

# Using Cameras to Remotely Measure Cardiac Physiology and More

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# Agenda

- Cardiac measures of neural control
- PhysioCam – a remote cardiac monitor
  - Sufficient precision to measure heart rate variability
- Alternatives to noncontact physiology

# Brain-Heart connection: Cardiac vagal tone

RED = Sympathetic fibers

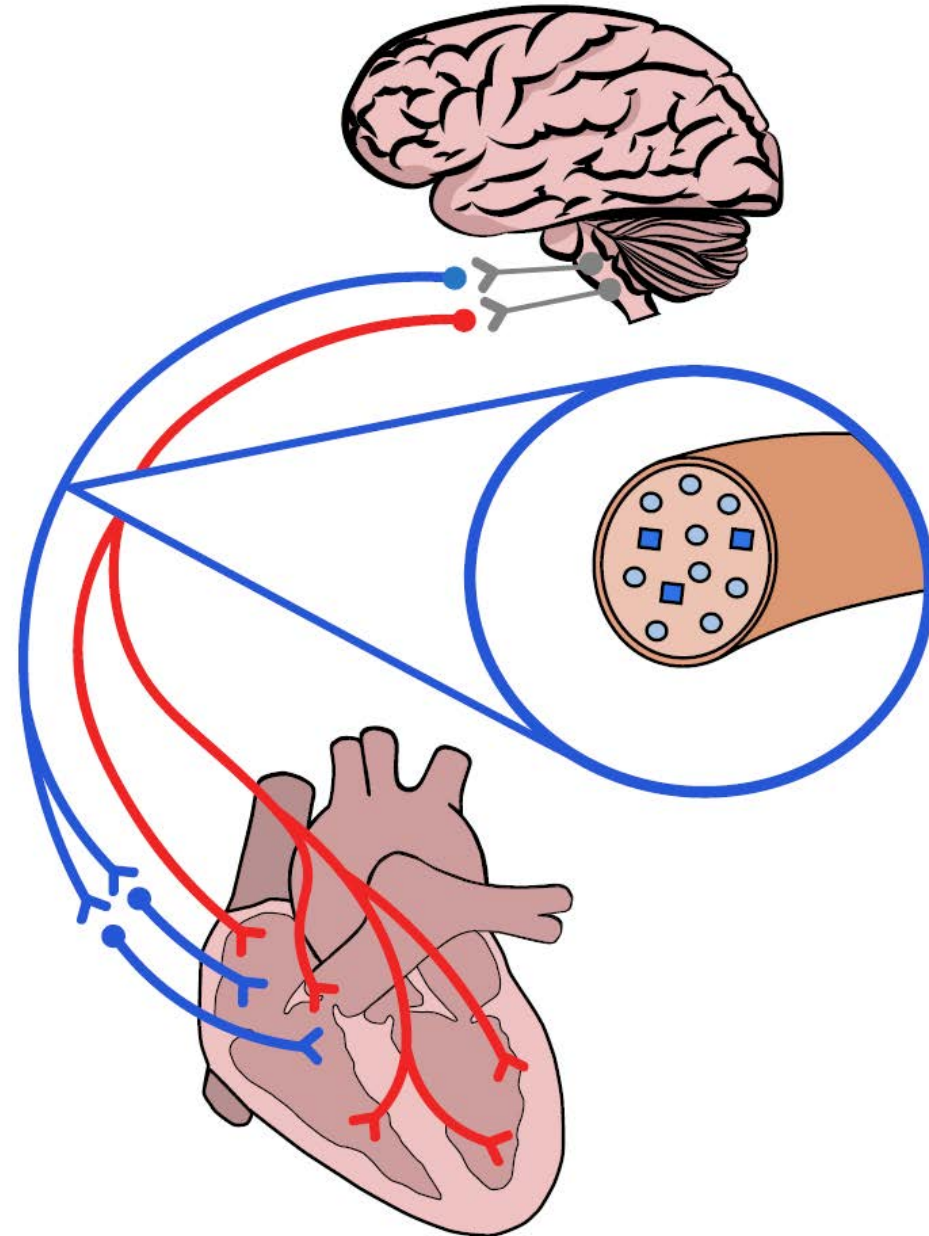
BLUE = Vagal fibers

 = Unmyelinated fibers (DMX)

 = Myelinated fibers (NA)

NA = nucleus ambiguus

DMX = dorsal motor nucleus



# What is heart rate variability?

- Beat-to-beat variation in heart rate
- Contains patterns that are specific to NA control of cardiac output
- Sensitive to cognitive, emotional, and social processing
- Useful in predicting and tracking recovery

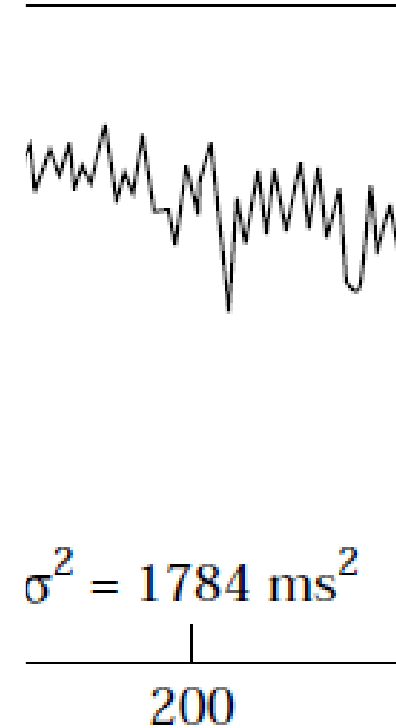
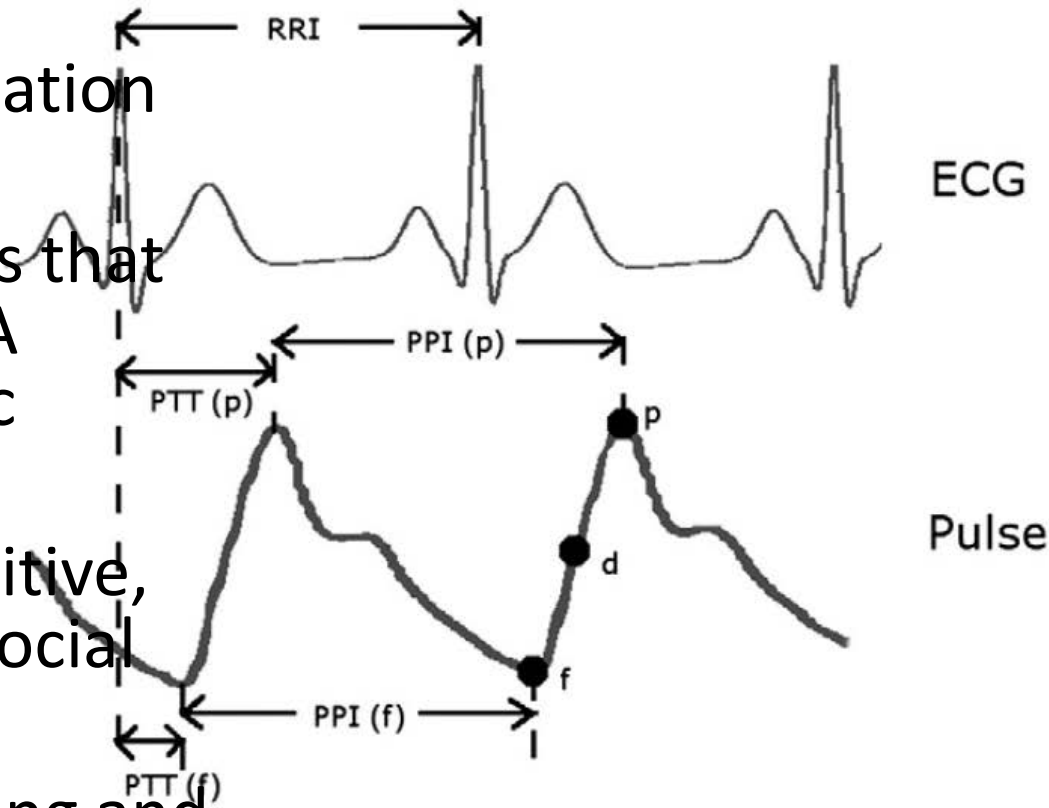
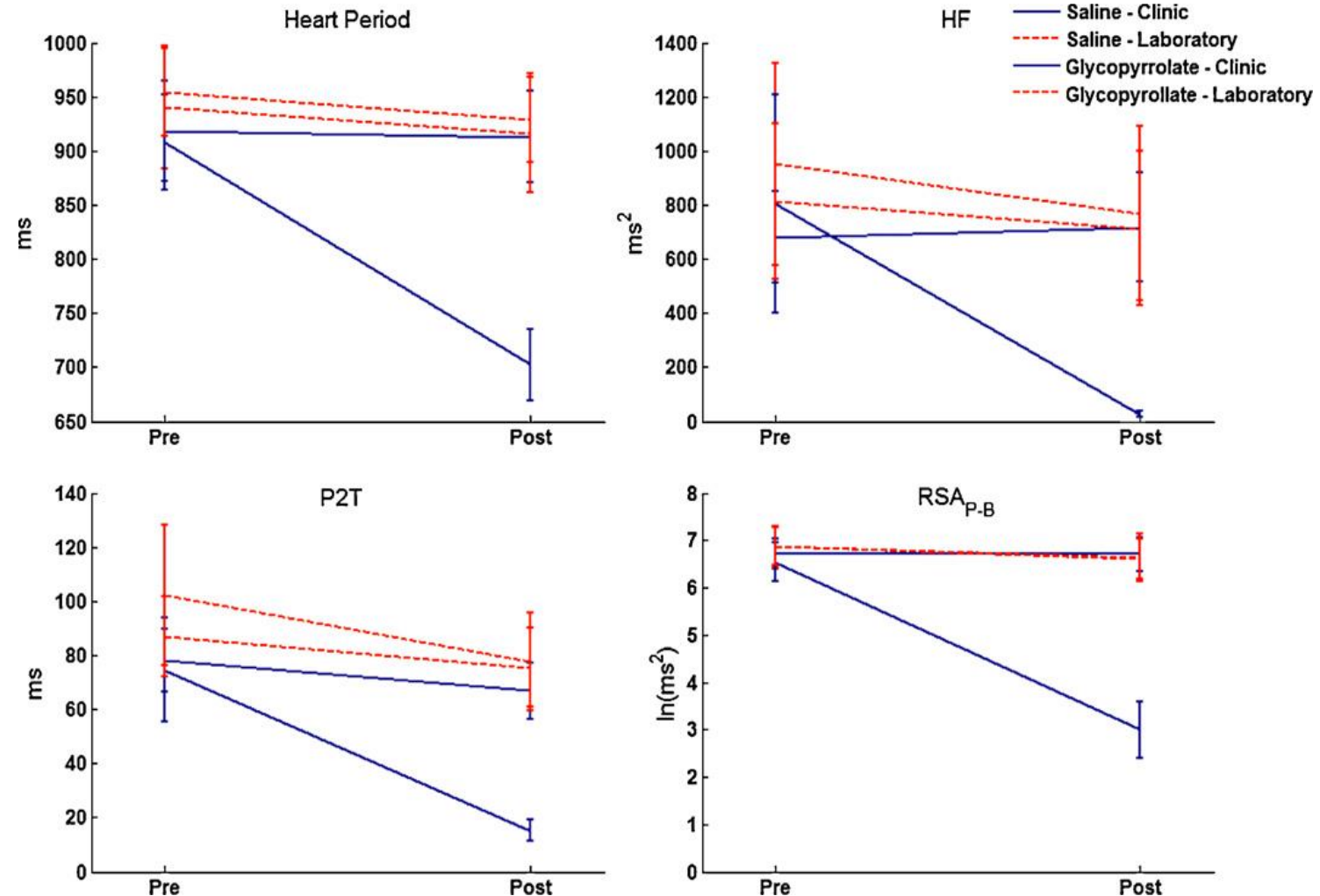


Fig. 1. An ECG and a pulse wave signal, illustrating the meaning of RR interval (RRI), pulse transit time (PTT), and pulse interval (PPI). The latter two quantities depend on the method to identify pulse cycle limits, e.g. to detect systolic peaks (p), points of maximum slope or 1st derivative (d), or diastolic minima/foot points denoting the onset of systole (f).

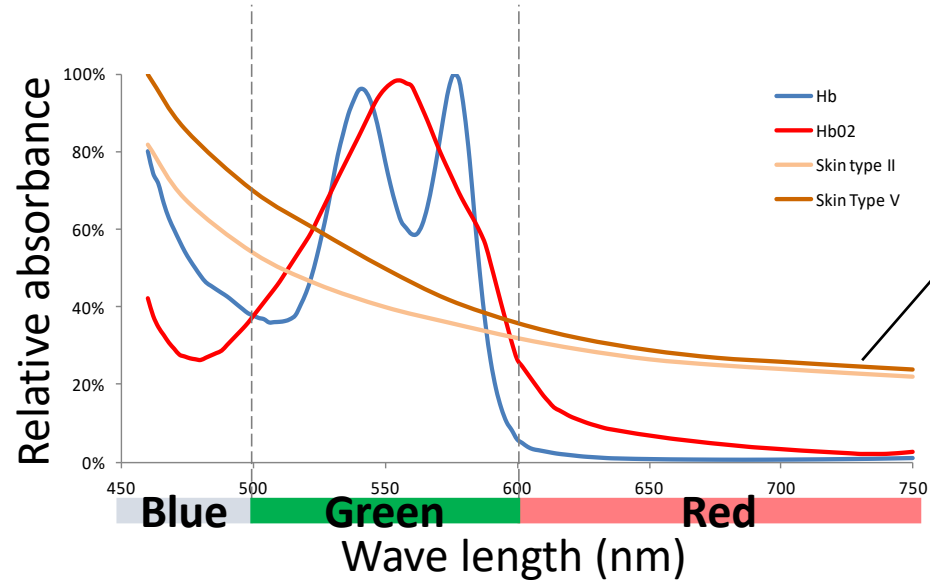
# Optimizing estimation of cardiac vagal tone

- Time and Frequency domain methods are common
- Porges-Bohrer method
  - Can track rapid changes in RSA



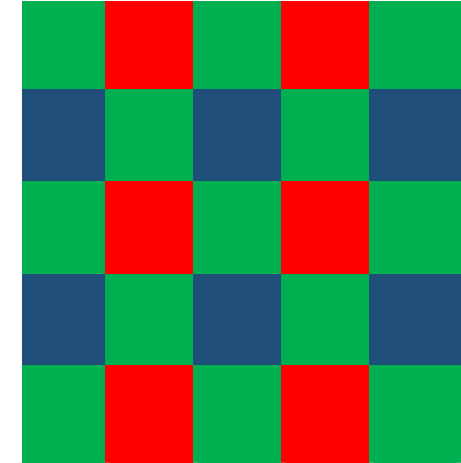
Lewis, Gregory F., et al. "Statistical strategies to quantify respiratory sinus arrhythmia: Are commonly used metrics equivalent?." *Biological psychology* 89.2 (2012): 349-364.

# Physics + Physiology → Sensor Selection

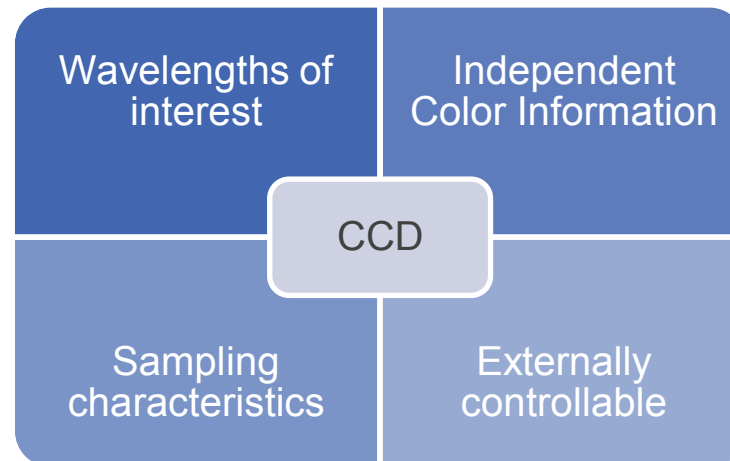


Impact of melanin (skin tone) on absorbance

### Camera Sensor



Bayer mapping of the Kodak Sensor



# RESULTS: Real-time heart rate, sufficient for HRV analysis

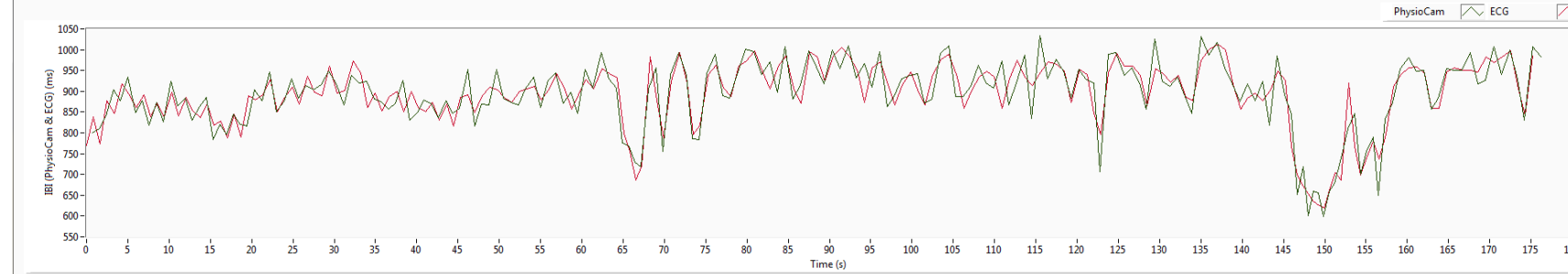
## Cold Pressor Recovery



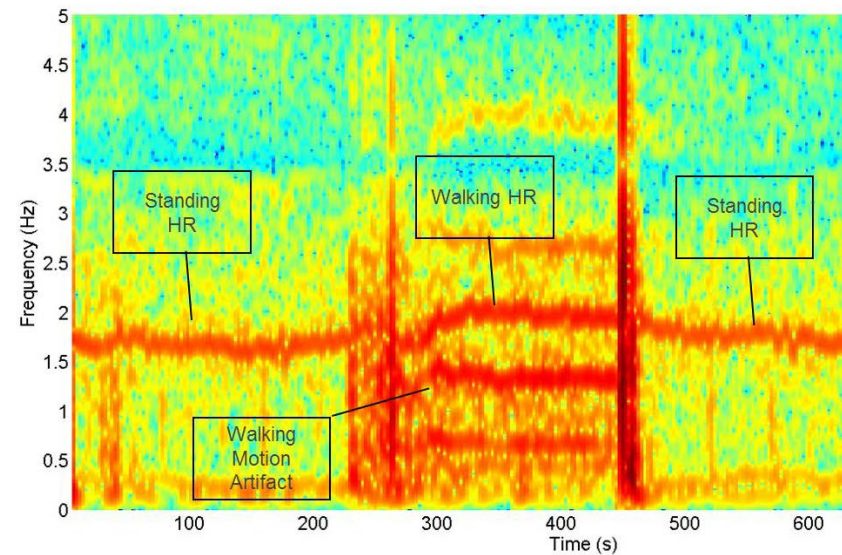
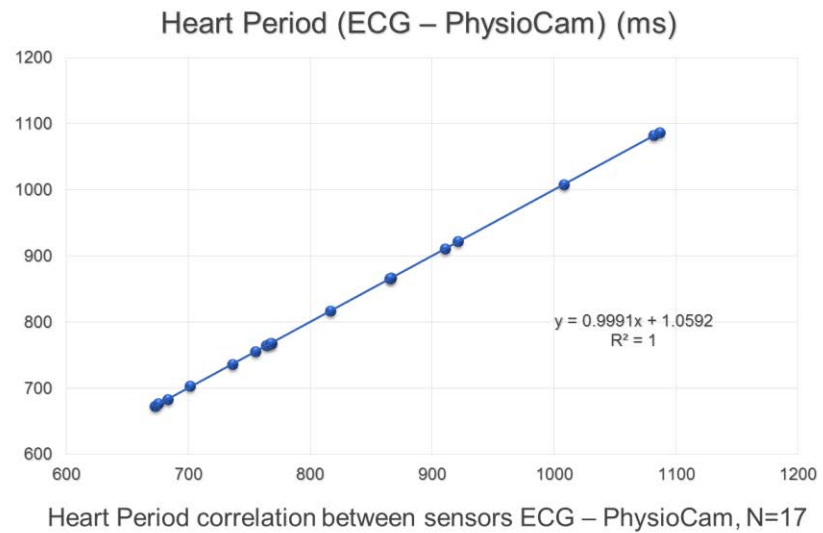
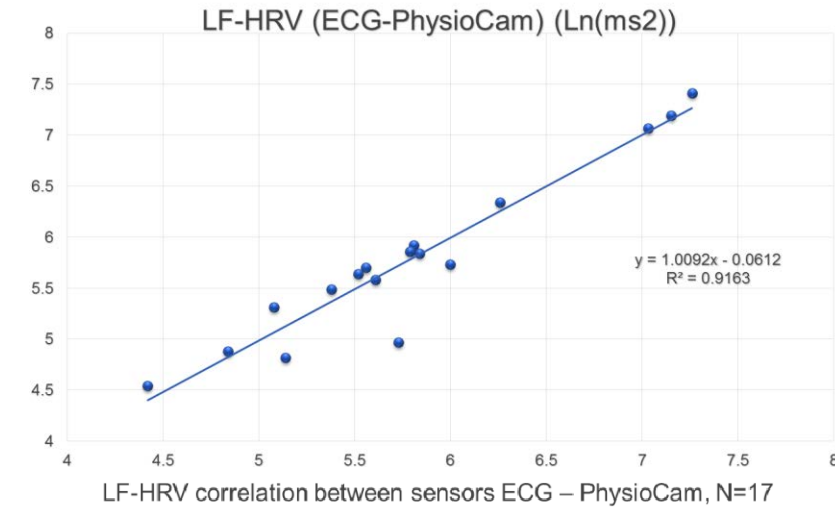
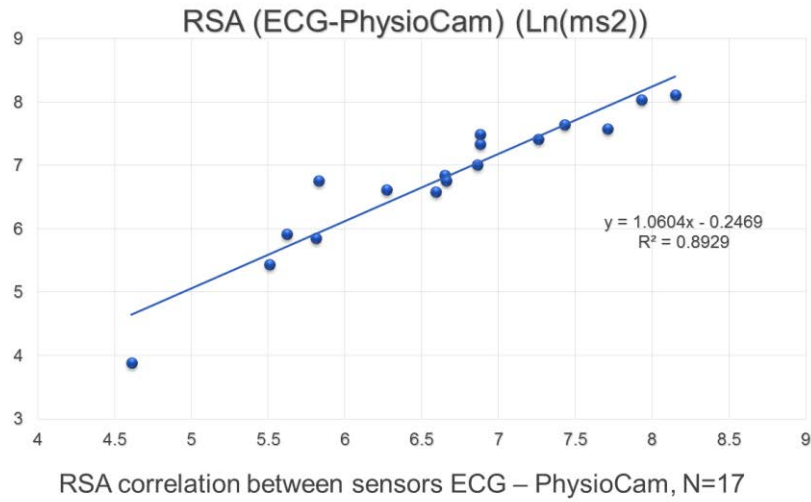
## Rapid Breathing



## Final Baseline



# RESULTS: Between subject correlations for HR & HRV (ECG vs. PhysioCam)







Heart Rate (beats/min)

80.46

Respiration Rate (breaths/min)

9

Inter Beat Interval-IBI (ms)

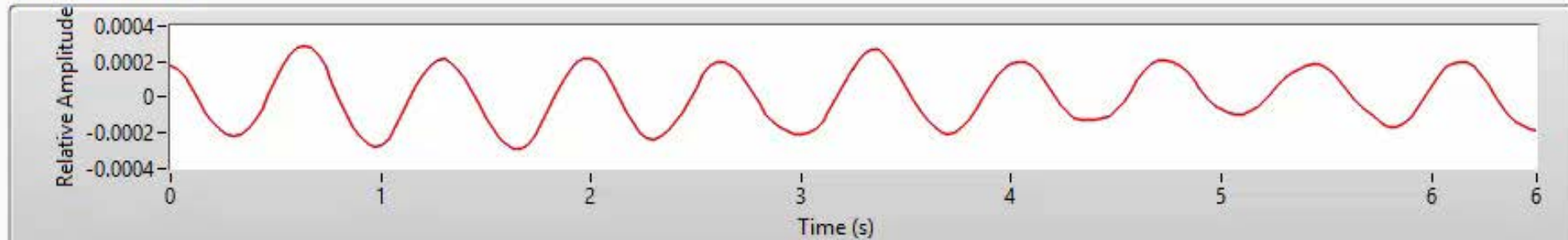
746

RSA

6.355

STOP

Arterial Pulse Signal



# Prototype system: Real-time feedback on patient status

Desktop PhysioCam



Changes color to reflect shifts in cardiac vagal tone

<https://www.neuralsolution.com/>

# Alternatives and future directions

- Ship heart rate monitors to every subject
  - ~\$100 per subject
  - Many subpar systems provide unreliable signals
- Collect self-report measures on autonomic reactivity
  - Validation ongoing but encouraging
- Working on: Telehealth 'plug-in' that works with standard webcam
  - Fighting against physical limitations of inexpensive CMOS sensors
  - Potential for greater bias due to melanin content

# THANK YOU

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