Multimodal vs Unimodal Estimation of Sympathetic-Driven Arousal States

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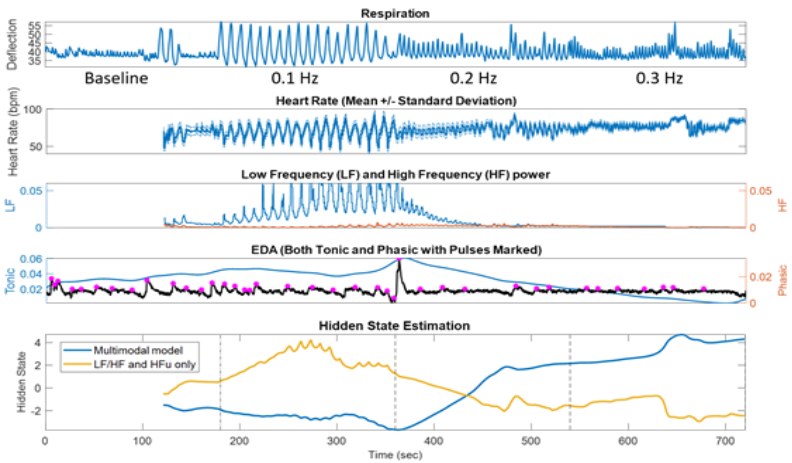
Introduction: Estimation of sympathetic-driven arousal state (SDAS) is traditionally done using frequency-based heartrate variability (HRV) metrics, such low and high frequency power (LF and HF). However, the unimodal nature of these indices can make them misleading, particularly in situations where the breathing rate is a confounding factor. We hypothesized that a multimodal approach to SDAS estimation would be more accurate and robust.

Methods: We collected multimodal data from five healthy volunteers during a three-stage paced breathing task. The slowest breathing rate fell directly within the LF range. We used a state space framework to estimate SDAS.

Results: A unimodal model based on only LF and HF derived observations estimates the highest SDAS at the slowest stage of breathing, likely due to the breathing rate. On the other hand, a multimodal model based on time and frequency domain HRV measures and electrodermal activity observations estimates a low SDAS during this stage that increases with breathing rate. This better reflects known physiology associated with deep, slow breathing.

Conclusion: These results support a multimodal paradigm for SDAS estimation, especially when there is no information about breathing rate.

Keywords: Autonomic control, heartrate variability, electrodermal activity, multimodal analysis



Data and SDAS estimation results for a representative subject