

Comparison of coherence and phase synchronization of the human sleep electroencephalogram

Kristína Mezeiová^{a,b}, Milan Paluš^{b,*},

^a*Institute of Measurement Science, Slovak Academy of Sciences, Dúbravská cesta 9, 841 04 Bratislava, Slovak Republic*

^b*Institute of Computer Science, Academy of Sciences of the Czech Republic, Pod vodárenskou věží 2, 182 07 Prague 8, Czech Republic*

Abstract

Objective: Potential differences between coherence and phase synchronization analyses of human sleep electroencephalogram (EEG) are assessed and occurrences of phase vs. complete synchronization between EEG signals from different locations during different sleep stages are investigated.

Methods: Linear spectral coherence, mean phase coherence (MPC) z-score and Pearson's correlation coefficient of analytic amplitudes were evaluated for different spectral bands of whole-night EEG recordings from 25 healthy subjects.

Results: Coherence and MPC z-score demonstrated practically the same statistical differences between vigilance stages, confirming the findings of previous coherence-based studies. MPC z-score and amplitude correlations were most correlated (>0.5) between homologous interhemispheric positions and least correlated between nonhomologous interhemispheric positions and between fronto-occipital positions.

Conclusions: Coherence and phase synchronization provided essentially the same information. Complete synchronization was manifested by highly coherent phases and correlated amplitudes, as well as by correlated changes of phase synchronization, coherence and amplitude correlations between vigilance states. In cases of weaker coupling, phase synchronization and coherence change in agreement, while behaviour of amplitude correlations differs.

Significance: Phase synchronization analysis is not superior to coherence analysis, although the coupling between EEG signals is dominated by phase synchronization which turns into complete synchronization in the most strongly coupled EEG signals.

Key words: Phase synchronization; Complete synchronization; Mean phase coherence; Permutation surrogate data; Coherence; Human sleep EEG

Highlights:

- Coherence and phase synchronization analyses yield practically the same statistical differences between stages of human sleep EEG.
- Coupling between EEG signals is dominated by phase synchronization which turns into complete synchronization in the most strongly coupled EEG signals.
- In gamma band the type of synchronization depends on sleep state, while in other spectral bands it is determined by topographic positions of considered electrodes.

* Corresponding author.

Email address: mp@cs.cas.cz (Milan Paluš).