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Temporal dynamics of mouth motor cortex activity during speech

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Introduction: In order to restore communication with severely paralyzed patients by using a BCI, attempts have been made to classify speech units [1,2]. Although classification of these units from the mouth motor cortex seems possible, accuracy levels are usually not sufficient for an assistive speech BCI. Understanding the source of the variability in mouth motor related brain signals might improve feature selection and classification. Here, we investigate the relationship between word duration and the temporal dynamics of the brain signals in the mouth motor cortex.

Material & Methods: Two epilepsy patients who were implanted with electrocorticography (ECoG) electrodes for clinical reasons at the UMC Utrecht hospital participated in this study. Both subjects had grid coverage over the right central hemisphere, including the mouth motor area (for subject 1 only the upper part). Subjects were asked to read out loud words presented on a screen that was positioned at a distance of about 1 m. Recorded signals were filtered for line noise and common average re-referenced, after which power in the high frequency band (HFB) range (65-135Hz) was extracted. Electrodes showing a significant response to the task were identified by computing the correlation with the task. The HFB power signals from these electrodes were normalized over time and averaged to create one motor mouth response signal per subject. Averaged signals were smoothed and epoched in 3-sec trials around voice onset. Trials were subsequently grouped into three groups based on speech duration (short, middle & long words). A one-way ANOVA was performed per time point to identify time periods with significant differences between groups. Additionally, for every trial, the HFB response duration was calculated as the width of the peak above a threshold (baseline mean + 2*sd). Differences in the total HFB response duration between short, middle and long words were tested for significance using t-tests.

Results: Electrodes showing a significant HFB power change to the task were located on the middle or inferior pre- and postcentral gyrus. Signals from these electrodes showed a clear speech-related HFB peak, followed by a period with significant differences in the HFB response between word durations (Figure 1). Total HFB response duration was significantly different between word durations for subject 2 (Figure 2).

Discussion: The results suggest that the duration of words influences the temporal dynamics of the brain signal in the mouth motor cortex. For all subjects, longer words tend to have a period after the HFB peak with higher activity than short words. Furthermore, subject 2 showed a positive linear trend in peak width. For subject 1, this effect was not statistically significant, which may be explained by the low number of trials and a suboptimal grid position. It may be possible that the temporal neural differences for short and long words are most obvious in the more inferior parts of the motor cortex. Whether or not the HFB response duration is related to the number of movements one makes during the articulation of a word should be further investigated.

Significance: The current results suggest that word length may be a strong but limiting feature for BCI classification. Research on decodability of patterns associated with specific words would benefit from using equal-length words to avoid the word length confound.

References

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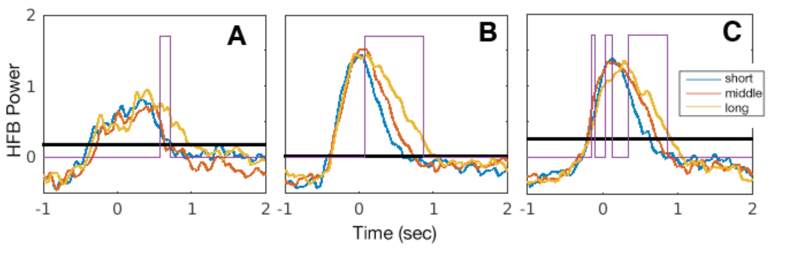

Figure 1. *Mean HBF response traces for short (blue), middle long (red) and long (yellow) words, for (a) subject 1, (b) subject 2 run 1 and (c) subject 2 run 2. On the x-axis, time is depicted with 0 being voice onset. On the y-axis the HFB power is shown. The black horizontal line is the threshold above which activity was assumed to be task related. The purple block function shows the periods with a significant difference in response between the three groups, indicated by a one-way ANOVA (FDR corrected).*

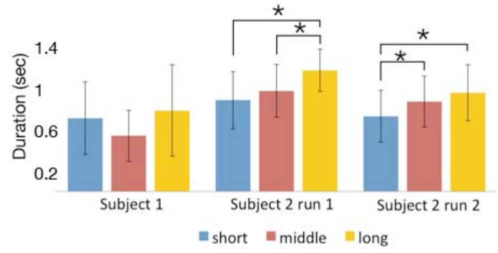

Figure 2. *Mean and standard deviation of the HBF peak duration (in sec) per dataset, for short, middle & long words. Significant differences are indicated with an astrix (α=0.05/3, bonferroni corrected).*