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

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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

Physics + Physiology $\rightarrow$ Sensor Selection

Impact of melanin (skin tone) on absorbance

Bayer mapping of the Kodak Sensor

Wavelengths of interest

Independent Color Information

CCD

Sampling characteristics

Externally controllable
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)
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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