Proceedings of the 3rd World Congress on Electrical Engineering and Computer Systems and Science (EECSS'17)
Rome, Italy – June 4 – 6, 2017
Paper No. ICBES 104
ISSN: 2369-811X
DOI: 10.11159/icbes17.104

Association between Phase Coupling of Respiratory Sinus Arrhythmia and Brain Activity during Sleep

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Extended Abstract

Our previous study [1] demonstrated that mental stress in humans exerts an influence on the oscillations of respiratory sinus arrhythmia (RSA), inducing an incoherent phase lag with respect to breathing, i.e., decrease in the phase coherence ( ) between RSA and respiration. The showed a positive correlation with high-frequency component (HF) of the frequency domain measures of heart rate variability (HRV) and a negative correlation with sympathovagal balance (low-frequency to HF; LF/HF), suggesting that the phase coupling of RSA could be used as a noninvasive measure for evaluating the activity of the autonomic nervous system (ANS). We hypothesised that similar to the mental stress condition, would be increased during non-REM sleep as reflecting cardiac parasympathetic activation, since it has been demonstrated a strong interaction between ANS activity and delta wave activity in the EEG during sleep [2][3]. The aim of the present study was to examine how is altered depending on the sleep status and to evaluate the temporal relationship between brain activity and during sleep. Overnight EEG and ECG of seventeen healthy volunteers were recorded. The EEG was band-pass filtered to extract the activity in the delta, theta, alpha and beta ranges, and then Hilbert transform was applied to each extracted signal to calculate the analytic amplitude. Respiratory signal was derived from the amplitude modulation of R-waves caused by breathing. Beat-to-beat R-R intervals (RRI) were determined and the time series of the RRI was further band-pass filtered with a frequency range of 0.15-0.4 Hz to determine RSA. From the oscillatory signals of RSA and respiration, each analytic signal was constructed from a real signal and its Hilbert transform, and then the time-dependent between RSA and respiration was obtained with 10-s window.

Using auto- and cross-correlation analyses, we found that periodicity of was quite similar to that of delta wave (93.3 min vs. 90.8 min, r = 0.900) and that overnight profiles of and delta wave were related with highly significant cross-correlation coefficients (0.46±0.11). The variation of preceded changes in delta wave by 7.6 min on average. These results demonstrate that and EEG delta activity are closely linked during sleep in healthy humans and suggest that the phase coupling analysis of RSA could provide important information on sleep status and cardiac autonomic modulation during sleep.

References

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