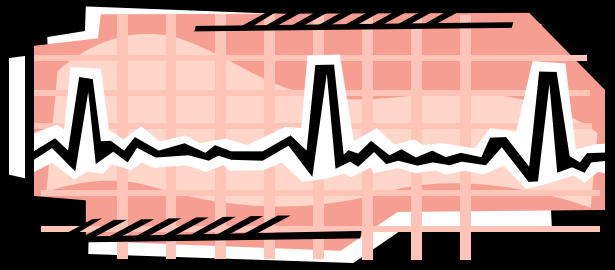
Heart Rate Variability (HRV) Biofeedback for Beginners



ABC's of HRV

Donald Moss, PhD, BCB, Saybrook University, and Fred Shaffer, PhD, BCB, Truman State University and Saybrook University

Fundamentals of HRV Biofeedback

- Heart rate variability (HRV) is the study of the various component rhythms and influences contributing to the overall phenomenon of heart rate
- Variability in heart rate is a marker of better health and adaptive capacity in a biological organism

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Fundamentals of HRV Biofeedback

- The healthy heart is NOT a metranome
- Healthier organisms show more variability
- As the heart loses its variability, the risk for illness and death increases

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Heart Rate Variability

- The *interbeat interval* (IBI) is the time between one R wave (or heart beat) and the next, in milliseconds
- IBI is highly variable within any given time period
- Multiple biological rhythms overlay one another to produce the pattern of variability

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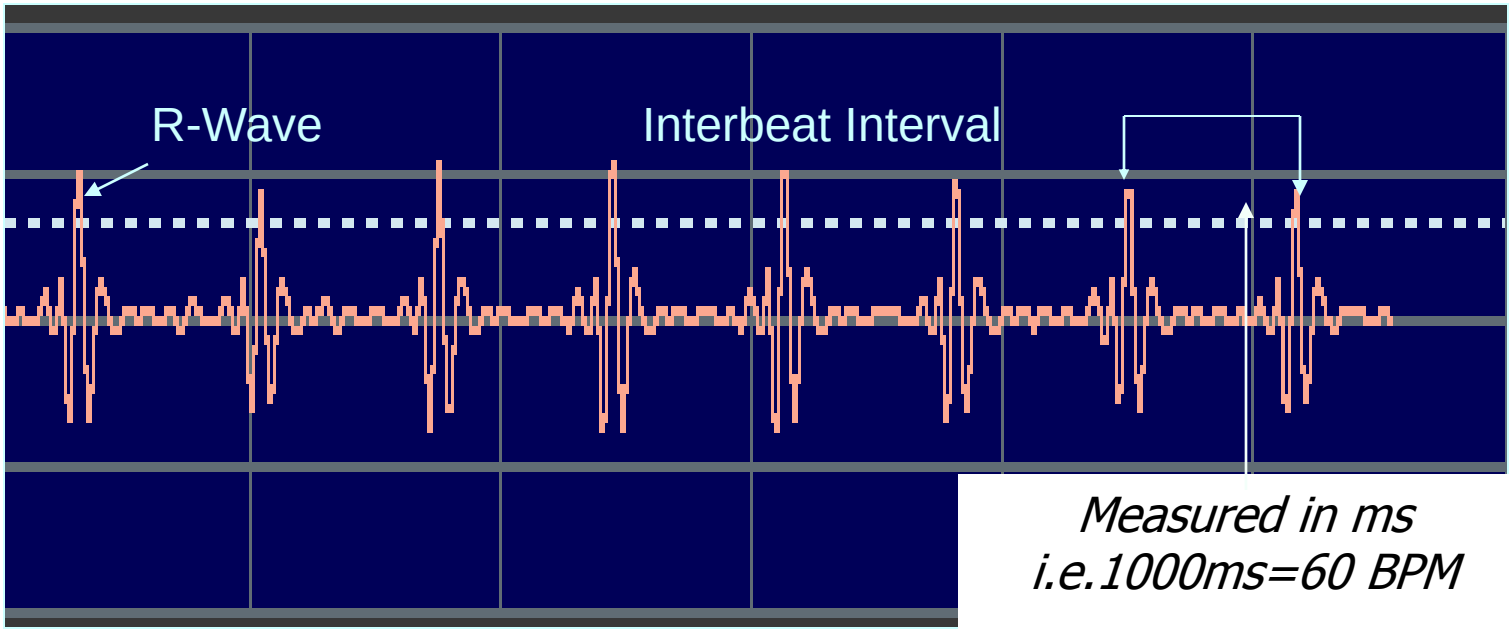
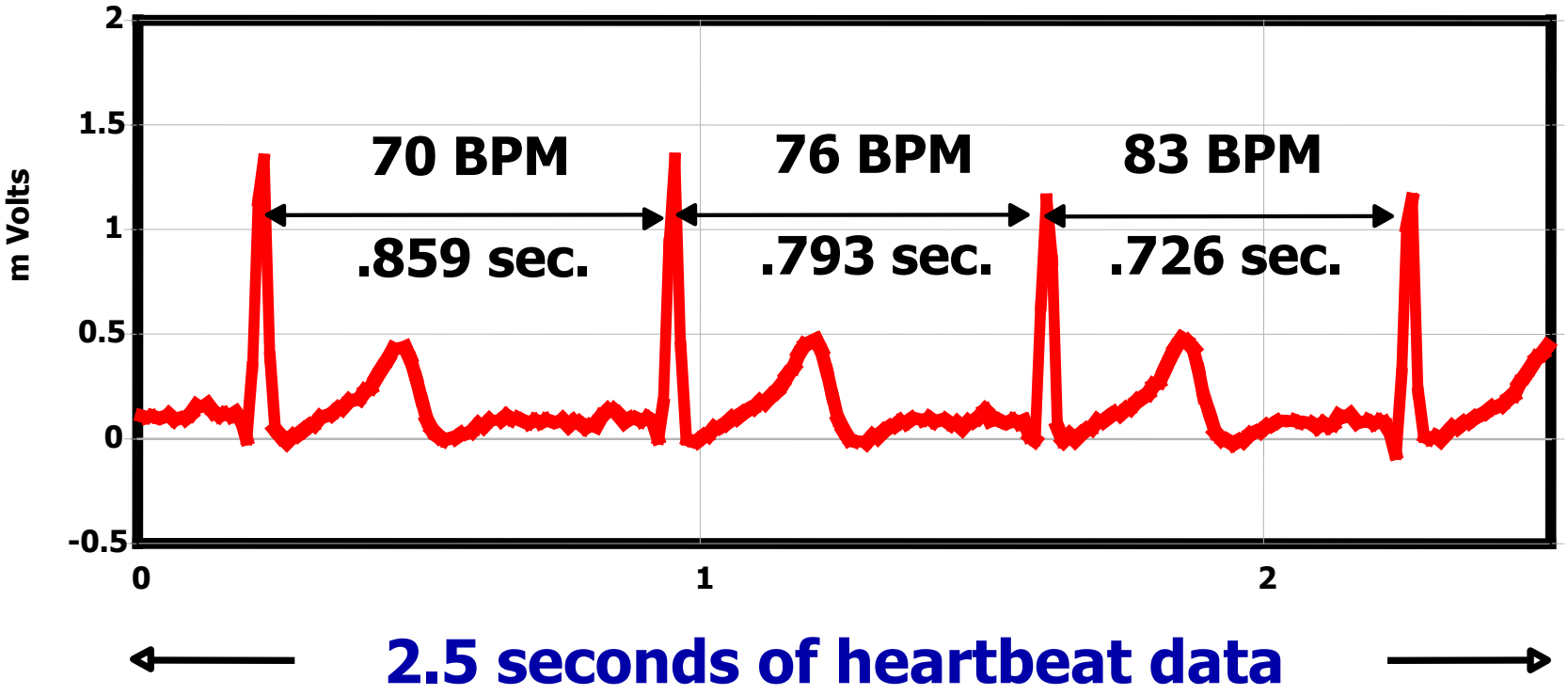
Measurement of R-Wave

- Electrocardiogram: The time between R-wave peaks is the interbeat interval or heart period. It is also called "NN" (the normal to normal) interval.

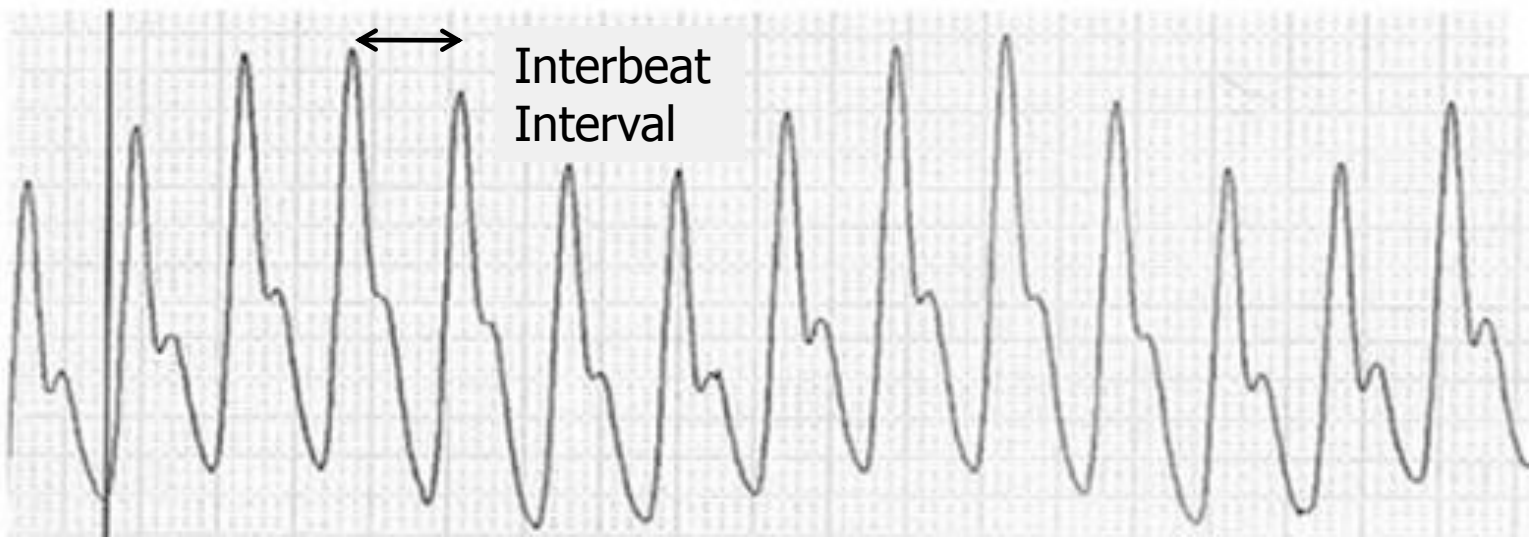


ABC's of HRV


m Volts
2
1.5
1
0.5
0
-0.5
0
1
2
70 BPM
.859 sec.
76 BPM
.793 sec.
83 BPM
.726 sec.
2.5 seconds of heartbeat data

Measurement of HR from Photoplethysmograph Signal

- The Interbeat Interval is measured from the curved peak of one pulse wave to the next curved peak.
- This measurement is less precise than the ECG measure, but adequate for clinical use.



Heart Rate Variability

- The rate at which the healthy heart beats is constantly changing
- HR increases with exertion, decreases with rest
- HR increases with anxiety, decreases with relaxation
- HR increases with inhalation, and decreases with exhalation

Heart Rate Variability

- HRV concerns constant variations in HR, even within a rest period or exercise period
- Mechanisms affecting heart rhythms operate at various frequencies
- Spectral analysis, using the Fast Fourier Transform, identifies the variation as waveforms elapsing within each time frame

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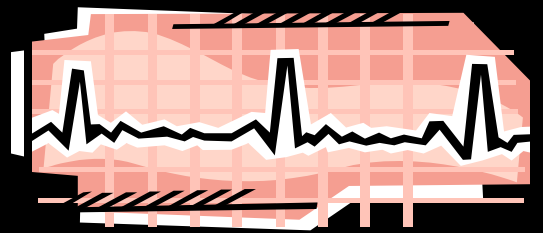
HRV Frequency Ranges



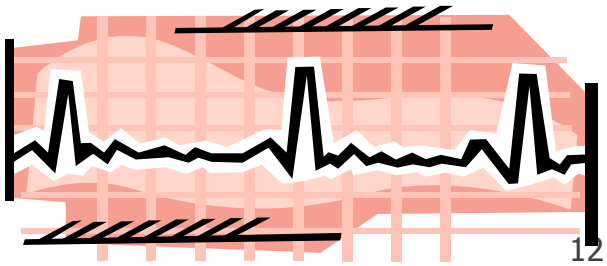
- The primary frequency ranges utilized in research and clinical practice are:
  - High Frequency -- .15 - .4 Hz
  - Low Frequency -- .04 - .15 Hz
  - Very Low Frequency -- .0033 - .04 Hz
  - Ultra Low Frequency -- < .0033, beyond biofeedback measurement technology
    - **Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996)**

Cardiac Rhythms: Do the Arithmetic

- High Frequency
  - .4 Hz: .4 cycles/second X 60 sec./min. = 24 cycles/min.
- Low Frequency
  - .1 Hz translates into 6 cycles/min.
- Very Low Frequency
  - .04 translates into 2.4 cycles/minute
  - .004 translates into 14.4 cycles in one hour
- Ultra Low Frequency
  - .001 Hz translates into 3.6 cycles in one hour

Cardiac Rhythms: Sources

- High Frequency – parasympathetic pathways, influences of respiration in normal frequencies on vagal tone
- Low Frequency – influence of BP rhythms (baroreceptors) on heart rhythms (meditative/slow breathing augments this range)
- Very Low Frequency – sympathetic pathways, influences of visceral and thermal regulation (rumination and worry augment this range)
- Ultra Low Frequency



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HRV: Developmental I

- HRV increases fivefold in infancy and early childhood
  - Some report RSA peaking at 4-6, others at 10-14
  - The proportionate variability in individuals (relative to age peers) is stable through childhood
    - Salomon (2005)

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HRV is Relatively Stable

- A pediatric study found that HRV during a stress trial predicted resting HRV in the same child 3 years later
  - Kristen Salomon (2005). RSA during stress predicts resting RSA 3 years later in a pediatric sample. *Health Psychology, 24* (1), 68-76/

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HRV: Developmental II

- HRV reduces over adult lifespan
  - Twenty year olds may show coherent swings of twenty beats per minute or more during breathing exercises
  - Individuals over fifty often show changes of ten *bpm* or less
  - This loss of variability correlates with loss of resilience in health

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SDNN: Medical Index of Heart Rate Variability

- N to N interval is the "normalized" beat to beat interval
- SDNN is the standard deviation of those interbeat intervals, a measure of how variable are those intervals
- The SDNN is a measure in milliseconds (ms), most accurate when derived from Holter monitoring or lengthy lab baselines

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SDNN: Medical Index (cont).

- SDNN allows for classification into health status, with corresponding morbidity and mortality:
  - "Unhealthy" (< 50 ms)
  - "Compromised health" (> 50 ms and < 100 ms)
  - "Healthy" (>100 ms)
- Moving from a lower range to a higher range is typically clinically significant for patient survival

pNN50: Research Index

- pNN50 and pNN30 are measures of HRV that are more reliable for brief sampling periods
- pNN50 refers to the % of interbeat intervals (NN intervals) that differ from the adjacent interval by 50 milliseconds or more
- pNN30 refers to the % of interbeat intervals (NN intervals) that differ from the adjacent interval by 30 milliseconds or more

HRV in Health

- Changes in the amount of HRV are related to change in autonomic activity in:
  - Aging: Decreases "vagal tone," decreases variability of HR
  - Exercise: Improves HRV
  - Stress: HRV decreases with SNS arousal
  - Circadian rhythms: HRV changes with time of day

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HRV: What Difference Does it Make?

- IBI changes precede incidents of fetal distress
- Reduced heart rate variability
  - Correlates with higher risk of post-infarction mortality
  - Predictor of mortality (all causes)
  - Especially sudden death

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Depression, HRV, and Mortality

- Depression in patients who have an MI increases mortality
- Recent research shows depressed patients twice as likely as non-depressed to have lower HRV (16 % vs. 7 %)
- Lower HRV is strong independent predictor of post-MI death
  - Carney et al (2001). *Circulation, 104* (17), 2024-2038.

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HRV is Sensitive Marker of Changes in Depression

- Nahshoni et al (2001). *American Journal of Geriatric Psychiatry, 255-60*
  - Cardiac vagal activity increased after ECT in 11 elderly depressed patients compared to controls.
  - Results similar to many medication studies

Medical Significance of HRV

- Training heart rate variability enhances the cooperative balance between the sympathetic and parasympathetic nervous systems
- For this reason any illness known to involve autonomic nervous system mechanisms may benefit from HRV biofeedback

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