The neurophysiological correlates of overt speech production:

Dissociation of the speech production phases and test-retest reliability

C. Theys[1-2], M. De Vos[3-4] & M. McAuliffe[1-2]
[1]New Zealand Institute of Language, Brain and Behaviour, University of Canterbury, NZ
[2]Department of Communication Disorders, University of Canterbury, NZ
[3]Institute of Psychology, University of Oldenburg, Germany
[4]Department of Engineering Science, University of Oxford, UK

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1. Introduction

Speech production is a complex behaviour that depends on rapidly changing neural processes. Its neural basis has mainly been investigated with techniques such as Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI) [1,2]. While these techniques have provided valuable information regarding the localization of brain activation, they are characterized by poor temporal resolution. In contrast, electroencephalography (EEG) provides excellent temporal resolution, but its usefulness for speech production studies has been hampered by the presence of movement-based contamination in the resultant signal. Recently, a new technique has been developed that allows the extraction of electromyographic (EMG) activity form the EEG data [3,4], providing a unique opportunity to finally map the temporal neural processes underlying overt speech production.

2. Aims

The aims of the current study were to

1. Dissociate the neurophysiological correlates associated with articulatory preparation (Contingent Negative Variation [5]), self-monitoring via the internal loop (Correct Response Negativity [4]) and self-monitoring via the auditory feedback loop (N100 [6]) during overt speech production
2. Assess the test-retest consistency of the overt speech measures

3. Methodology

3.1. Participants

Seven male and thirteen female subjects, aged 28 ± 9 years participated in the study. The participants did not have a history of speech, language, or neural impairments and their vocabulary and hearing were within normal limits. This study was approved by the Human Ethics Committee of the University of Canterbury.

3.2. Procedure

The stimuli consisted of colour drawings of 100 familiar monosyllabic words retrieved from the MRC psycholinguistic database. All words started with either a bilabial consonant or a vowel to allow the identification of the onset of articulatory EMG activity. All stimuli were presented using E-prime 2.0 Professional, with on-line recording and voice-key triggering of the participants' responses. In addition, EMG activation of the lip muscles was recorded. EEG recordings were performed with a 32-channel Biosemi system (Amsterdam, The Netherlands). The participants performed delayed [5] and immediate [4,7] overt picture naming tasks. The same set of experiments was repeated one week after the first test session.

3.3. Data analysis

Data were analyzed using Brain Vision Analyzer 2 and EEGLAB. After removal of the error trials, an Independent Component Analysis was performed to remove the artifacts associated with eye movements and heartbeat. For removing the EMG artifacts caused by articulation, a Blind Source Separation Algorithm based on Canonical Correlation Analysis (BSS-CCA) was used [3]. Data were rereferenced to the bilateral ears. For all the tasks, we conducted a response-locked analyses, where the response was either the onset of lip EMG activity or the onset of the acoustic signal as measured with the voice key.

4. Results

Preliminary results of the response-locked analysis to the onset of speech production (i.e., voice key onset) show that the applied procedure allowed identification of the 3 event-related potentials of interest just before and during overt speaking. The event-related potentials between the 2 test sessions were highly correlated but a significant change in amplitude was identified between the two test sessions (e.g. Figure 1).

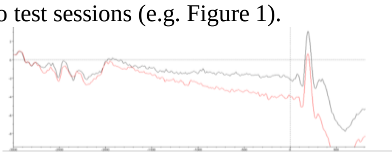

Figure 1: *Grand average CNV amplitude over Cz. At 0 msec the average amplitude was -2.1µV during the first test session (black line) and -3.9 µV during the second test session (red line). Negative plotted downwards.*

5. Discussion

The results of the current study showed that recent advancements in the processing of EEG data allow us to dissociate different neurophysiological processes associated with overt speech production. In addition, the data show that a learning effect is evident over test sessions. Overall, this study shows that EEG offers a novel opportunity for studying the fast neural changes occurring during overt speech production.

6. References

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