PHYSIOLOGICAL DATA ANALYSIS FOR EDUCATIONAL TECHNOLOGIES

SDNN/RMSSD AS A SURROGATE FOR LF/HF: A REVISED INVESTIGATION

Hui-Min Wang and Sheng-Chieh Huang
AGENDA

1. Introduction
   1. Research Goal
   2. LF/HF
   3. SDNN (SDRR)
   4. RMSSD
   5. A proper surrogate?

2. Method
   1. Experimental Design
   2. HRV Analysis
   3. Data

3. Results
   1. Correlation
   2. Surrogate for LF/HF

4. Data Analysis Demo
   1. mean HR
   2. mean RR
   3. SDRR
   4. RMSSD
   5. SDRR/RMSSD
   6. STILA
INTRODUCTION
RESEARCH GOAL

- Is SDNN/RMSSD a good surrogate for LF/HF?
- Hypothesis is supported by two special cases (resting in supine state, prefrontal cortex patients)
**LF/HF**

- **EnergyRatio** = \( \frac{LF}{HF} \)

- LF/HF represents the sympatho-vagal balance of the autonomic nervous system (ANS)

- High Energy Ratio: Predominance of sympathetic modulation → Stress

SDNN (SDRR)

- correlation with LF power
- SDNN indicates standard deviation of normal to normal R-R intervals
- SDNN and RMSSD = the activity of the cardiac system

http://4.bp.blogspot.com/-RAqsA51ytkQ/UW8PqSp3jsI/AAAAAAAAAEw/0VeQuTSa28/s1600/feather_0031.jpg
RMSSD

- correlation with HF power (in sleep)
- RMSSD is a short-term variation of heart rate
- indicator for atrial fibrillation (AF) and sudden unexplained death in epilepsy (SUDEP)
A PROPER SURROGATE?

CONTRAS

1. association of respiration and HF → RMSSD not significantly affected by changes of respiration

2. RMSSD no proper model of HF power → mapping of vagal control onto heart rate

http://www.bartleby.com/107/images/large/image970.gif
METHOD
EXPERIMENTAL DESIGN

PARTICIPANTS

- 32 healthy young male adults
  (students in National Chiao Tung University)
- 21 to 25 years
  (mean = 23 years)
EXPERIMENTAL DESIGN

EQUIPMENT

- three-lead electrocardiograph (MSI E3-80, FDA 510(k) K071085)
- 500 Hz sampling rate
- Nyquist → max Freq ≈ 250Hz
EXPERIMENTAL DESIGN

SETTING

- Time: afternoon
- Activity: Sitting in a chair with closed eyes for 20 minutes
- for 6 successive weeks

http://ethw.org/images/thumb/1/13/Electrocardiography_2.png/300px-Electrocardiography_2.png
EXPERIMENTAL DESIGN

ANNOTATIONS

- 53%: completed in 6 weeks
- 38%: completed in 7 weeks
- 9%: completed in 8 weeks
HRV ANALYSIS

INTRODUCTION

1. detection of heartbeats (QRS complexes)
2. time domain analysis reports activity of circulation system
3. frequency domain analysis reflects sympathovagal balance of ANS
HRV ANALYSIS
INTERPOLATION

- Interpolation before FFT
- RR interval time series is an irregularly time-sampled signal
- Additional harmonic components are generated in the spectrum
- 4 Hz cubic spline interpolation
HRV ANALYSIS

FREQUENCY DOMAIN MEASURES

- spectral composition of variations
- spectral components grouped into three bands: VLF, LF, HF
- LF/HF power ratio is used as an index for assessing sympathovagal balance

https://benthamopen.com/contents/figures/TONEUJ/TONEUJ-4-39_F1.jpg
DATA

ONE SUBJECT

- instability of subjects in the beginning of the measurement, the head and tail of 20-minute ECG data were obsolete
- features: MH, MR, SD, RM, LF, HF, SD/RM, LF/HF

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DATA

ONE EPOCH

- Correlation of LF/HF and SD/RM for 32 subjects for one epoch of 5 minutes

**Figure 2:** Calculation of the Pearson correlation coefficient of SDNN/RMSSD and LF/HF. The period of sampled epoch is 5 minutes and the number of subjects is 32. The correlation coefficient $r$ is determined by the slope of the regression line and the determination coefficient $R$-Sqr.
RESULTS
CORRELATION

5 MIN EPOCHS

- steady decrease (week 2-5)
- not true for week 1 and week 6.

**Figure 3:** Pearson correlation coefficients of 6 weeks for 5-minute epochs.
CORRELATION

3 MIN EPOCHS

- no decrease phenomenon
- larger vibration

Figure 4: Pearson correlation coefficients of 6 weeks for 3-minute epochs.
CORRELATION DISTRIBUTION

- almost identical
- slightly higher for 5 min epoch

Figure 5: Normal distribution of Pearson correlation coefficients for 5-minute and 3-minute epochs. The x-axis indicates the correlation coefficient and the y-axis indicates the percentage of the related coefficient.
CORRELATION

3 MIN TREND

![Graph showing the trend of Pearson correlation coefficients with 3-minute epochs during 6 weeks.]

5 MIN TREND

![Graph showing the trend of Pearson correlation coefficients with 5-minute epochs during 6 weeks.]

Figure 7: The trend of Pearson correlation coefficients with 3-minute epochs during 6 weeks.

Figure 6: The trend of Pearson correlation coefficients with 5-minute epochs during 6 weeks.
SURROGATE FOR LF/HF

- no confirmation based on the collected data
DATA ANALYSIS DEMO
MEAN HR

mean HR 01.12.16

Zeit [hh:mm]

mean HR [s]

09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00

50 60 70 80 90 100 110 120

mean HR [s]
SDRR

![SDRR 01.12.16 Graph](image_url)
STILA

Heart Rate Variability
Computed Stress

From Dec 1, 2016 08:22:01 To Dec 1, 2016 20:16:44