

Time-Frequency Analysis of Cardio-Respiratory Response to Mental Task Execution

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OBJECTIVE: Heart rate, heart rate variability (HRV) and respiratory effort have been proposed in numerous studies with the goal of correlating physiological parameters with mental workload. Aim of this study was to analyze the cardio-respiratory response to a mental task (Sternberg Task) from a single lead ambulatory ECG recording, in healthy subjects. **METHODS:** Under no assumptions on stationarity, short-term HRV was analyzed in the time-frequency domain by means of the Hilbert-Huang Transform (HHT). Results were compared with the power spectral density (PSD) estimate based on Welch periodogram. HHT marginal energy spectrum was computed to estimate normalized LF and HF energy evolution over time. A surrogate respiratory signal (SRS) was extracted from the ECG by means of an established principal component analysis (PCA) based method, and its spectrum was computed in the range 0-0.5 Hz for respiratory rate and power analysis. SRS was extracted from the same sliding window of ECG data used for HRV, to allow synchronous and consistent analysis. **RESULTS:** HRV analysis in the time-frequency domain and in the frequency domain lead to similar results in terms of normalized LF and HF components (LF: $r^2 = 0.63 \pm 0.17$, HF: $r^2 = 0.54 \pm 0.20$) evolution, the first being more evident and also the most relevant in literature to the characterization of the cardio-respiratory response to a mental task in healthy subjects. A significant though not sustained increase in LF was found in this study in most subjects in response to the mental task start. Frequency domain PSD analysis of SRS showed a dominant respiratory rate between 0.20 Hz and 0.35 Hz (12 rpm and 20 rpm, respectively) in most subjects, which in some cases was associated with a transient lower frequency component (0.15-0.20 Hz) with higher power in proximity of the task start.