Findings from Modeling Peaks in Electrodermal Activity during Sleep as a Point Process

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Introduction

Spontaneous electrodermal activity (EDA) responses during sleep, or sleep storms, have been observed since the 1960s [1,2]. The rate of EDA peaks is typically captured in features like the total number of peaks in a window of time; however, this completely ignores any historical dependence present.

We can more accurately model the rate of EDA peaks by using a state-space based point process [3]. This leads to several interesting results, including earlier peaking being correlated with higher morning energy.

Data Collection

- 62 undergraduate students
- 30 days each
- Nearly 24-7 EDA data from wrist worn sensor
- Sleep timing and energy level reported each morning via online survey

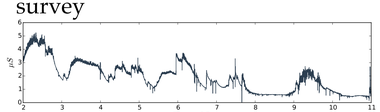
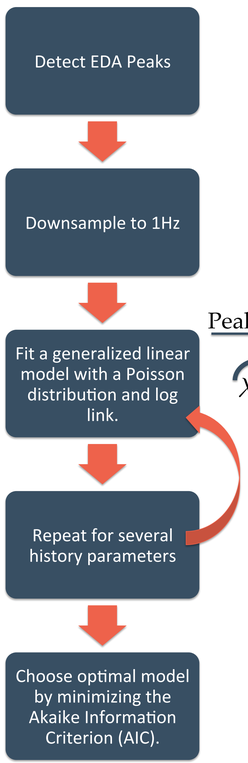


Figure 1: *Example electrodermal activity (EDA) data during sleep from the wrist*

Methods



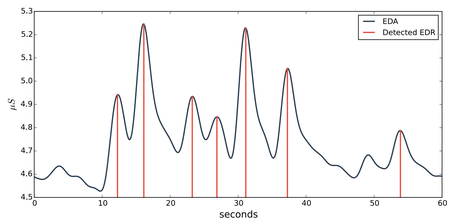


Figure 2: *Example of detected EDA peaks*

Peak rate depends on between-night and short-term history

$$\lambda(l\Delta|\theta_k, \gamma, H_{k,l}) = \lambda^S(l\Delta|\theta_k)\lambda^H(l\Delta|\gamma, H_{k,l})$$

current time

$$\log \lambda^S(l\Delta|\theta_k) = \sum_{r=1}^{R} \theta_{k,r} g_r(l\Delta)$$

time parameters — *time since sleep onset function*

$$\log \lambda^H(l\Delta|\gamma, H_{k,l}) = \sum_{j=1}^{J} \gamma_j n_{k,l-j}$$

history parameters — *binary indicator of observed spike*

Results

Median number of peaks detected per night: 74

The rate of peaking in the first 3 hours of sleep is significantly higher than during the last 3 hours ($p<0.001$)

There is a suppression in the rate of peaking 1-2 seconds after a peak, while 3-4 seconds after a peak there is an average 4.9 fold increase in rate of peaking ($p<0.01$)

There is a correlation of -0.38 between the expected first peak time of the EDA during the night's sleep and the average energy reported the following morning ($p<0.01$)

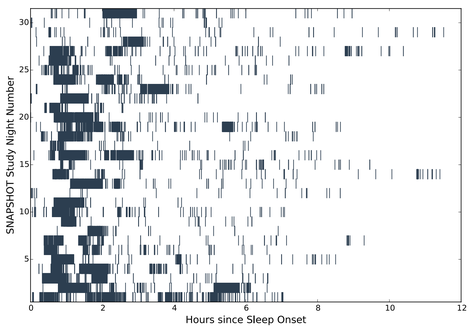


Figure 3: *An example of detected EDA peaks for one participant.*

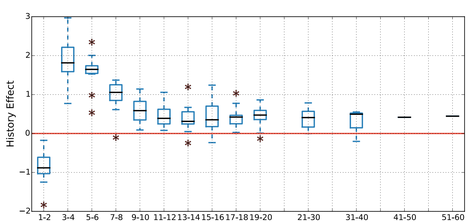


Figure 4: *History effect parameters. Parameters above (below) the red line increase (decrease) the probability of detecting an EDA peak.*

Key Findings

- EDA peaks during sleep can be modeled as a point process
- Peaking is more likely to happen in the first 3 hours of sleep
- There is a 1-2 second suppression of EDA peaks after a peak
- Earlier peaking is correlated with higher morning energy

Acknowledgements

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References

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