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Cardio-respiratory coupling in health monitoring

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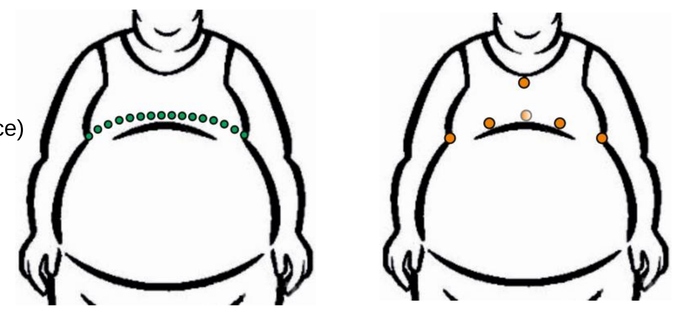
Context

- Monitoring of obese patients
  - Prone to cardiac/autonomic disease
- Smart-shirt
- Electrocardiogram (ECG) and respiration signals
  - Phase relation between respiratory and cardiac signals is an indicator of autonomic nervous system balance

Respiration (impedance) sensors in smart-shirt



ECG electrodes in smart-shirt

Cardiovascular coupling

- Autonomic nervous system controls heart rate (HR)
  - Vagal: resting state, decrease in HR
  - Sympathetic: fight-or-flight, increase in HR
- HR variability at respiratory frequencies: *respiratory sinus arrhythmia (RSA)*
  - Inhalation: increase in HR
    - Absence of vagal control
  - Exhalation: decrease in HR
    - Vagal control

⇒RSA is an indicator of vagal/sympathetic balance

  - Current indices are based on power. What about phase?

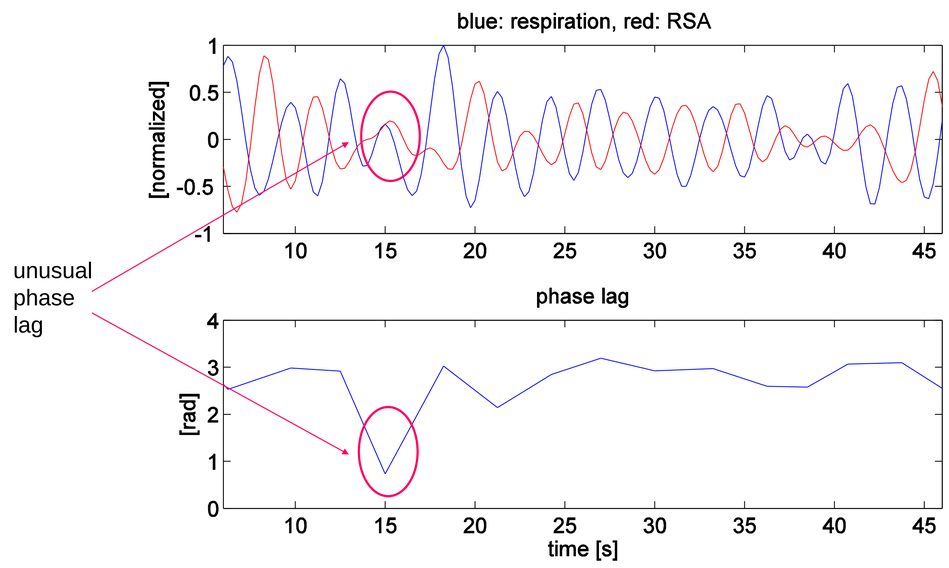
Phase lag

- Instantaneous phase of respiration and RSA according to the Hilbert transform
  - φ_{resp} and φ_{RSA}
- Phase lag: $|\varphi_{resp}(t_p) - \varphi_{RSA}(t_p)|$, where t_p denotes respiratory peak (inhalation) locations

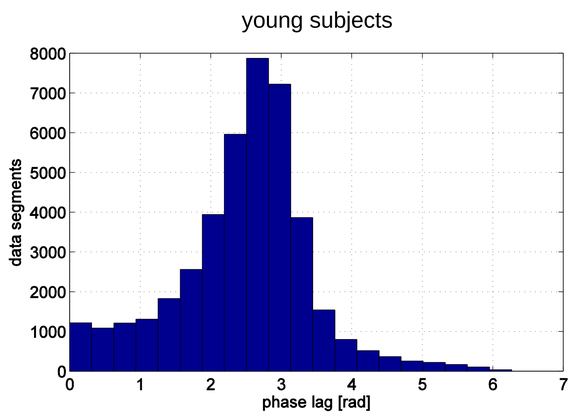
Data

- Age: young v.s elderly
  - Data: public Physionet Fantasia

Results



- Phase lag is larger (closer to π) and less variable for young subjects than for the elderly



	Mean**	Skewness*	Kurtosis**
young	2.46 ± 0.16	-0.37 ± 0.65	4.46 ± 1.44
elderly	2.08 ± 0.19	0.09 ± 0.48	3.33 ± 0.86

**p<0.01, *p<0.05

Conclusions

- Phase lag is different with age

Future work

- Extension to the assessment of autonomic balance during illness, e.g., diabetes