIs use tones stimuli [2], but also paradigms with natural sounds [3] and words [1] have been used. Working towards an attention-constrained rehabilitation paradigm, a setup with monosyllabic word stimuli has been evaluated for young healthy participants [4]. Although the elicited ERP components differ in latency from those of artificial tones [2], monosyllabic word ERPs can be classified on a comparable level in single trial [4]. Based on normally aged subjects, who match in age with patients with aphasia induced by (first) stroke, the present study aims at evaluating the feasibility of single-trial target versus non-target decoding for even more complex bisyllabic word stimuli.

Methods: Twenty elderly native German speaking subjects (mean age 60.20±8.04 years, normal hearing, no history of neurological deficits) were familiarized with 6 word stimuli (see Fig. 1B) and matching sentences prior to a single offline EEG session (64 channel passive Ag/AgCl electrodes). Seated in a ring of 6 loudspeakers (AMUSE paradigm, [2]), the target word and direction of each trial was cued by a matching sentence. A trial contained 90 stimuli (15 iterations of 6 word stimuli). Six runs with 6 trials each were recorded, adding up to 540 target EEG responses and 2700 non-target responses within a single session. Word stimuli were presented in pseudo-random order from 6 directions at an stimulus onset asynchrony (SOA) of 250 ms. Additional conditions with a single loudspeaker and headphones were conducted but will not be reported on here.

Results: Fig. 1 shows (A) the grand average (GA) *target* and *non-target* ERPs in two selected channels and (B) GA classification accuracies. Two colored rows in Fig. 1(A) indicate the signed *r*-squared value between the two classes for the selected channels. An early class-discriminative negative response (*N200*) followed by a prolonged discriminative positive response is observed. From each channel, the amplitudes of eleven time intervals (ranging 100ms-1200ms) were extracted after baseline correction. The GA classification accuracy when combining all words, using these 704 features, evaluated via chronological 5-fold cross-validation with a shrinkage-regularized LDA, was 72.85% (with 62.20% chance level). Using only 7 early time intervals from 100ms to 400ms resulted in an GA accuracy of 68.79%, which demonstrates that the early negative response alone contains substantial information about the attended word. Specialized classifiers for each word performed on similar levels (Fig. 1(B)), showing neither significant differences (*t*-test, *p*-value>0.05) among each other nor relative to the combined classifier.
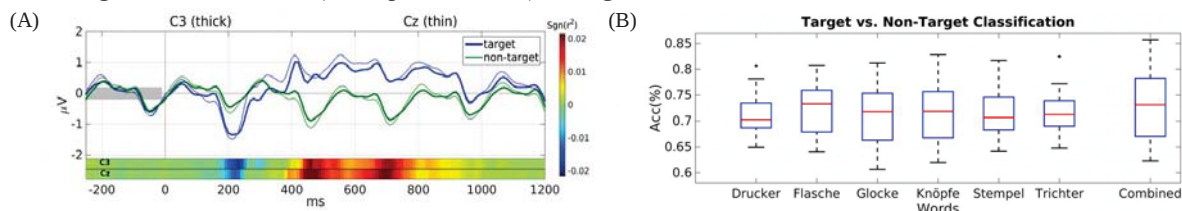
Figure 1.   *(A) GA target and non-target ERP responses for channels C3 and Cz. (B) classification accuracy of word-specific classifiers.*

Discussion and Significance: The ERPs of the elderly people upon bisyllabic words are slightly prolonged and delayed compared to those reported for monosyllabic words in [4]. A similar age-related effect was reported by van Dinteren et al. [5]. Nevertheless, also the delayed ERPs upon our more complex and slightly longer natural stimuli are sufficiently discriminative for an online paradigm for rehabilitation of aphasic patients, with accuracy close to those of monosyllabic words (71.2%) [4] and artificial tones (68.5%) [2].

References

[1] Sellers, E. W., et al. (2006). Brain-computer interface research at the University of South Florida Cognitive Psychophysiology Laboratory: the P300 speller. *IEEE Trans. Neural Syst. Rehabil. Eng., 14*(2), 221-224.
[2] Schreuder, M., et al. (2010). A new auditory multi-class brain-computer interface paradigm: spatial hearing as an informative cue. *PloS one*, *5*(4), e9813.
[3] Höhne, J., et al. (2012). Natural stimuli improve auditory BCIs with respect to ergonomics and performance. *J. Neural Eng.*, *9*(4), 045003.
[4] Tangermann, M., et al. Towards aphasia rehabilitation with BCI. Proc. 6th Int. Brain-Computer Interface Conf., 65–68, Graz, 2014.
[5] van Dinteren, R., et al. (2014). P300 development across the lifespan: a systematic review and meta-analysis. *PloS one*, *9*(2), e87347.