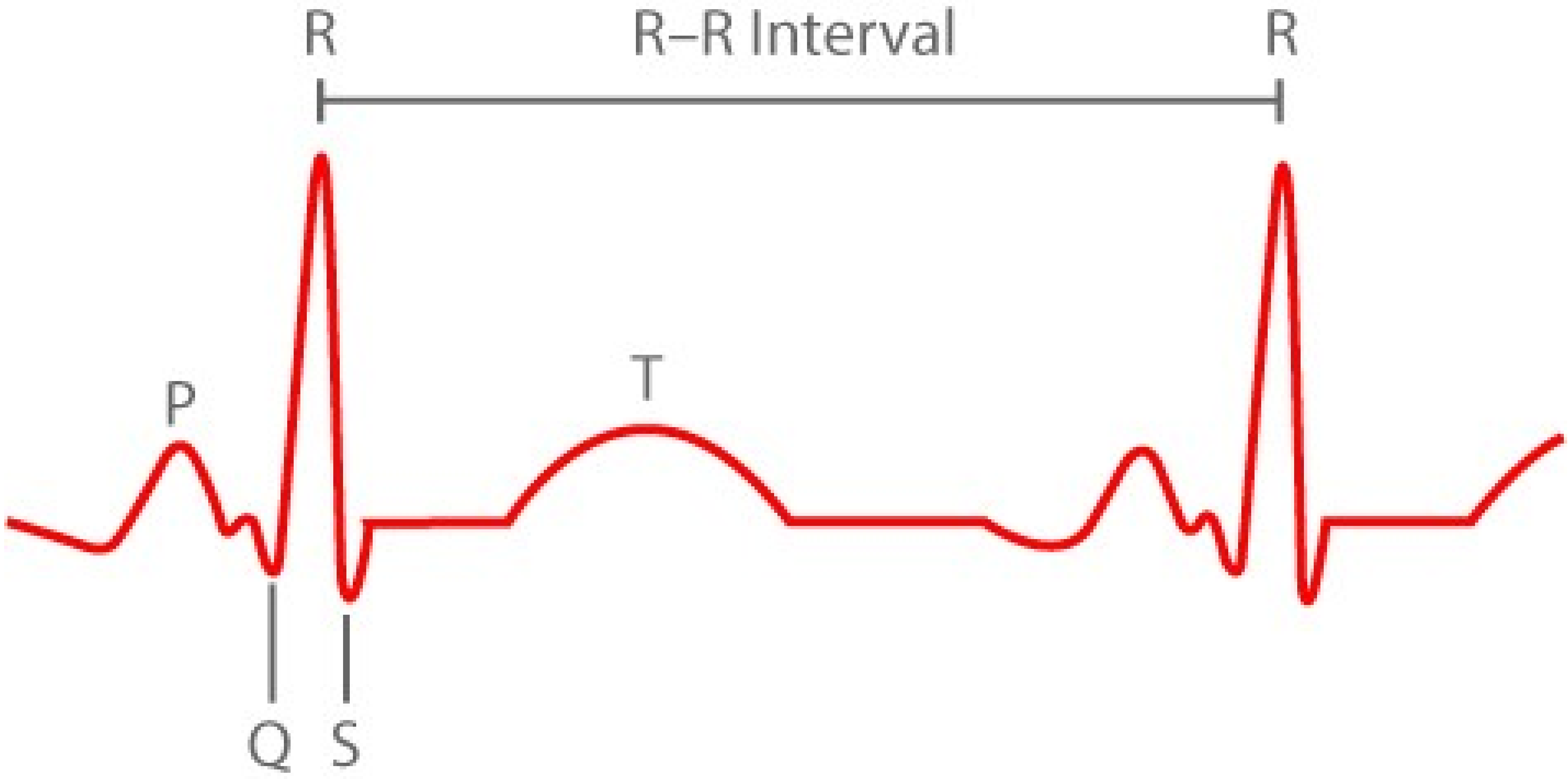
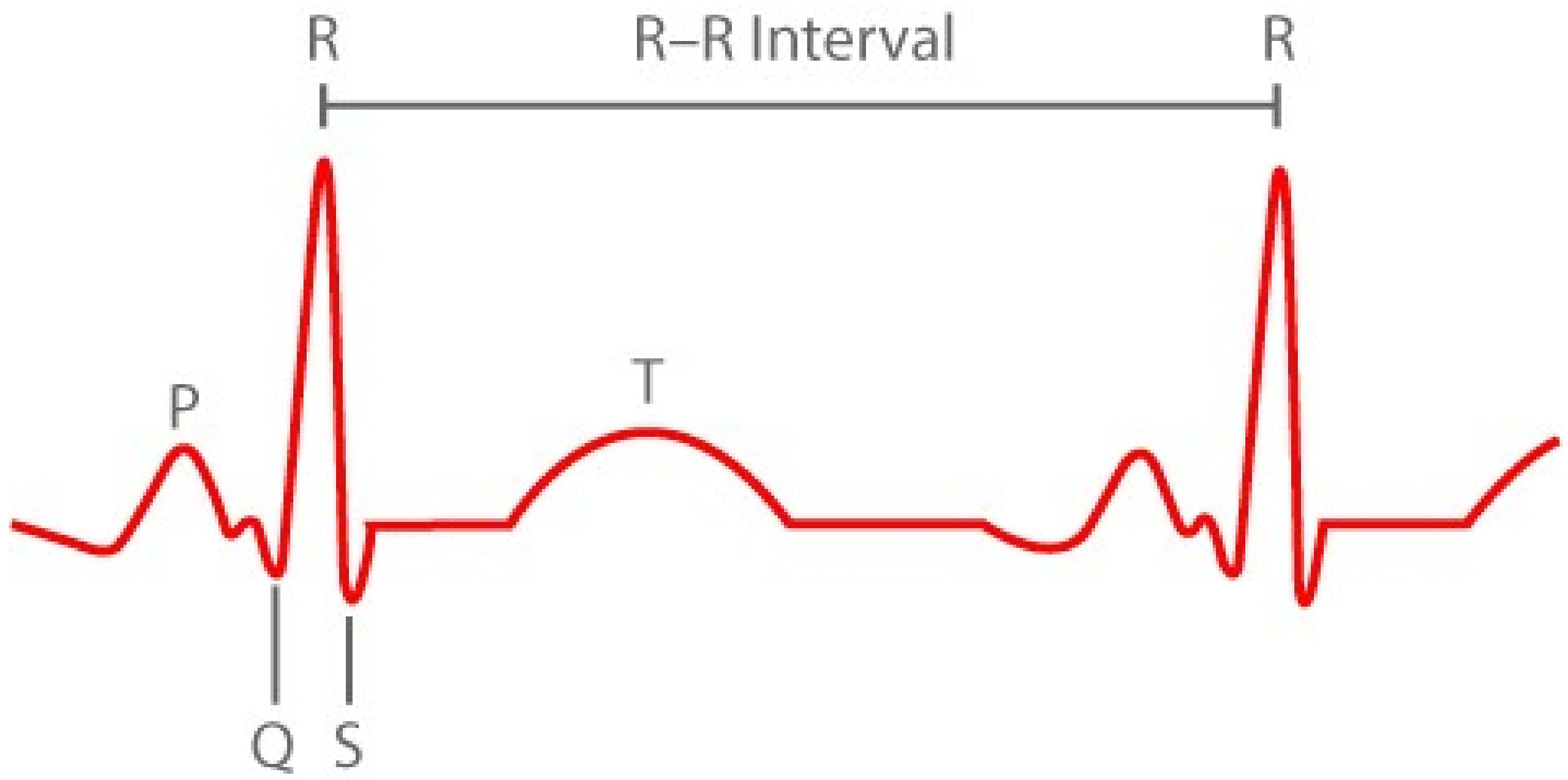
Heart rate variability (HRV)



Warsaw University of Technology

Source: https://www.myithlete.com/what-is-hrv

Linear methods – time domain



Source: https://www.myithlete.com/what-is-hrv

- mean RR

$$\overline{RR} = \frac{1}{N} \sum_{i=1}^{N} RR_i$$

- RR variation

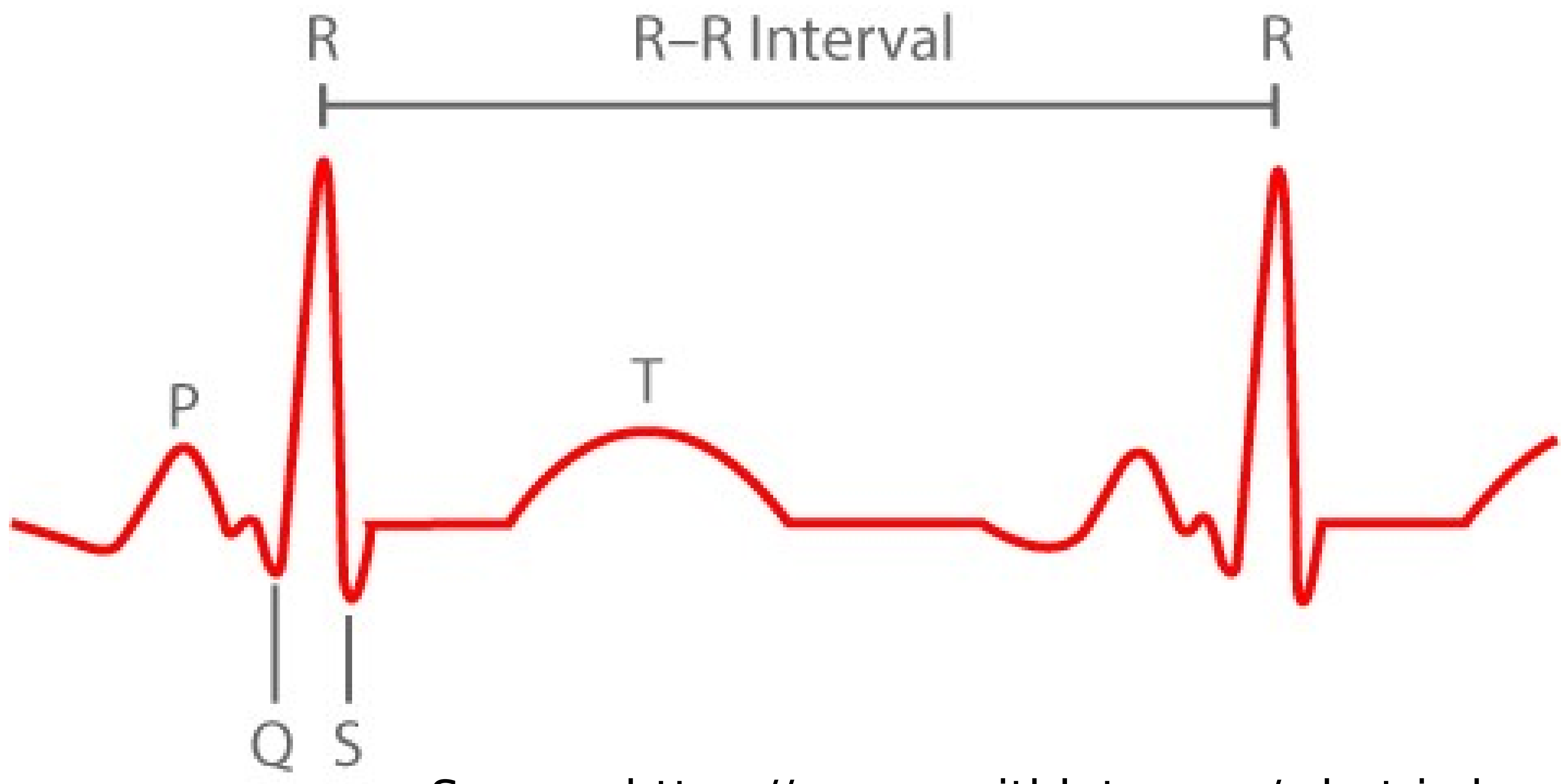
$$RR_{variation} = \frac{\left(RR_{max} - RR_{min}\right) \times 100}{RR_{mean}}$$

- std RR

$$std\ RR = \sqrt{\frac{1}{N-1} \sum_{i=1}^{N} \left(\overline{RR} - RR_i\right)^2}$$

Warsaw University of Technology

Linear methods – time domain



Source: https://www.myithlete.com/what-is-hrv

- RMSSD (root mean square of successive differences)

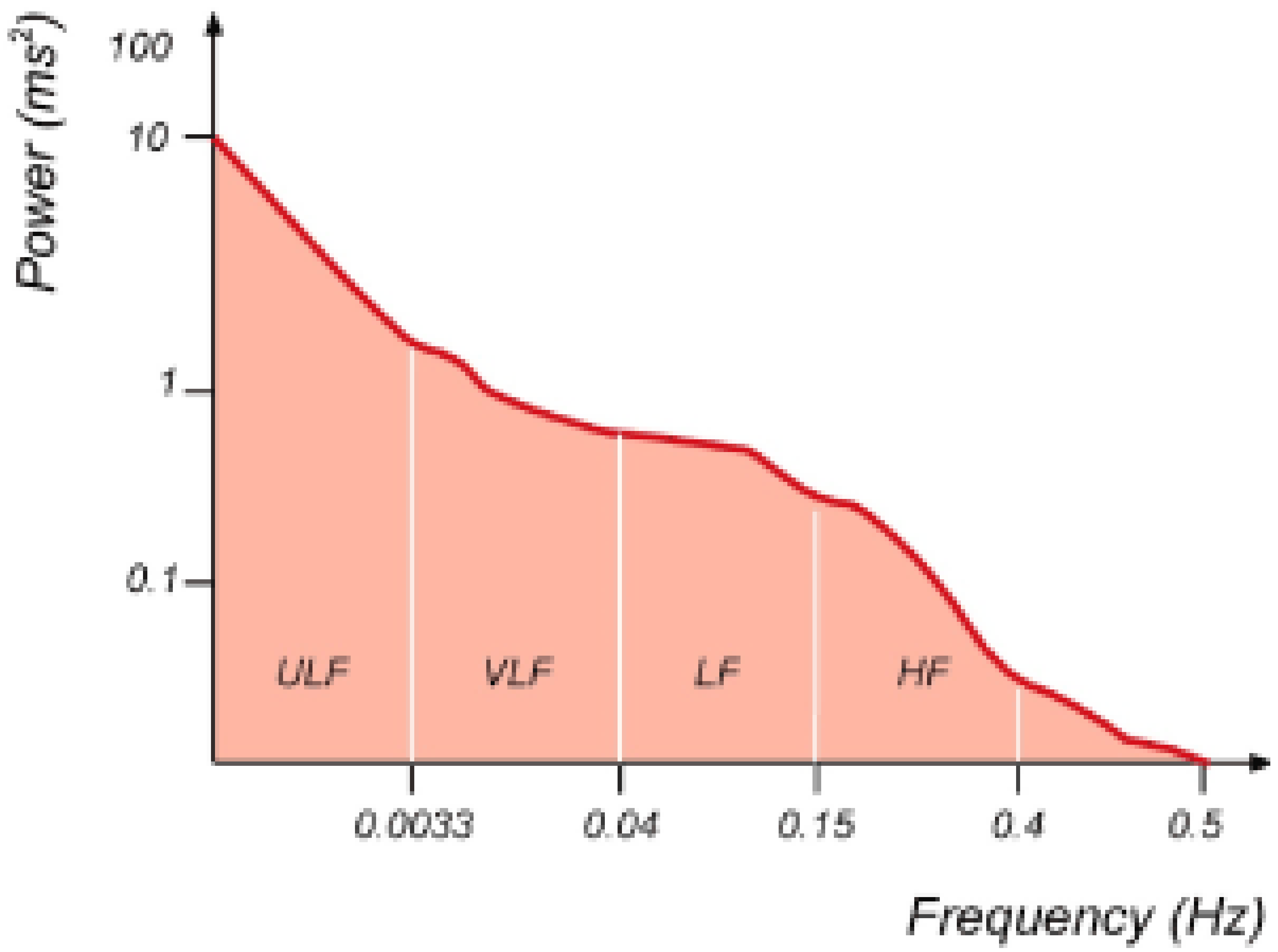
$$RMSSD = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(RR_{i+1} - RR_i\right)^2}$$

- successive RR interval > 20 or 50 ms

$$P\left(\left|RR_{i+1} - RR_i\right| > 50\ ms\right)$$

Linear methods – frequency domain

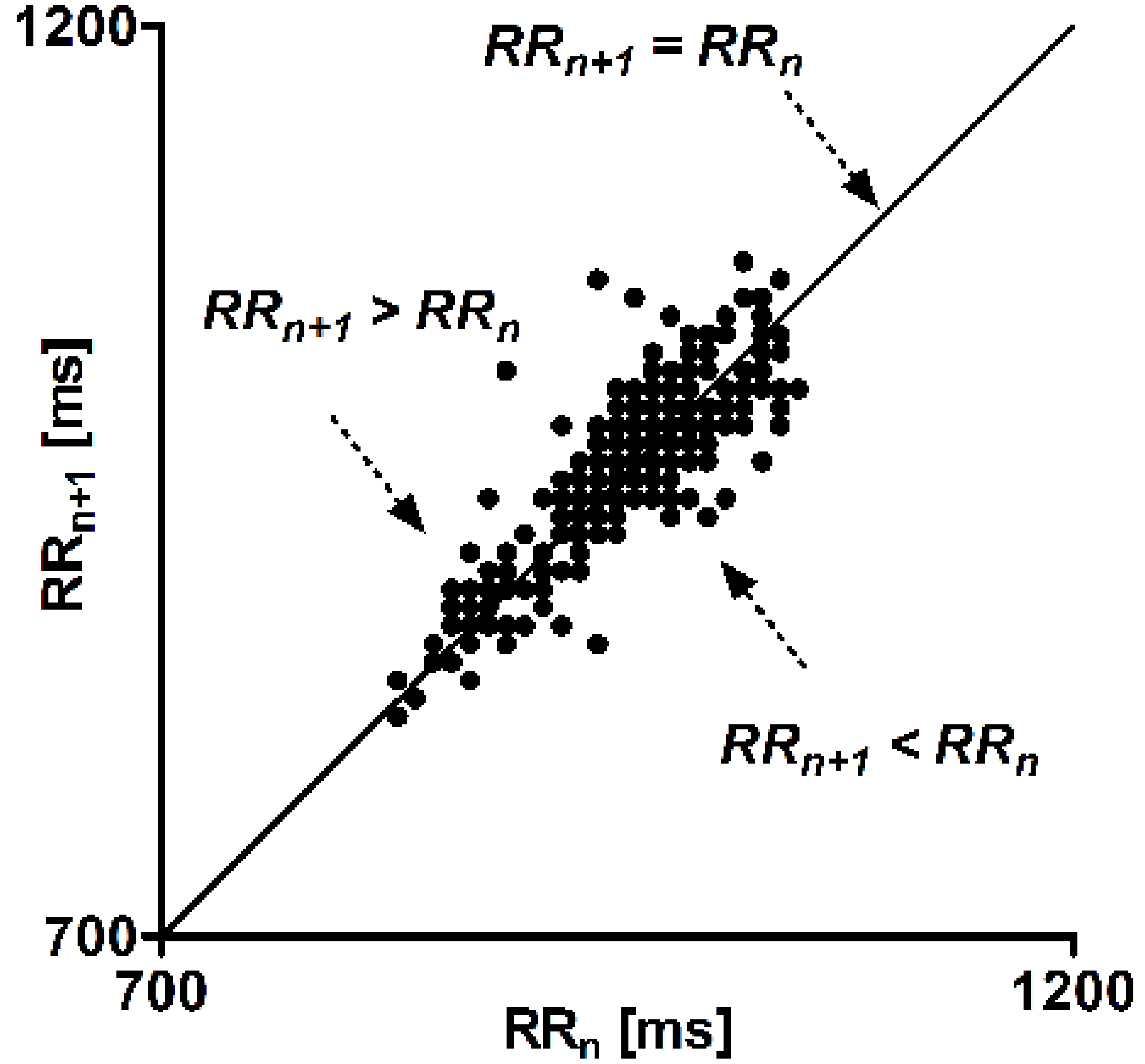
- total power (TP);
- ultra-low frequency (ULF) (<0,003Hz);
- very low frequency (VLF) (0,003−0,04Hz);
- low frequency (LF) (0,04−0,15Hz);
- high frequency (HF) (0,15−0,4Hz);



Source: Yilmaz M, Kayancicek H, Cekici Y, Heart rate variability: Highlights from hidden signals, Journal of Integrative Cardiology, January 2018, 5:265

Nonlinear method - Poincare plot

- Visual pattern whereby the shape of the plot is categorized into functional classes that indicate the degree of heart failure;
- Can be evaluated quantitatively through the computation of the SD indexes of the plot.



Source: Guzik P., Piskorski J., Krauze T., Correlation between the Poincare Plot and conventional Heart Rate Variability Parameters Assessed during Paced Breathing, The Journal of Physiological Science, March 2007, 57(1):63-71

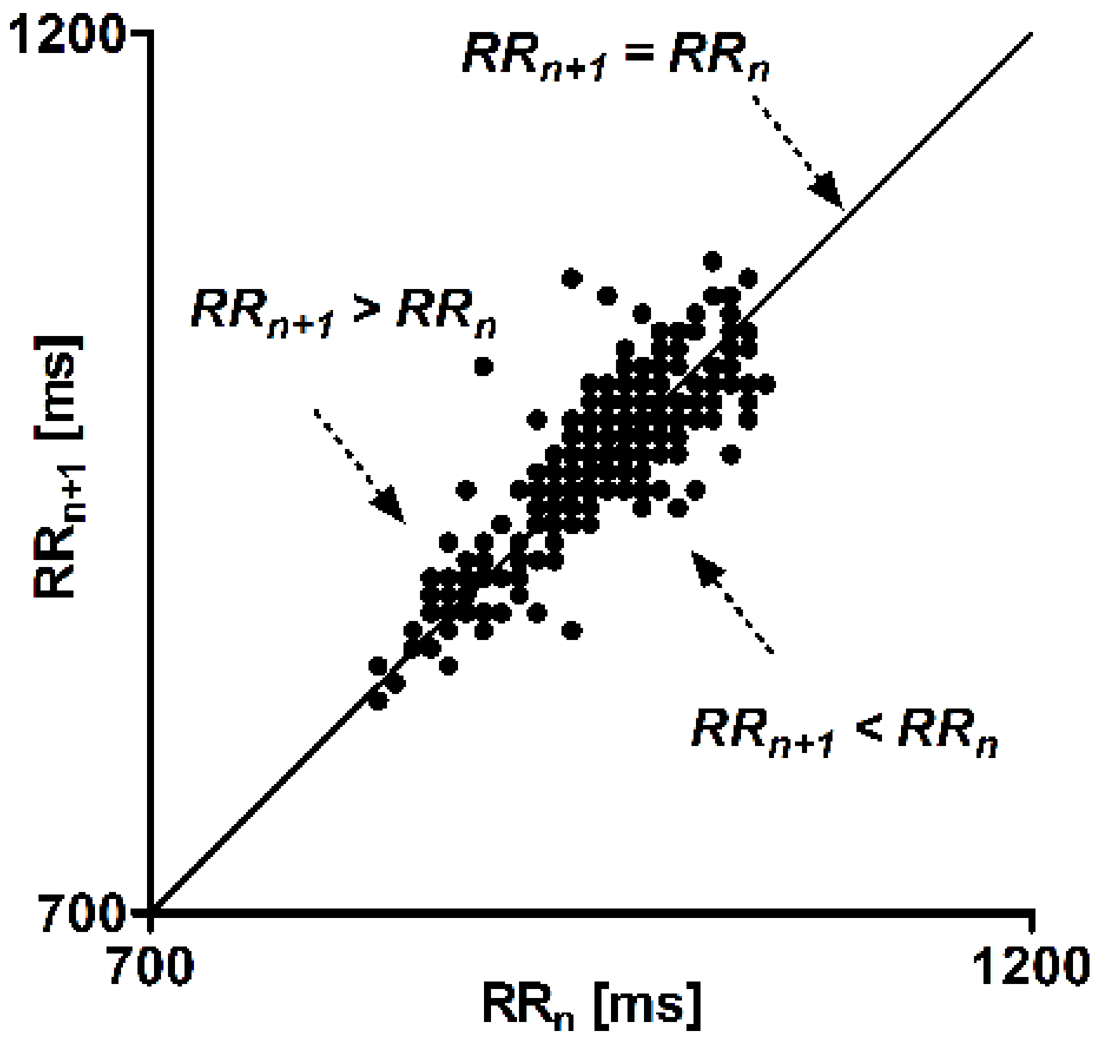
Time irreversibility/asymmetry in HRV

- Guzik index (GI)

$$D_i = \frac{|RR_i - RR_{i+1}|}{\sqrt{2}} \qquad GI = \frac{\sum_{i=1}^{C(P_i^+)} (D_i^+)^2}{\sum_{i=1}^{N-1} (D_i)^2} \times 100\%$$

- Porta index (PI)

$$PI = \frac{C(P_i^-)}{C(P_i^+) + C(P_i^-)} \times 100\%$$

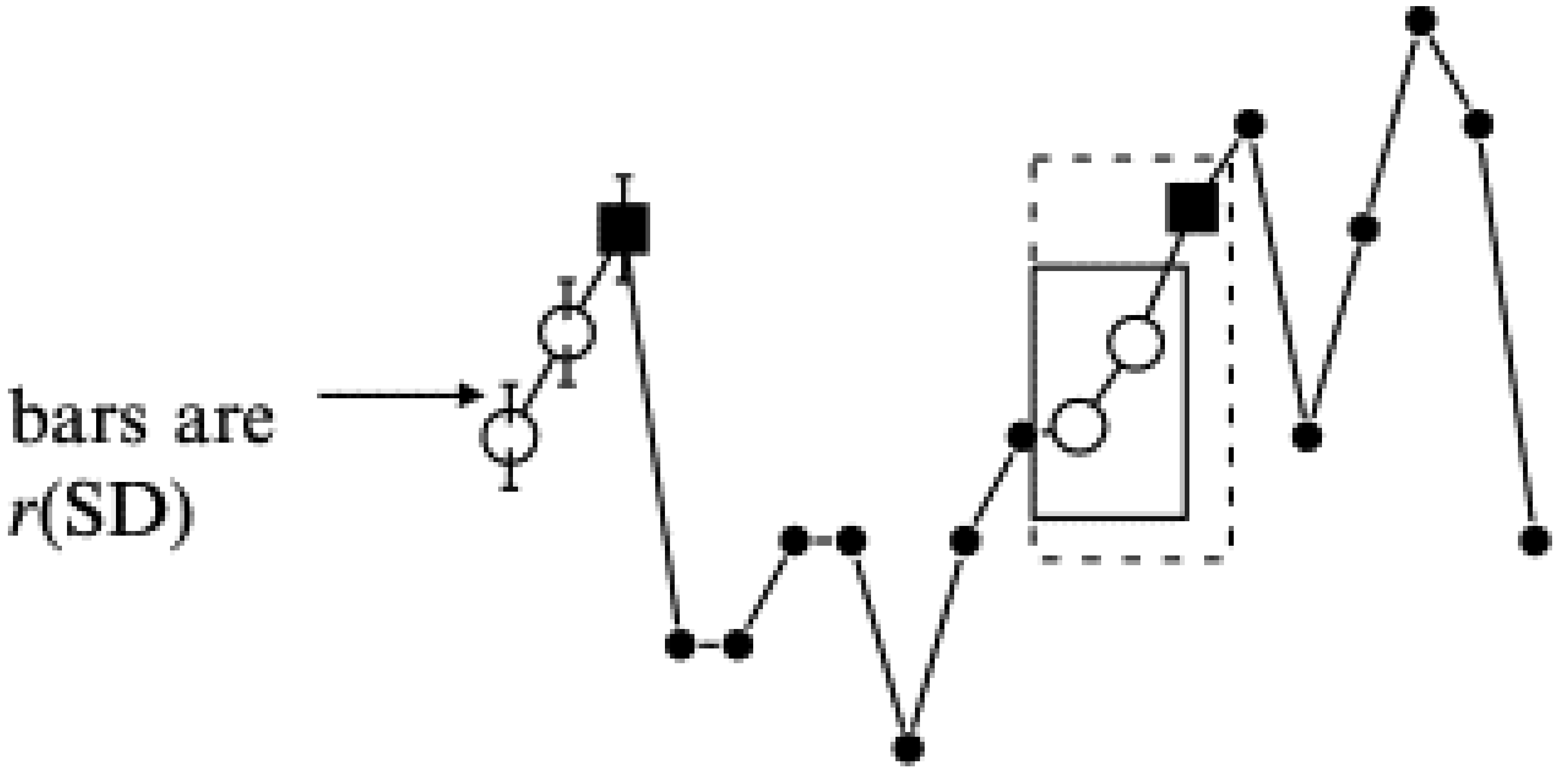


Source: Guzik P., Piskorski J., Krauze T., Correlation between the Poincare Plot and conventional Heart Rate Variability Parameters Assessed during Paced Breathing, The Journal of Physiological Science, March 2007, 57(1):63-71

Warsaw University of Technology

Sample Entropy

$$SampEn(m, r, N) = -\ln\left[\frac{A^m(r)}{B^m(r)}\right]$$



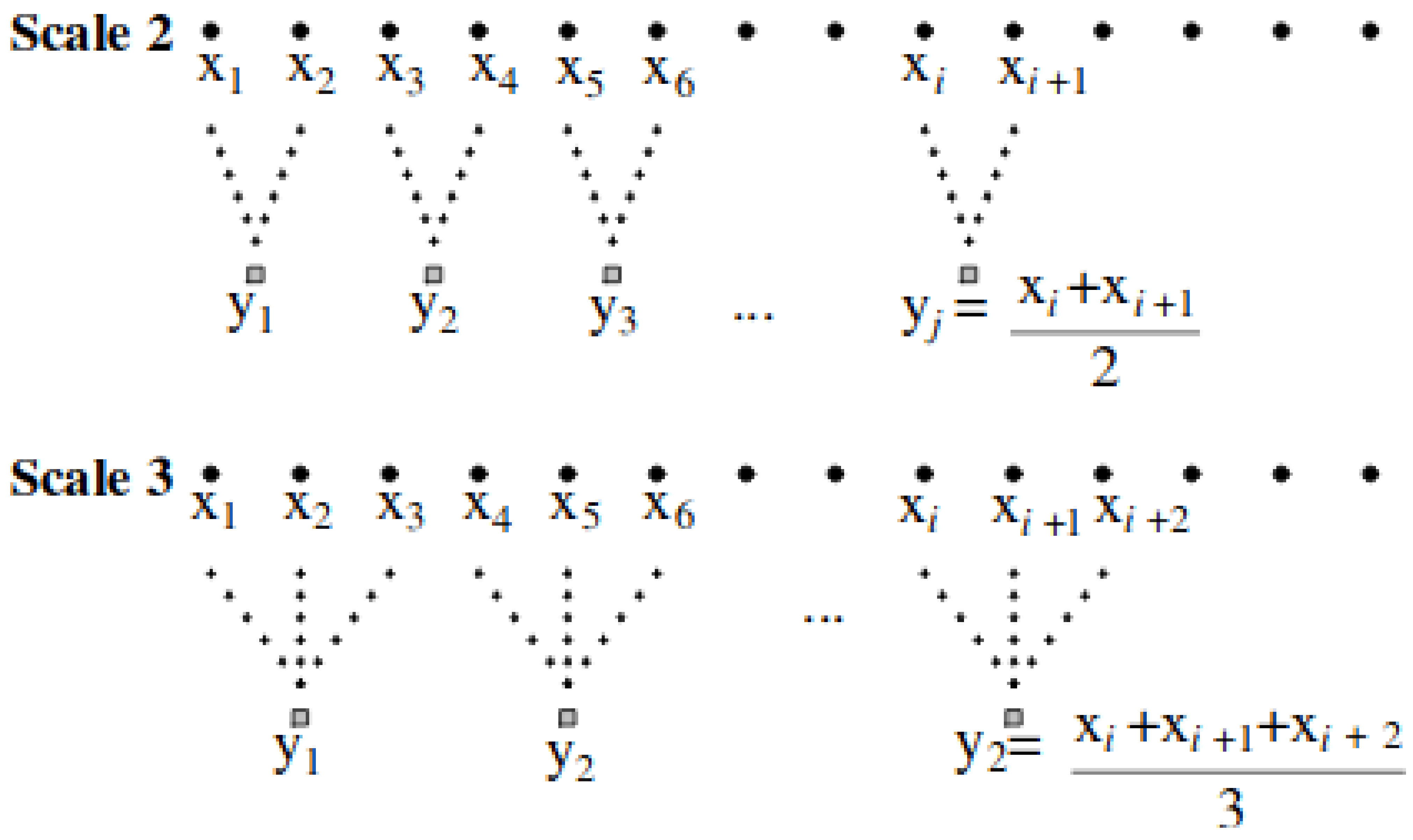
■ A_i = number of matches of length $m+1$ with ith template

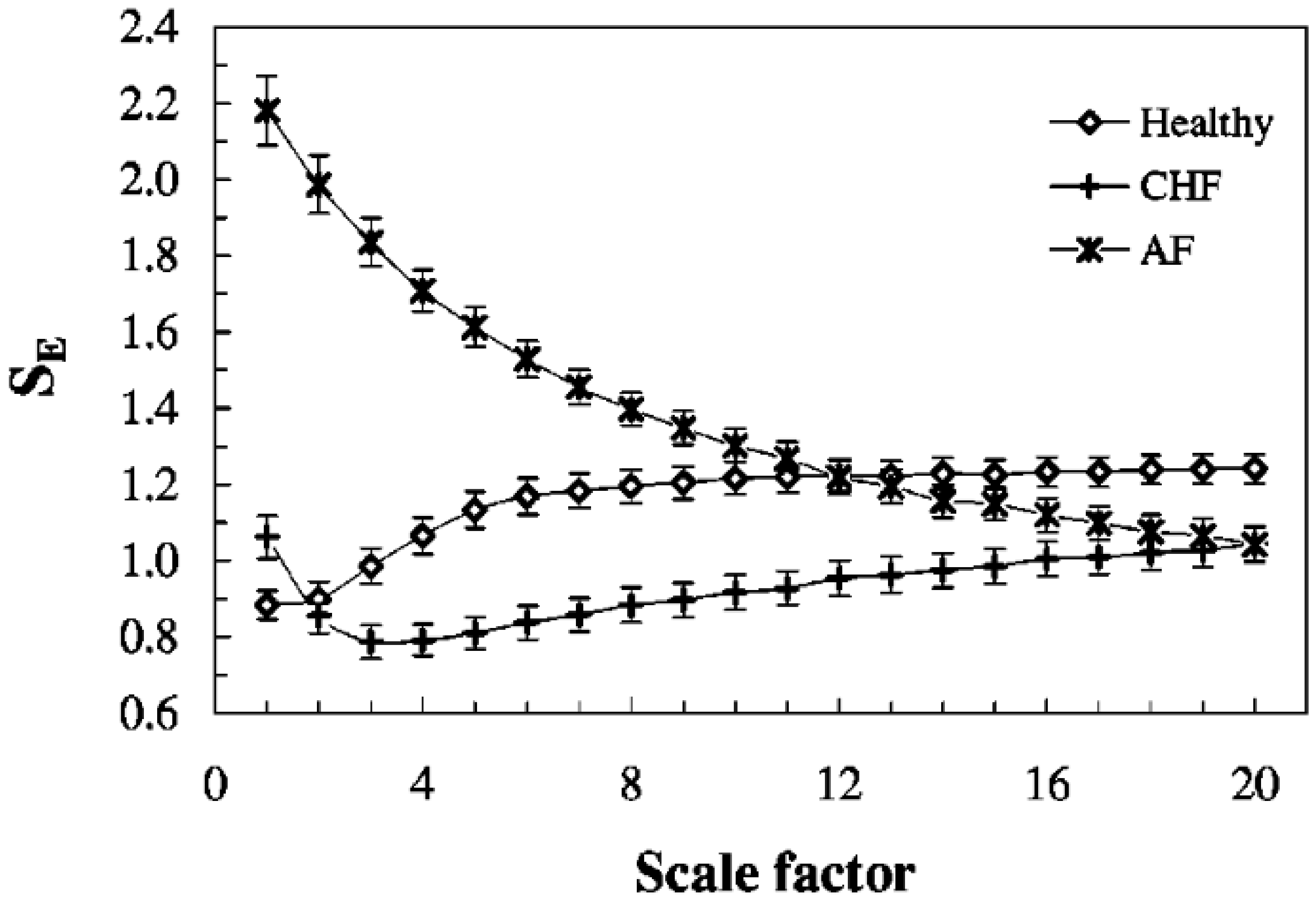
○ B_i = number of matches of length m with ith template

$$\text{SampEn} = -\log\left((\Sigma A_i)/(\Sigma B_i)\right) = -\log A/B$$

Source: Richman J., Lake D., Moorman R., Sample Entropy, Methods in Enzymology 2004, 384:172-184

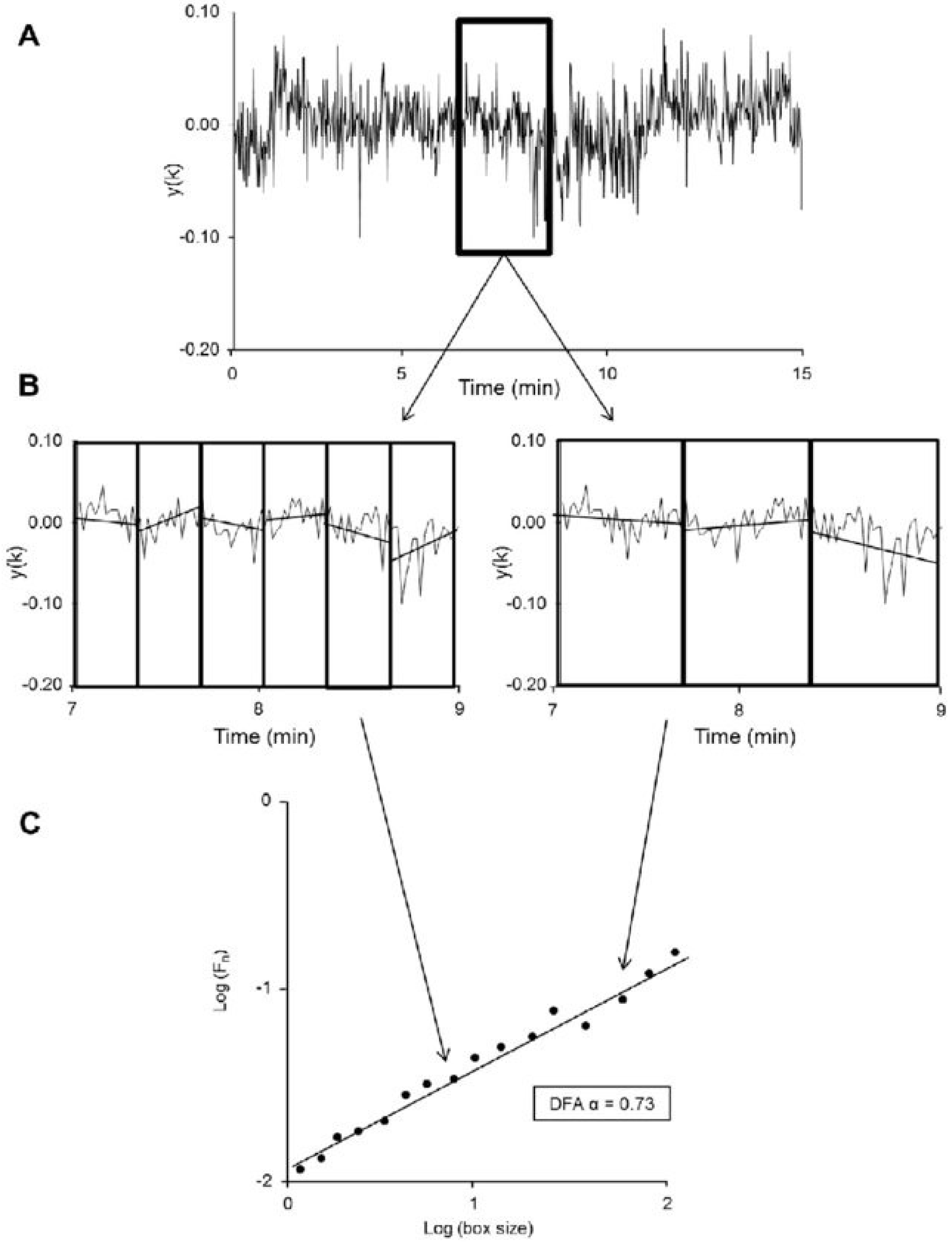
Multiscale Entropy



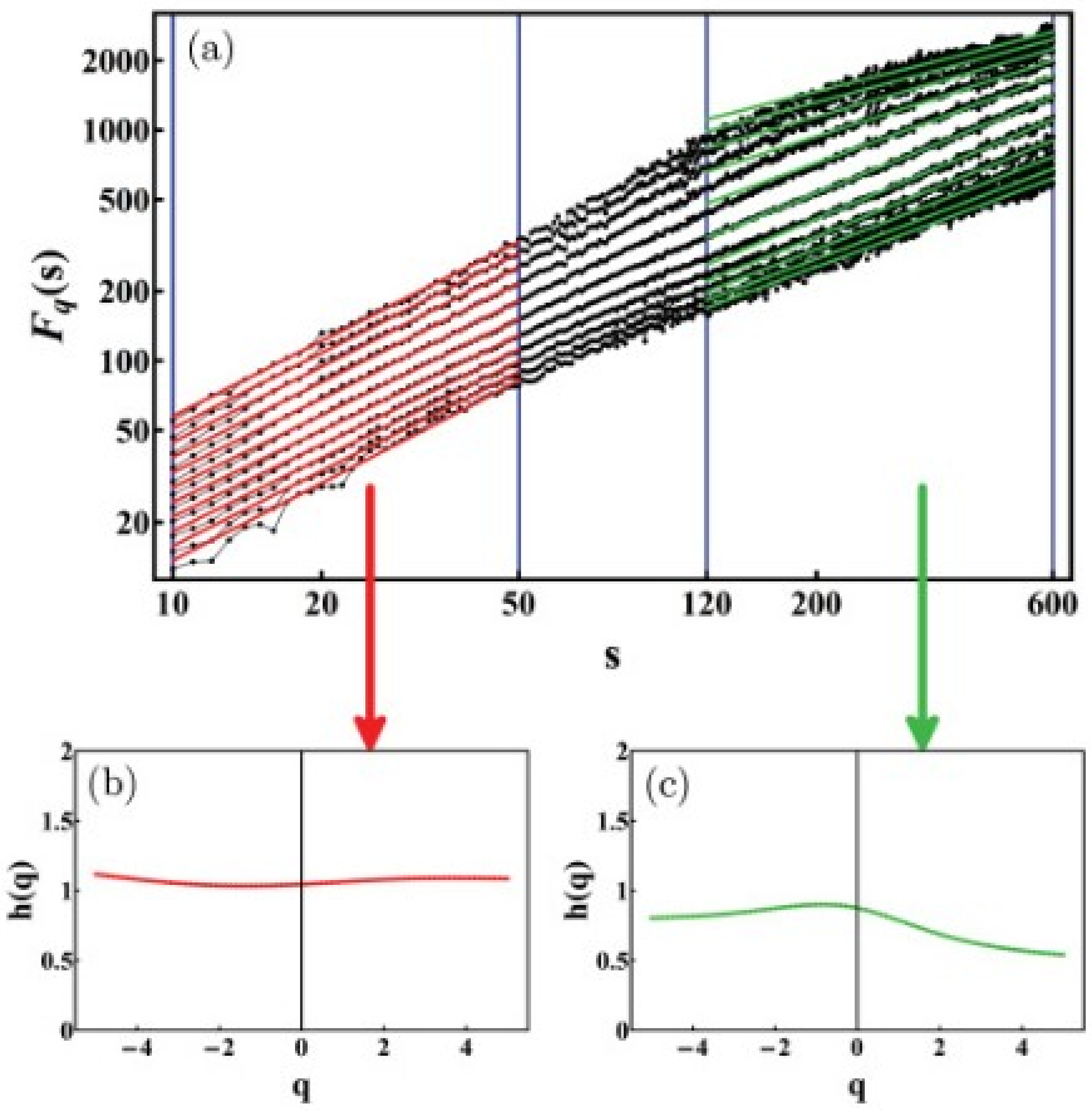


Source: Costa M.; Golderberg G.; Peng C.-K. Multiscale entropy analysis of complex physiologic time series. Physical Review Letters, 89, 2002

Multiscale Multifractal Analysis (MMA)



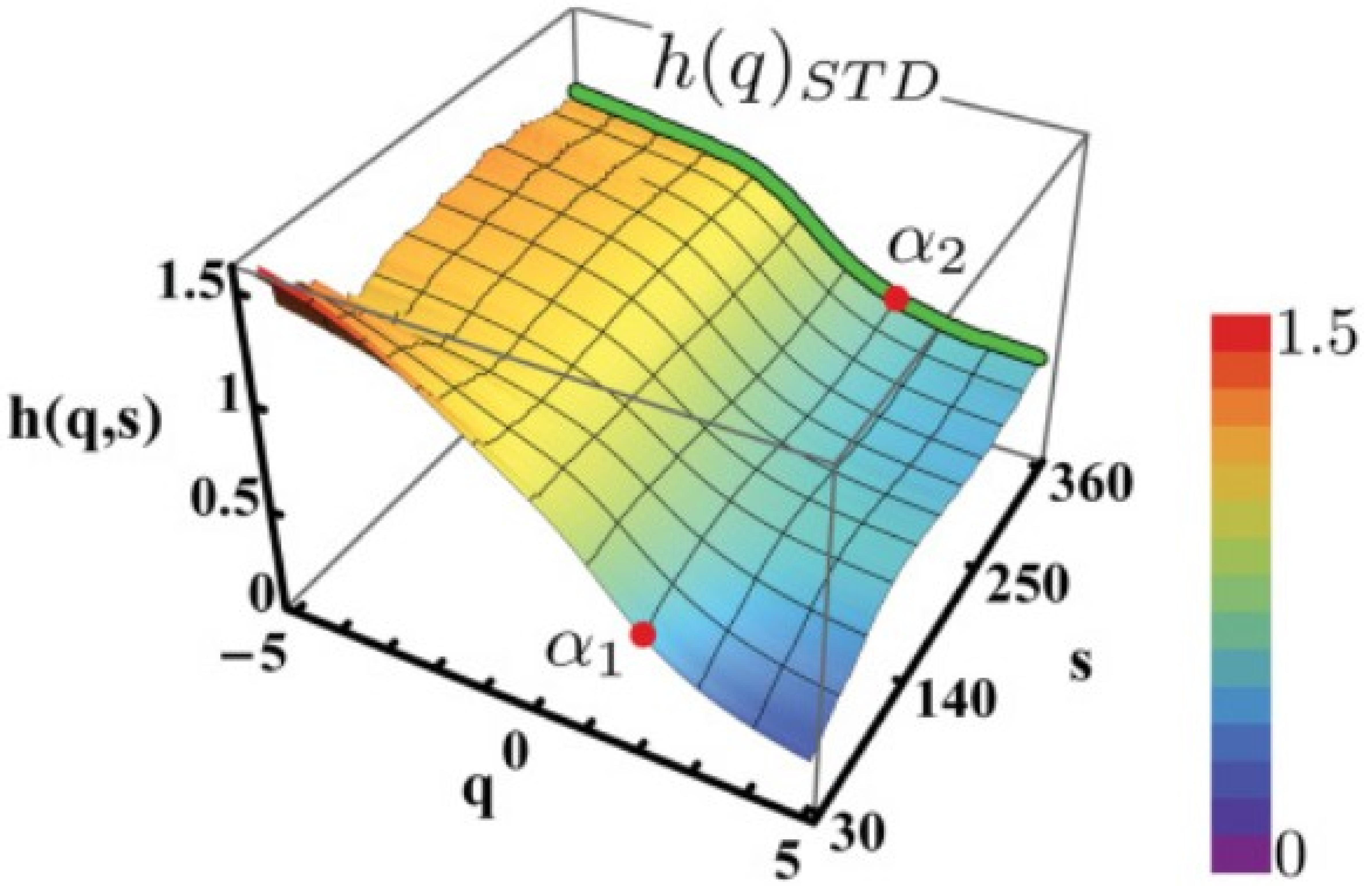
Source: Costa M.; Golderberg G.; Peng C.-K. Multiscale entropy analysis of complex physiologic time series. Physical Review Letters, 89, 2002



Source: Gieraltowski J.; Żebrowski J.J.; Baranowski R. Multiscale multifractal analysis of heart rate variability recordings with a large number of occurrences of arrhythmia. Physical Review E, 85, 2012

Warsaw University of Technology

Multiscale Multifractal Analysis (MMA)



Source: Gieraltowski J.; Żebrowski J.J.; Baranowski R. Multiscale multifractal analysis of heart rate variability recordings with a large number of occurrences of arrhythmia. Physical Review E, 85, 2012

Warsaw University of Technology