EEG evidence of phonemic processing in severely brain-injured patients

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Summary and Conclusions
- We present an EEG-based method of detecting linguistic processing at the level of phoneme class.
- All patients analyzed showed EEG evidence of differential processing of phoneme classes.
- The spatial pattern of differential responses was highly variable in healthy subjects and patients.
- In this limited patient sample, the temporal pattern of responses in CMD patients was similar to that of healthy controls; while responses in MCS and confusional patients tended to occur later and, surprisingly, with greater frequency.

Motivation
Assessment of cognitive ability in brain-injured patients is crucial for their care, and language is a key component of cognition. Though processing of speech has previously been studied in brain-injured patients at the level of comprehension, the hierarchical nature of language calls for studies at lower levels as well. Here, using electroencephalography (EEG), we studied language processing at the phonemic level in brain-injured patients.

Methods
Participants: 15 patient subjects (PS) were tested (see table).
Level of consciousness was classified as minimally conscious state (MCS), confusional state, or cognitive-motor dissociation (CMD) on the basis of the Coma Recovery Scale Revised (CRS-R) and EEG and/or fMRI tests of command following, at one to three admissions (v1, v2, v3). Ten healthy controls (5M; avg. age: 39 years) with no history of neurologic disease were also tested.

Data Collection: EEG was recorded at 250 Hz at 37 electrodes (augmented T10-T20 international system, except for PS12, where 21 electrodes were used, due to small head size).

Audio Stimulus: A 148 sec. section of Alice’s Adventures in Wonderland, read by a female (www.librivox.org) was presented via ear-buds at multiple times during each 2-3 day admission. Testing occurred when the patient appeared most wakeful.

Screening: EEG recordings were analyzed after screening for motion artifacts and eye movements. Subjects had 79.2% (43 of 55 datasets) for PS and 71.8% (23 of 32 datasets) for HC. Data from 2 HC and PS02 were discarded.

Preprocessing: The EEG was bandpass-filtered at 2-15 Hz. The audio was annotated for phonemes using Praat [1] to obtain markers for extracting time-locked responses.

Analysis
The analysis was done at the level of consonant phoneme categories. The audio sample contained 173 approximants, 254 fricatives, 142 nasals, and 312 plosives.

Healthy Controls (n=8)
All CMD patients showed EEG evidence of differential processing of phoneme classes. While there was substantial variability across individuals, differential responses tended to occur early in the analysis window.

Cognitive-Motor Dissociation (n=10)
Both MCS patients showed EEG evidence of differential processing of phoneme classes. One had an early peak in differential responses; both had differential responses late in the analysis window.

Minimally Conscious State (n=2)
Both confusional state patients showed EEG evidence of differential processing of phoneme classes, primarily in the middle and end of the analysis window.

Confusional State (n=2)
Both confusional state patients showed EEG evidence of differential processing of phoneme classes, primarily in the middle and end of the analysis window.

References