Cardiac Signals

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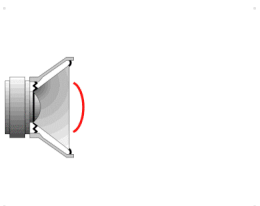
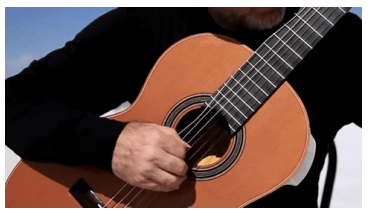
Physiological signals

Audio signals

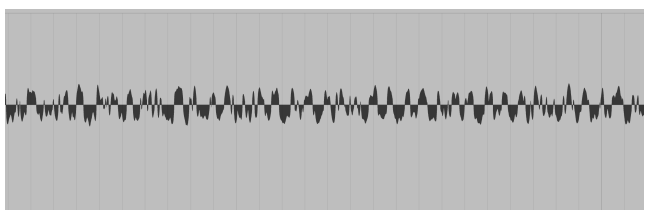
We have just learned how physical sounds are represented as audio signals.



Sound waves from speakers



Instruments



Represented as waveforms

Audio signals

…and we can analyse these signals to describe and reveal many of the underlying properties that make up sound.

img from python analysis

Physiological signals

Our bodies also generate signals.

Walking

EEG

Breathing

Heart beat

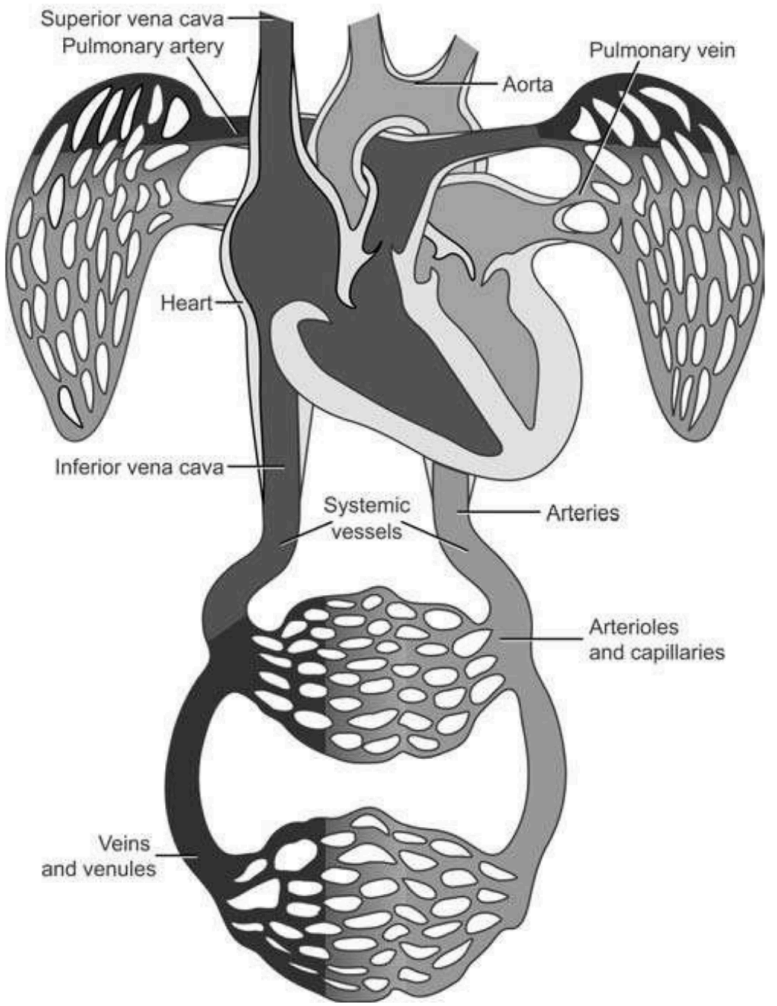
Physiological signals

Psychologists are interested in these signals as well—what can they tell us about underlying properties of human behaviour, cognition, and perception?

The heart

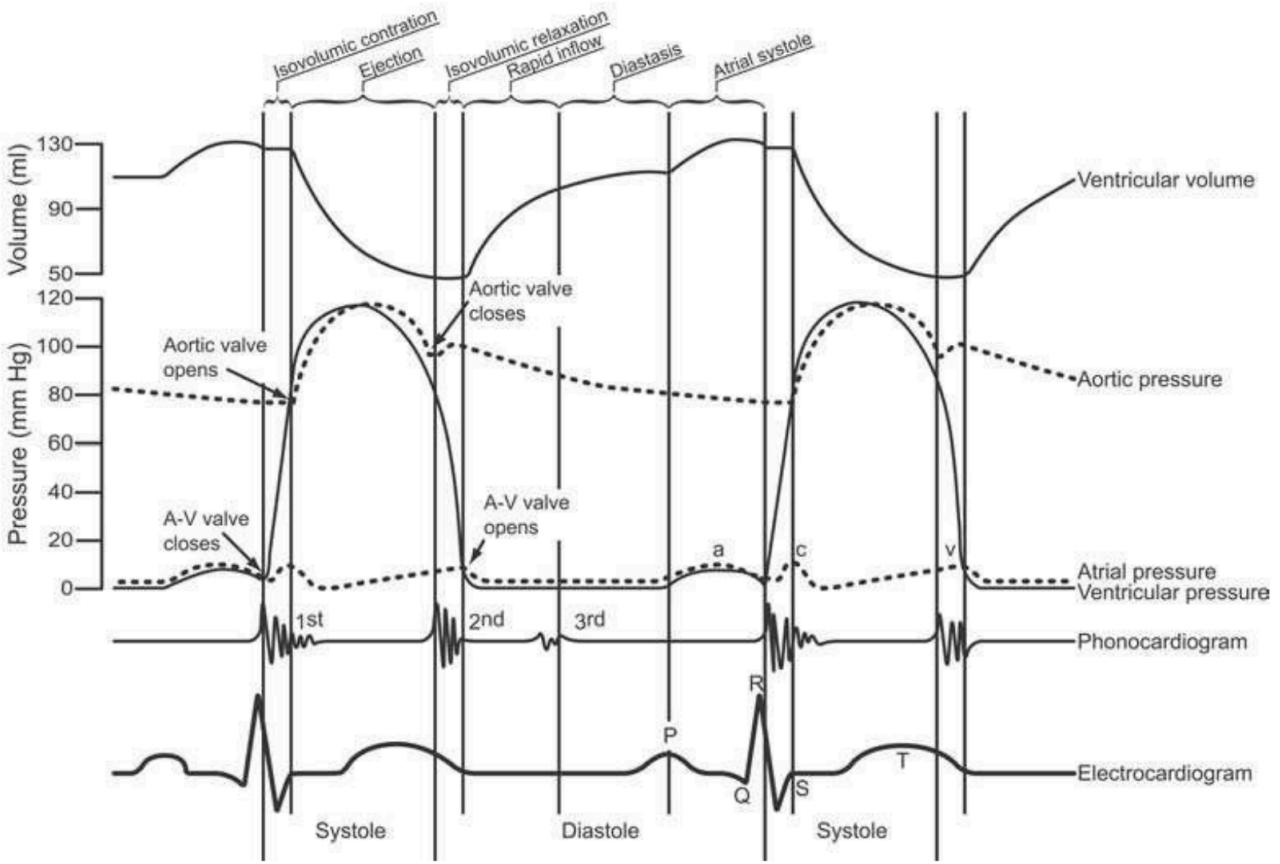
Overview

Cardiac anatomy



The heart circulates blood, rich in oxygen, nutrients, hormones, etc., throughout the body with precision [1].

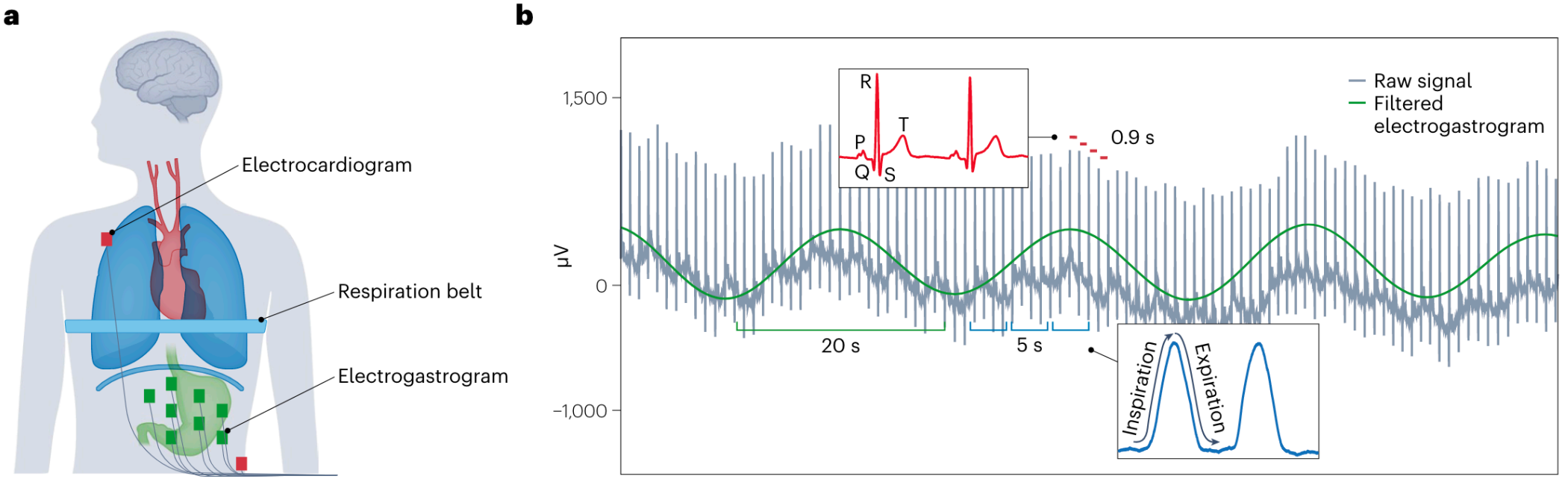
The cardiac cycle



[Note the bottom line: the Electrocardiogram] The cardiac cycle consists of a large voltage 'spike' from cells in the heart, causing the heart to contract (*systole*, pushing blood into the body); followed by a period of relaxation (*diastole*, where the heart refills with blood from the body) [1].

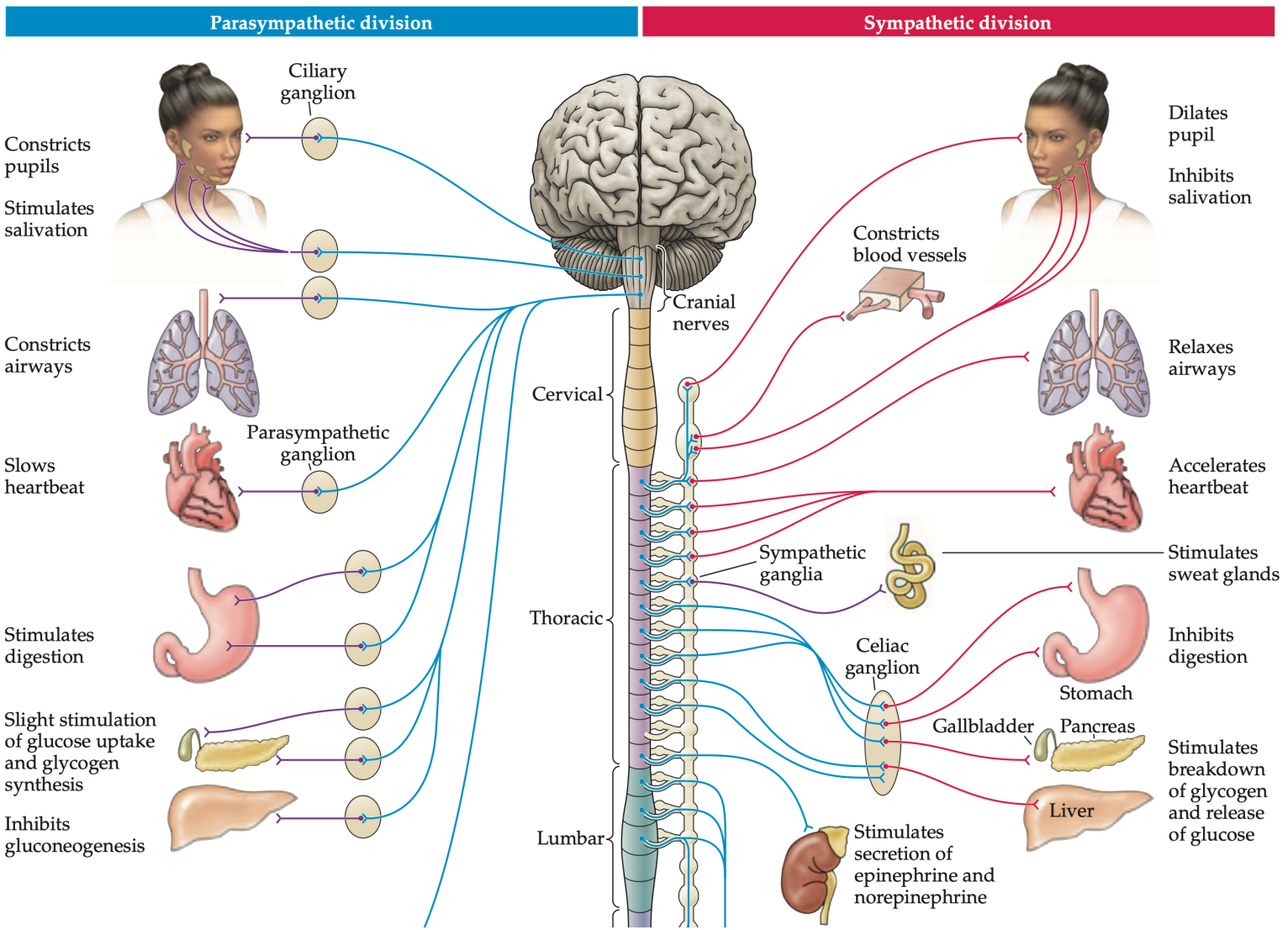
Why is this interesting?

Intrinsic rhythms



Only a few organs produce internal bodily rhythms. These rhythms are affected by bodily states [2].

The heart *is influenced by* our nervous system



The heart also *influences* our nervous system

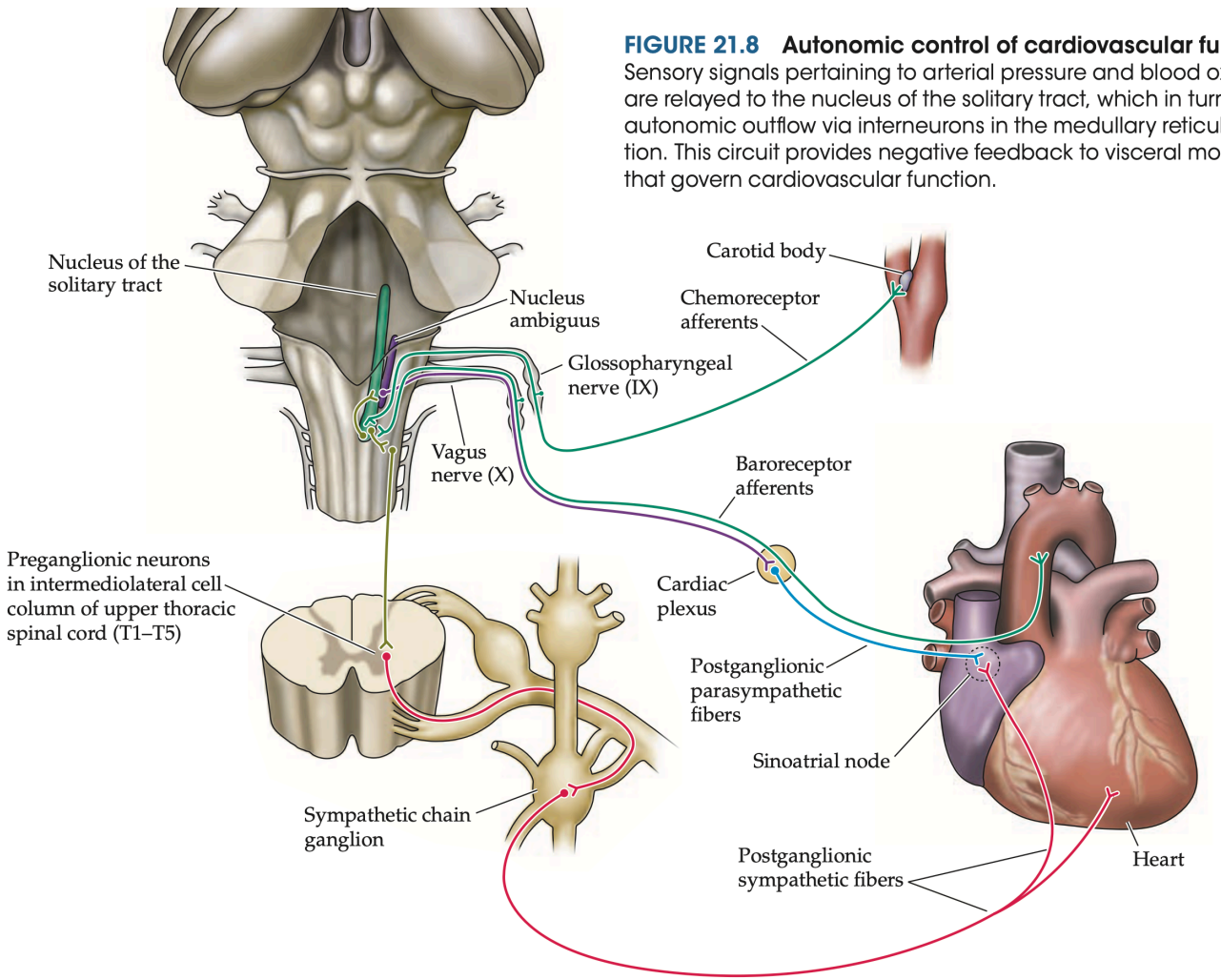
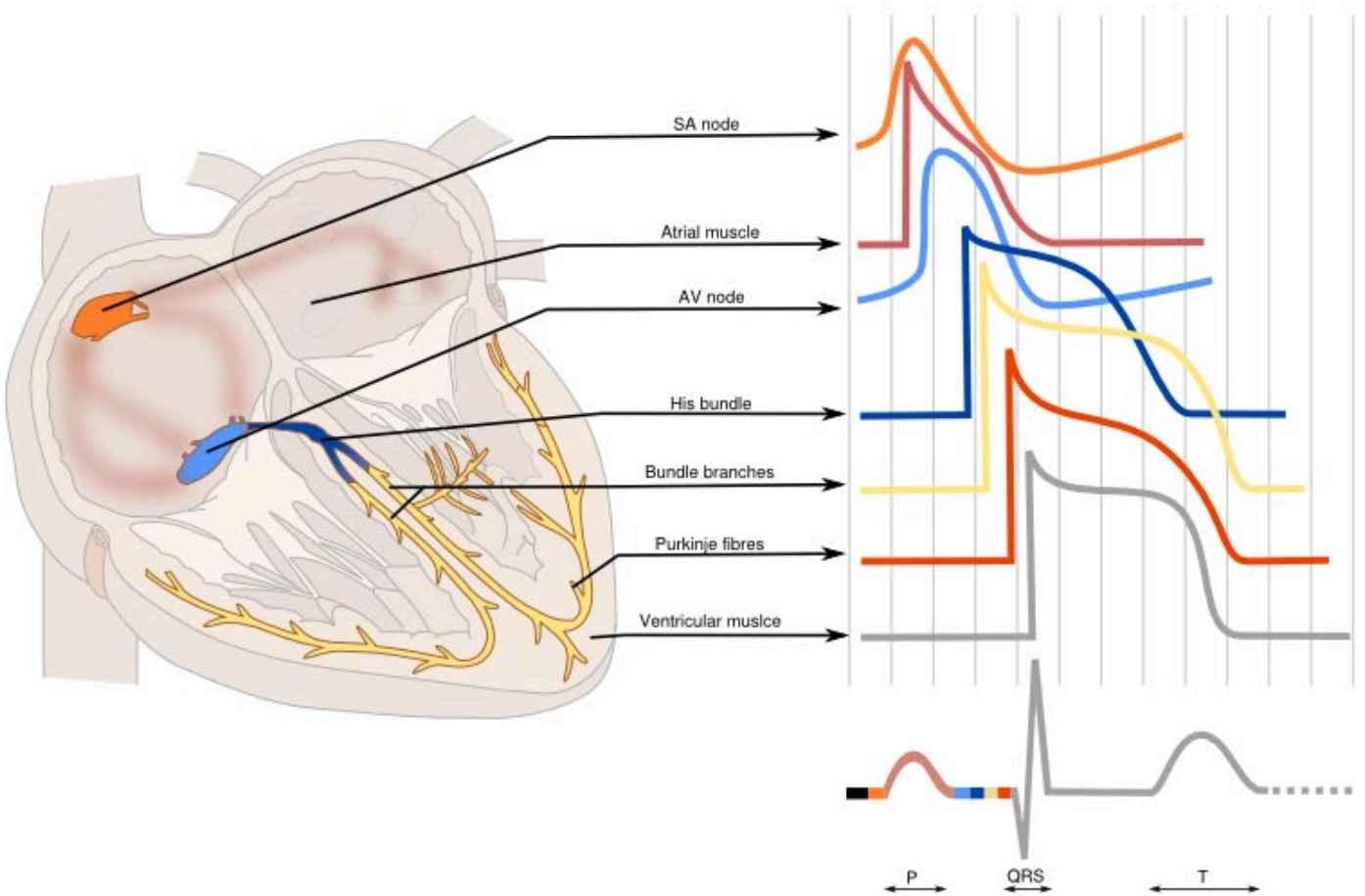


FIGURE 21.8 Autonomic control of cardiovascular function. Sensory signals pertaining to arterial pressure and blood oxygenation are relayed to the nucleus of the solitary tract, which in turn organizes autonomic outflow via interneurons in the medullary reticular formation. This circuit provides negative feedback to visceral motor neurons that govern cardiovascular function.

We can (easily*) detect cardiac signals!

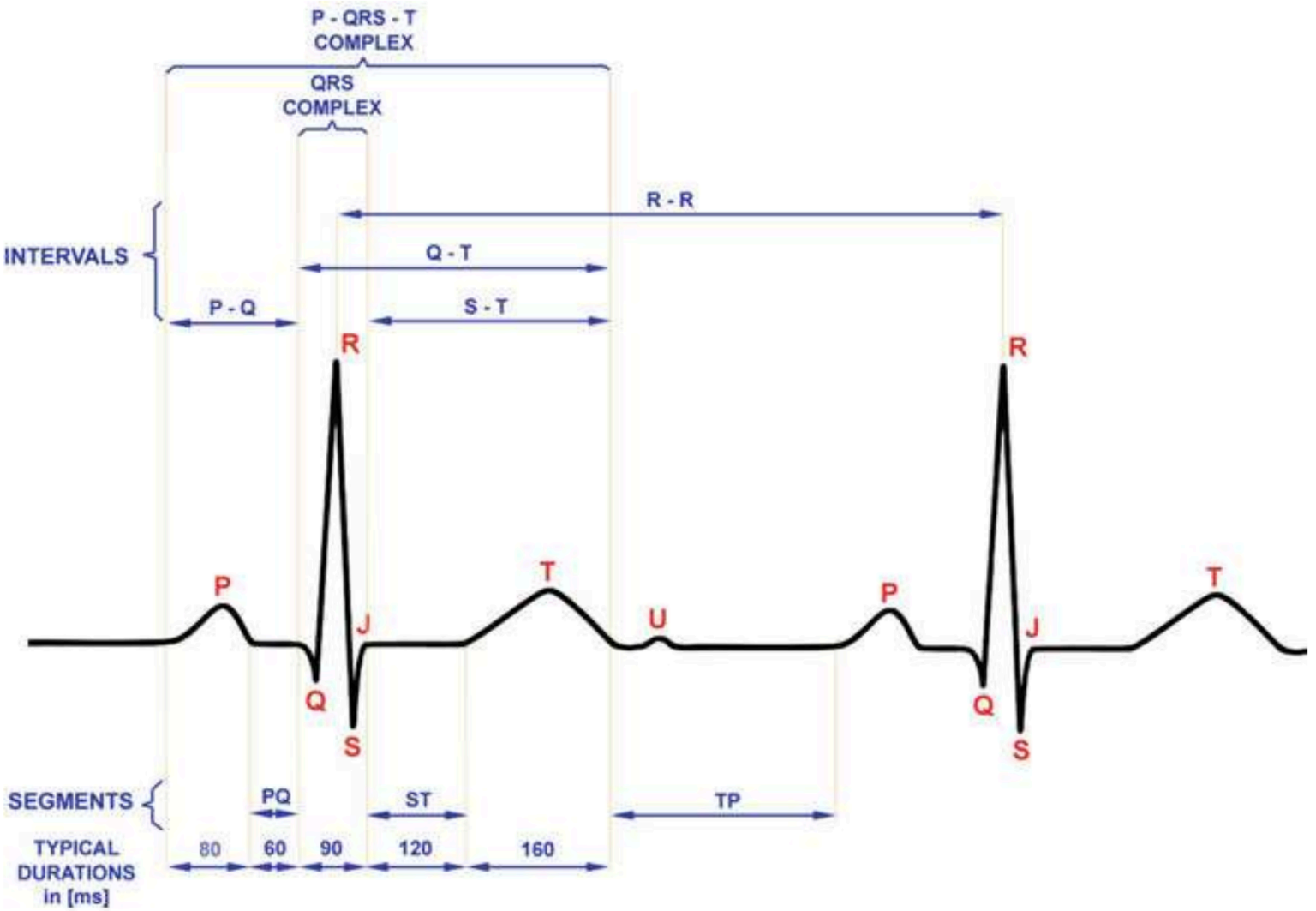
Measuring cardiac activity

Electrocardiogram (ECG/EKG)



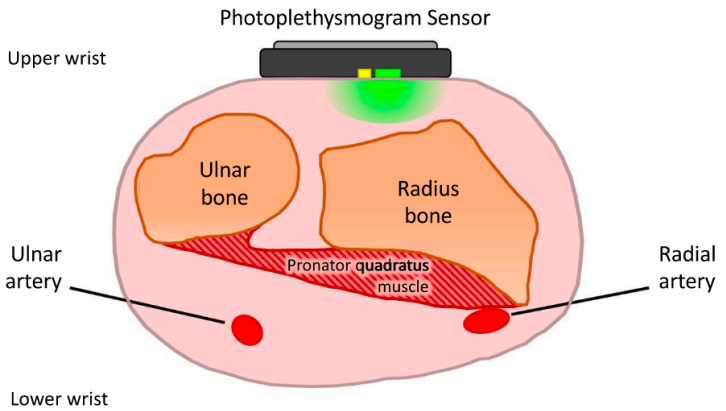
Electrical potentials produced by the heart [4]

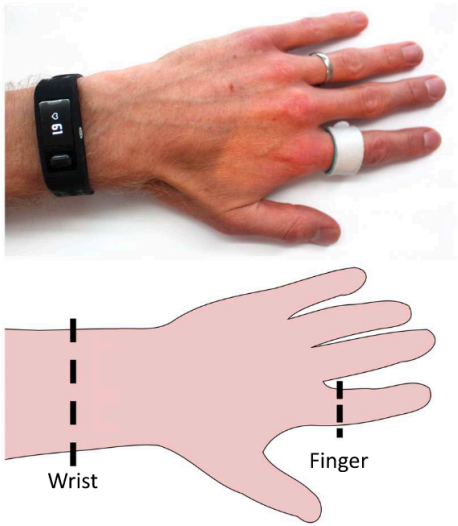
Electrocardiogram (ECG/EKG)

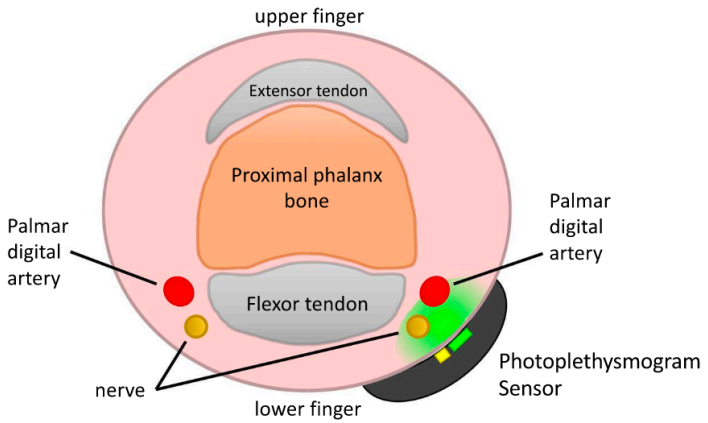


Combine to produce a waveform

Photoplethysmogram (PPG)

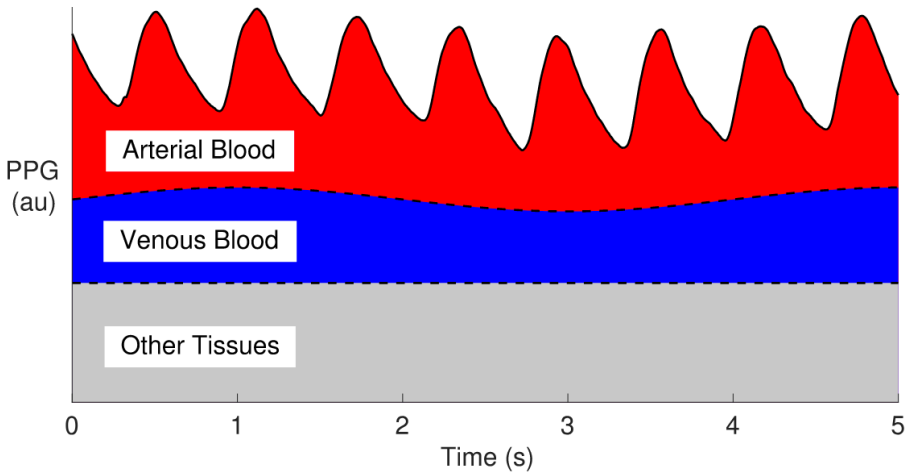






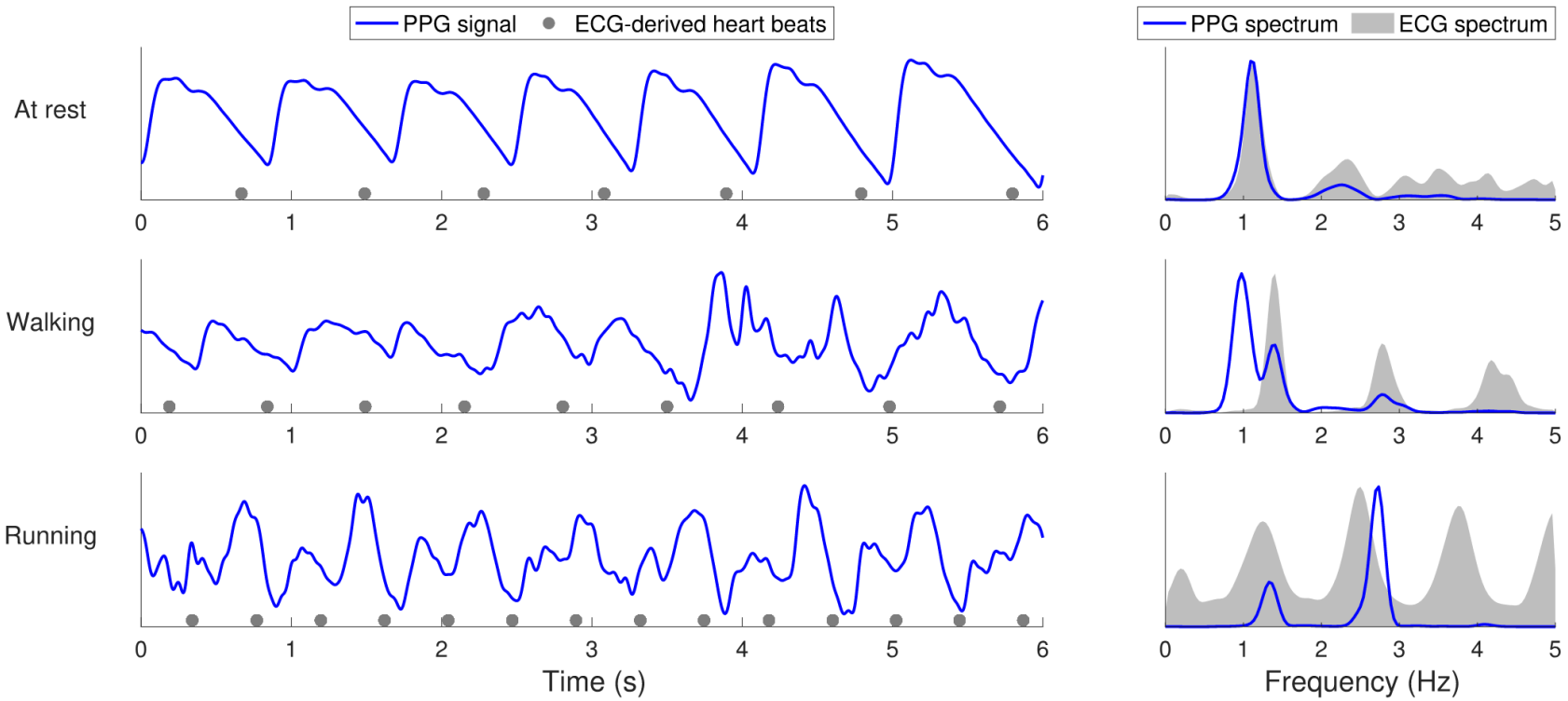
Changes in blood volume are detected with light [5]

Photoplethysmogram (PPG)



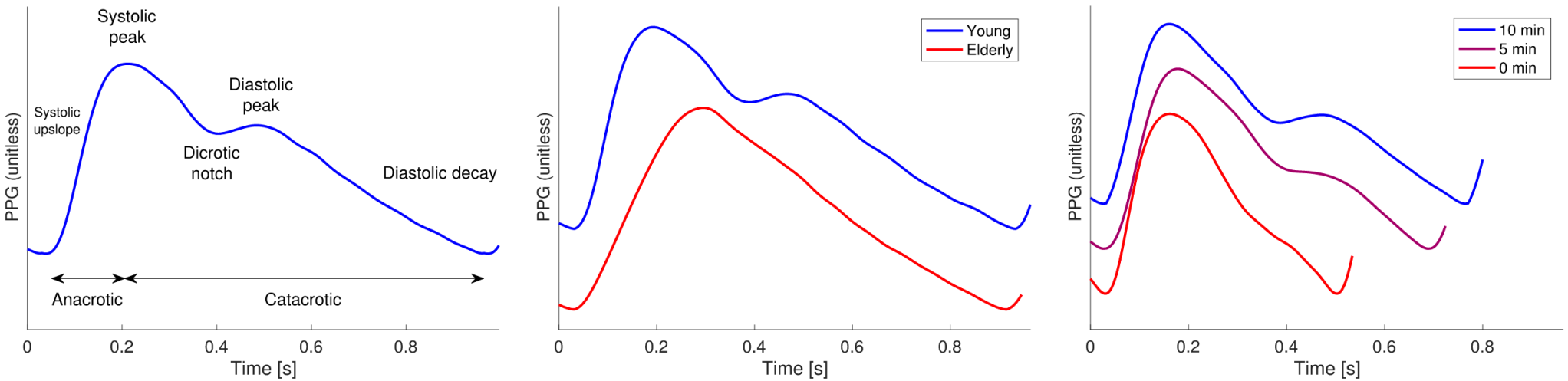
Blood volume cycles in phase with the heart [5]

Photoplethysmogram (PPG)



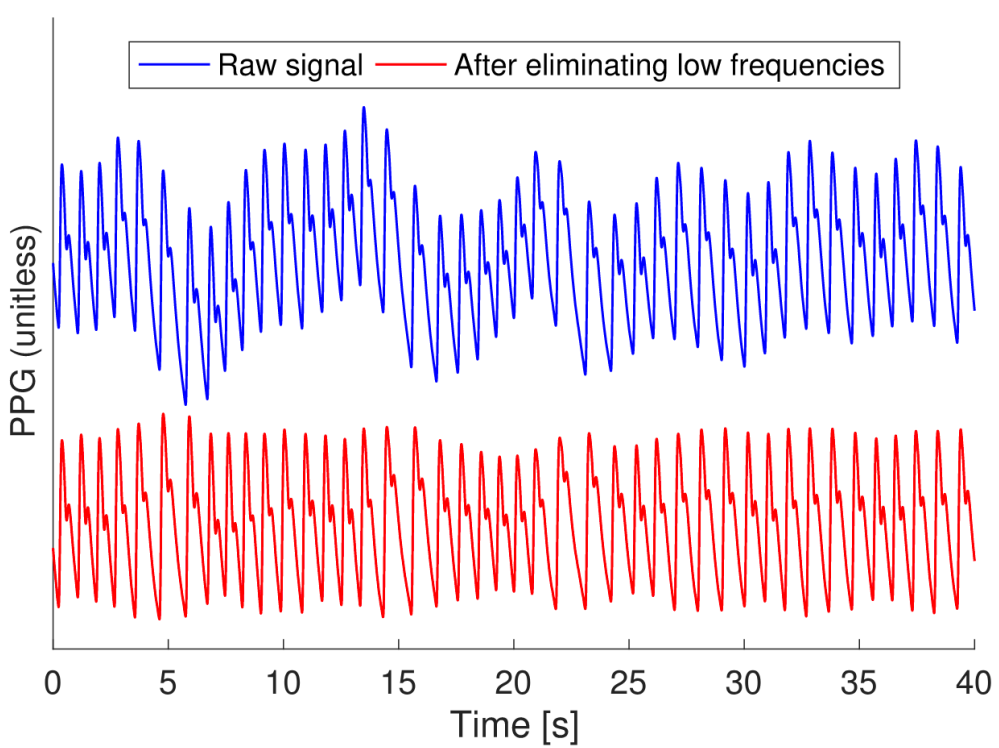
Here is what the detected blood pulse looks like as a PPG signal [5]

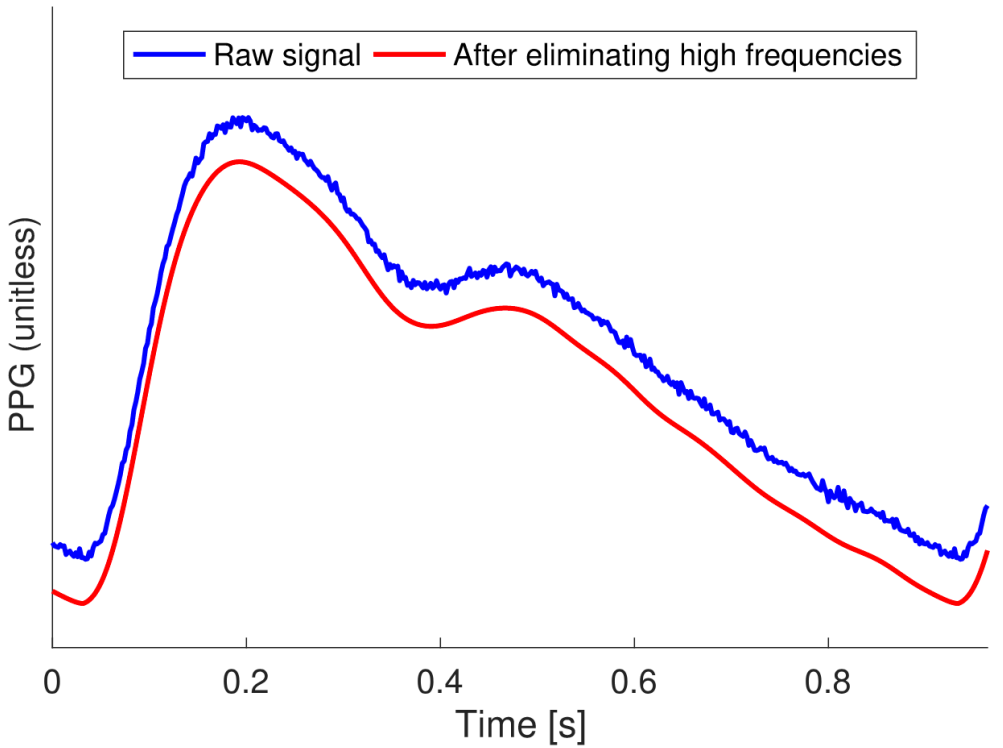
Photoplethysmogram (PPG)



Details of the PPG waveform [5]

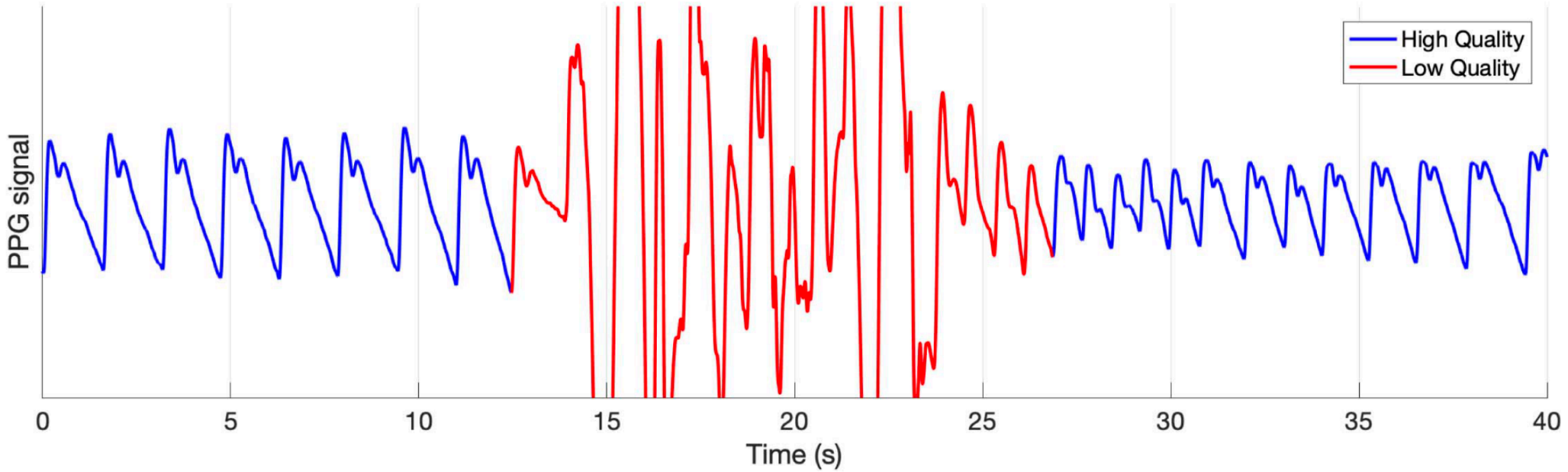
Photoplethysmogram (PPG)





Filtering PPG signals [5]

Photoplethysmogram (PPG)



Motion artifacts [5]

Demo

*external site connected to node

References

[1] Berntson GG, Quigley KS, Lozano D. Chapter 8: Cardiovascular Psychophysiology. Handbook of psychophysiology. 4th ed, Cambridge, United Kingdom: Cambridge university press; 2017, p. 182–210.

[2] Engelen T, Solcà M, Tallon-Baudry C. Interoceptive rhythms in the brain. Nature Neuroscience 2023;26:1670–84. https://doi.org/10.1038/s41593-023-01425-1.

[3] Purves D, Augustine G, Fitzpatrick D, Hall W, LaMantia A, Mooney R, et al. Neuroscience. Sixth. Oxford University Press; 2018.

[4] ECG (EKG) - Bundle branch block - Oxford Medical Education 2014.

[5] Charlton PH, Kyriacou PA, Mant J, Marozas V, Chowienczyk P, Alastruey J. Wearable Photoplethysmography for Cardiovascular Monitoring. Proceedings of the Ieee Institute of Electrical and Electronics Engineers 2022;110:355–81. https://doi.org/10.1109/JPROC.2022.3149785.