Robust Estimator of the Cardiorespiratory Coupling

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Introduction: In general, methods for non-invasive quantification of the cardiorespiratory coupling combine information from heart rate variability (HRV) and respiratory signals. Abnormal beats alter the reliability of the HRV and thus hinder the evaluation of the cardiorespiratory coupling. This is particularly problematic for methods based on autoregressive models due to their sensitivity to outliers. An alternative approach based on robust regression is proposed in this abstract. *Methods*: A vector $\mathbf{y}$ containing the HRV, and a matrix $\mathbf{X}$ with an embedding of the respiratory signal, are constructed. $\mathbf{X}$ and $\mathbf{y}$ train a weighted Least Squares Support Vector Machines regression model which is used to predict $\mathbf{y}$. Afterwards, the residuals of the prediction ($\mathbf{e}$) are derived. The cardiorespiratory coupling is characterized by $\eta = 1 - IQR(\mathbf{e})/IQR(\mathbf{y})$, where $IQR(*)$ refers to the interquartile range. η measures how good the prediction is. The prediction, in turn, is better for signals with a stronger coupling. *Materials*: Respiratory and ECG signals from polysomnographies of 100 apnea patients were used. Both, HRV and respiration were segmented into 5-minutes epochs. The respiratory component of the HRV, $\mathcal{P}_x$, was derived using subspace projections. The linear coupling between HRV and respiration was confirmed with a surrogate analysis applied to $\mathcal{P}_x$. Ten ranges of $\mathcal{P}_x$ were defined to split the segments into 10 groups. Afterwards, the epochs were contaminated with random numbers of simulated ectopic beats and the coupling was evaluated before ($\mathcal{P}_x$, η) and after ($\mathcal{P}_x^c$, η^c) contamination. *Results and conclusion*: Figure 1 shows an example when 8 ectopics are added. Despite significant differences (Kruskall-Wallis, $p < 0.05$) before and after contamination, the visual trends suggest that η is more robust compared to $\mathcal{P}_x$. The trends with $\mathcal{P}_x$ are affected when more than 2 ectopic beats are present. In contrast, these are maintained up to 9 ectopic beats with η. The application of the method in data with real ectopics needs to be evaluated.

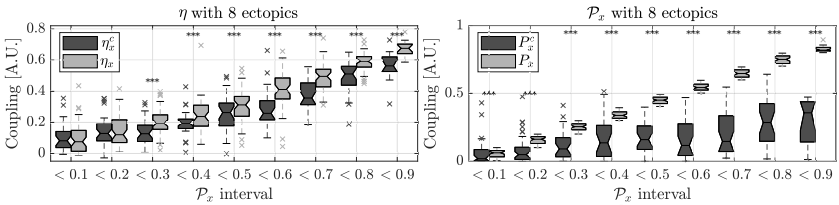

Figure 1. Cardiorespiratory quantification with η and $\mathcal{P}_x$