Quantitative Analysis of Electrodermal Activity during Sleep

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Introduction

What is Electrodermal activity (EDA)?

Electrodermal activity (EDA) provides a fine measure of sympathetic nervous system activity, one of the main branches of the autonomic nervous system, and a measure widely used in psychophysiology. Classically, EDA has been measured as skin conductance and involves attaching wired and gelled electrodes to the skin. This study uses a wireless non-invasive sensor worn on the wrist that measures EDA (also called "galvanic skin response"), motion (actigraphy), and temperature (Q sensor, Affectiva).

EDA storms during sleep

Studies have shown that EDA is more likely to have high frequency peak patterns called "storms" during deep sleep (Asahina, 1962). EDA has also been shown to have characteristic differences associated with wake and sleep, although its patterns are not uniquely associated with EEG-based sleep stages (Koumans et al., 1968).

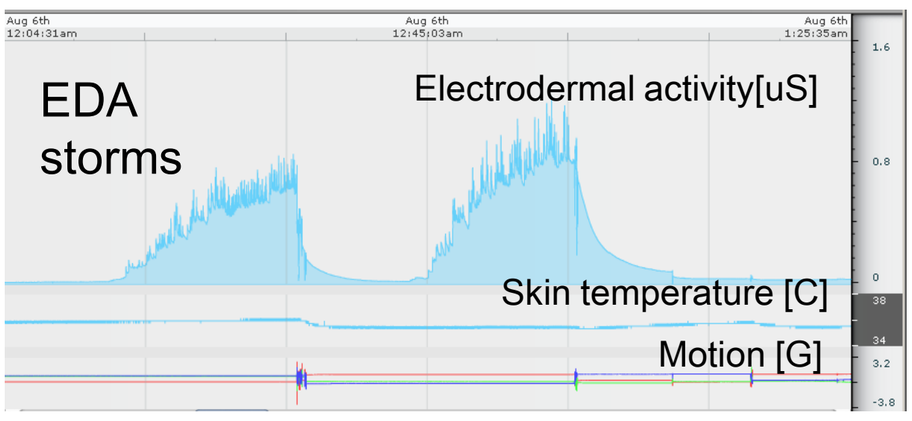
Objectives

It is now easy to get long-term monitoring of electrodermal activity (EDA) during natural sleep at home. The objective of this study is to quantitatively characterize electrodermal activity (EDA) during sleep.
EDA high frequency peaks do not necessarily occur corresponding to deeper sleep stages. Quantitative analysis is needed to clarify the characteristics of the EDA peaks

Data & Analysis

We measured

-One night of wrist EDA, skin temperature and actigraphy with concurrent polysomnography (PSG) from 8 healthy adults in a sleep lab
-30-night of wrist EDA from 7 healthy adults in sleep at home.



The data is analyzed as follows:

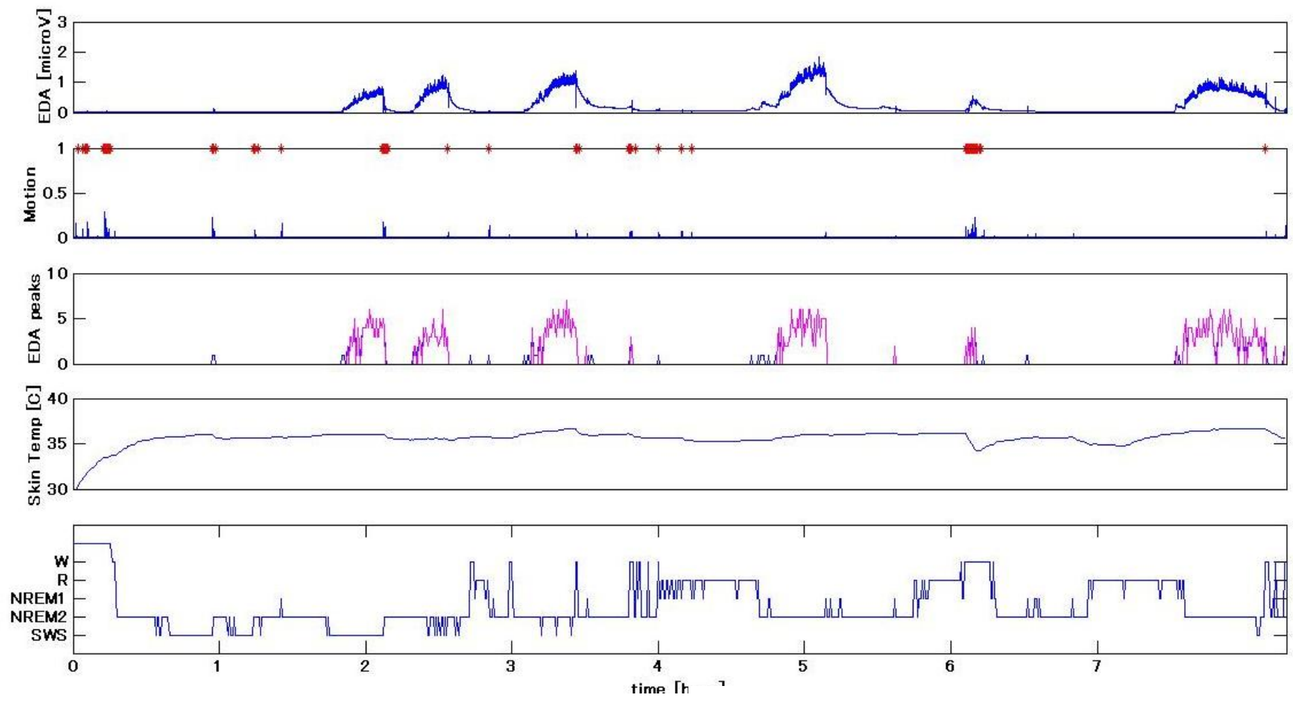
1. Pre-processing: Standard zero-crossing and Cole's function were applied to the accelerometer data to discriminate between sleep and wake. EDA data was low-pass filtered (cutoff frequency 0.4 Hz, 32nd order FIR filter).

2. We detected EDA "storm" regions, where "storm" (Burch, 1965) refers to a region of EDA with a burst of high frequency peaks. Burch originally quantified a storm as a minimum of five galvanic skin responses (GSRs)/min for at least ten consecutive minutes of sleep. In this paper, EDA peak epochs were identified when EDA exhibited > 4 peaks per minute, then also EDA "storms" were detected when EDA peak epochs lasts more than 10 minutes. We analyzed the characteristics of EDA peaks and storms with sleep stages.

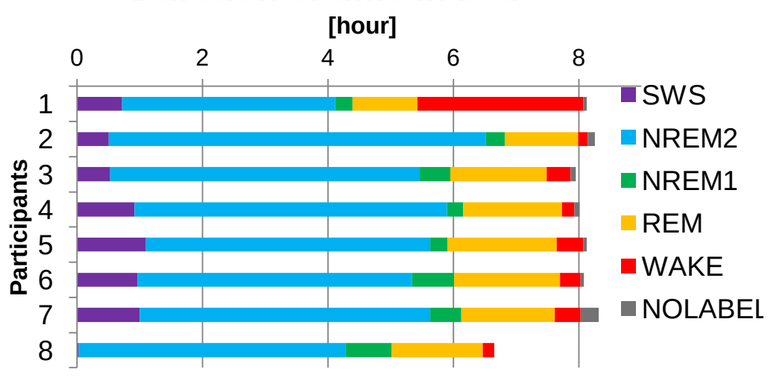
Full Disclosure: Picard is a full professor at MIT and also co-founder, chief scientist, and chairman of Affectiva, who made the sensors used to collect the data in this study. The author participates fully in MIT's monitoring of conflict-of-interest procedures.

Results

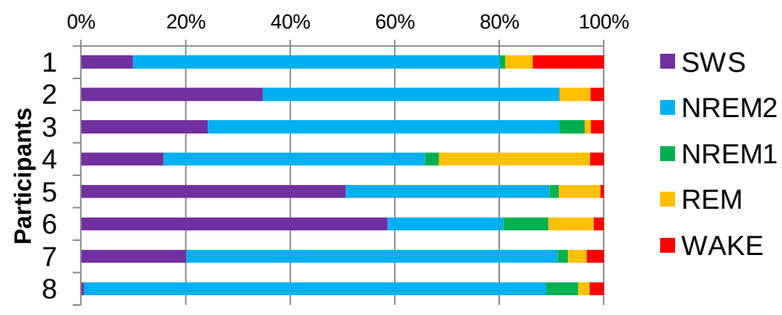
Example: EDA raw data with EDA peaks and sleep stages



Duration of time in bed

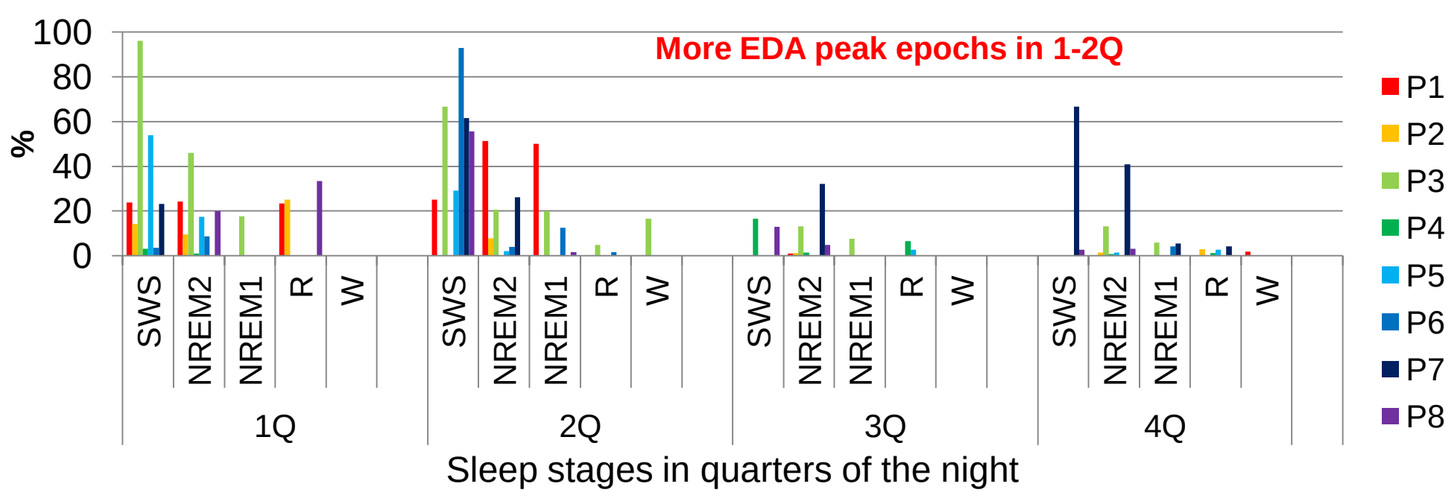


When EDA peaks happened, which stages did they occur in?

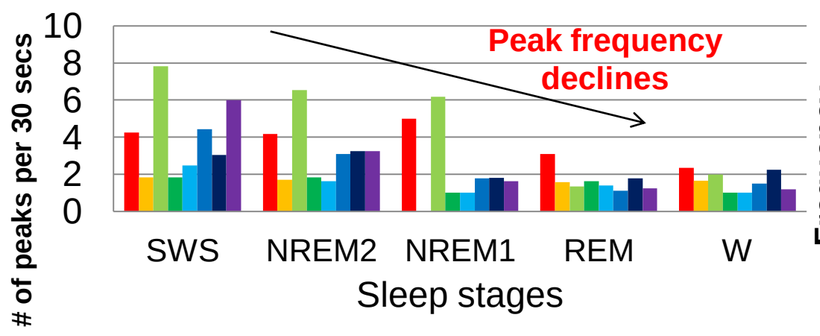


85 % of EDA peak epochs occurred in SWS and NREM2

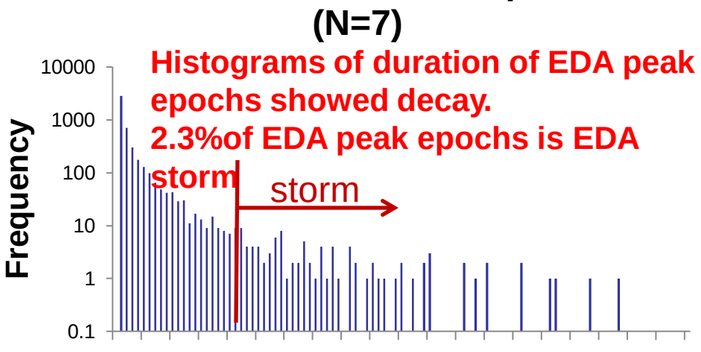
Percentage of peak epochs in each sleep stages in quarters of the night

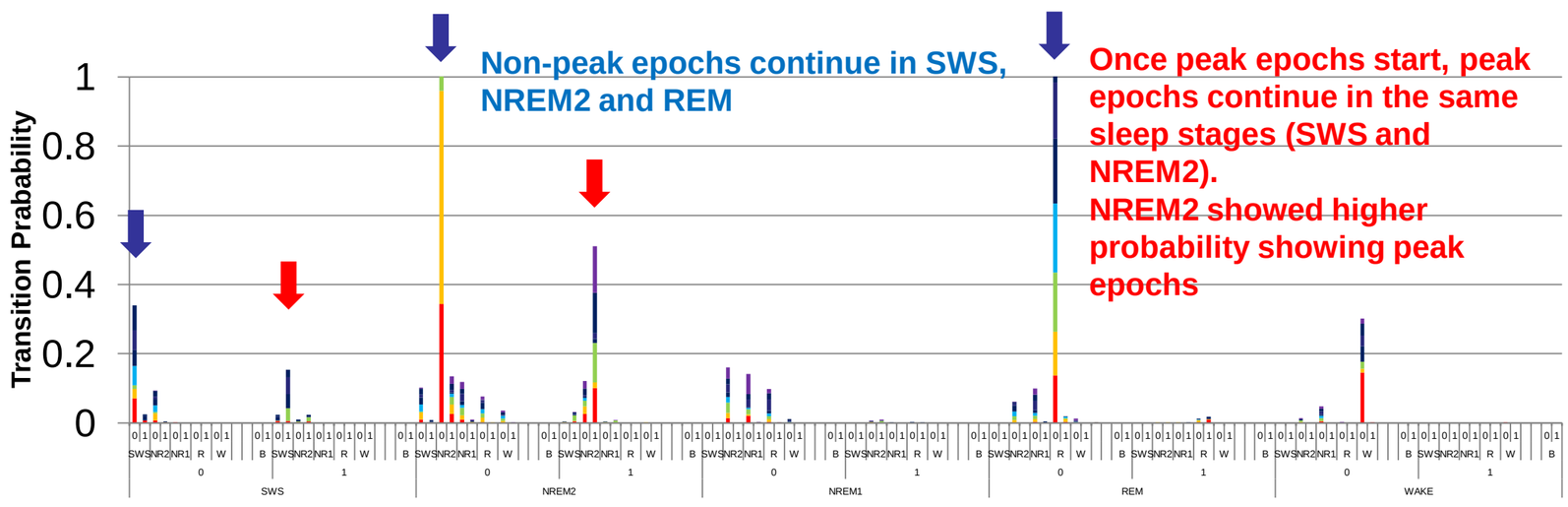


Mean EDA Peak Frequency in Sleep Stages



Duration of EDA Peak Epochs (N=7)





Sleep stage (n-1) to sleep stage (n) with peaks(1) or without peaks(0)

Conclusions

We quantitatively characterized EDA for over 200 nights from home and lab sleep and described a basic taxonomy of EDA peaks and storms, validating their tendency to occur in NREM2 and SWS with higher frequency

References

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