Point Process Heart Rate Variability Assessment during Sleep Deprivation

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Heart rate variability (HRV) is an important quantitative marker of cardiovascular regulation by the autonomic nervous system. Recently, links between cardiac oscillations and circadian rhythms have been reported in several correlation studies in humans and other animals. Furthermore, changes in autonomic tone are correlated with changes in states of alertness and during performance tasks, as well as during sleep deprivation.

To demonstrate the potential relationships between HRV and objective performance - subjective alertness measures, we used data from healthy young subjects participating in a 52-hour Constant Routine protocol, an extended period of enforced wakefulness (sleep deprivation) in a semirecumbent position with frequent small meals and with minimal masking from exogenous factors.

A novel point process algorithm was applied to the RR series constructed from recorded ECG. The stochastic structure in the RR intervals is modeled as an inverse Gaussian renewal process, derived directly from a physiologically-based integrate-and-fire model. The parasympathetic and sympathetic inputs to the SA node are modeled by a uniform time-sampled regression on a continuous estimate of the most recent RR intervals, allowing for spectral decomposition into classic low frequency (LF, 0.04-0.15 Hz) and high frequency (HF, 0.15-0.5 Hz) spectral components. The point process algorithm is able to estimate the time-varying behavior of each derived spectral index at any time resolution.

The results demonstrated the point process high time resolution characteristics for sympatho-vagal balance as measured by LF and HF estimates during the 52h monitoring. Correlation analysis on subjects further reveals a considerable correspondence between the LF/HF index and subjective alertness measures during the first part of the experiment. At long time awake, high correlation levels between LF/HF and objective performance indicate an increasing sympathetic drive as performance measures worsen. These exciting results point at our HRV assessment as a potential real-time physiologic predictor of performance-alertness.