

Autonomic Sleep Patterns in Children with Autism Spectrum Disorders

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Introduction / Motivation

Sleep disorder in Autism Spectrum Disorders

44 to 83 percent of children with autism spectrum disorders (ASD) have greater rates of sleep disorders than typically developing children, such as insomnia, which generates long sleep latency and fragmented sleep. (Johnson et al, "Sleep in Children with Autism Spectrum Disorders", Current Neurology and Neuroscience Reports, 8, 2, 155-161, 2008) Sleep disorders reduce children's concentration for learning and contribute to increased problem behaviors as well as stress for them and their families.

Long-term sleep monitoring at home

Polysomnography (PSG) is a gold standard to evaluate and diagnose sleep patterns, but the sensors tend to be uncomfortable and expensive, and may interfere with sleep. Actigraphy is a much less invasive method often used to evaluate daytime and sleep activity with a wrist device; however, it is limited to measurement of movement, and can suggest you are asleep even when you are awake. Our research group has developed a wireless non-invasive sensor to measure **electrodermal activity (EDA)** to observe sympathetic nervous activity. This poster examines how combining actigraphy and EDA can provide details of children's sleep and can be comfortably used for low-cost long-term sleep monitoring at home.

This poster presents a first version of a taxonomy of automatic sleep patterns using EDA in ASD. We aimed to first evaluate sleep patterns in children with ASD using both PSG and a wearable sensor that enables comfortable measurement of actigraphy, skin temperature and EDA (via skin conductance) on the wrist.

Questions

- (1) Do children tolerate this new sensor?
- (2) Does EDA give rich data beyond actigraphy?
- (3) Does EDA show more arousals pre-sleep for children who had difficulty falling asleep?



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. El Kaliouby is research scientist at MIT and also co-founder and CTO of Affectiva. Both authors participate fully in MIT's monitoring of conflict-of-interest procedures.

Data

| ID | Gender | Age | Sleep Parental Questionnaire | Dominant Hand |
|---------|--------|-----|------------------------------|---------------|
| AF3PL | Female | 3 | Poor | Left |
| AF6PR | Female | 6 | Poor | Right |
| AF6PR+M | Female | 6 | (With melatonin) | Right |
| AM8GR | Male | 8 | Poor | Right |
| AF6GR | Female | 6 | Good | Right |
| AM8GR | Male | 8 | Good | Right |

Five children diagnosed with ASD (ages 3-8) participated in overnight measurement in a sleep lab. One subject (AF6PR) participated in two nights of measurement, one night without melatonin and the other night with 1mg melatonin, 4cc Natrol liquid thirty minutes before bedtime. Skin conductance, actigraphy, and skin temperature during sleep from the inside of left and right wrists were measured (only right wrist for AF6PR+M) and the behaviors of these signals were compared to PSG. All children were evaluated as good or poor sleepers based on parental.

We obtained thirty-second epochs of sleep stages (Wake, REM, Stage1, 2 and 3) labeled by sleep experts.

Analysis

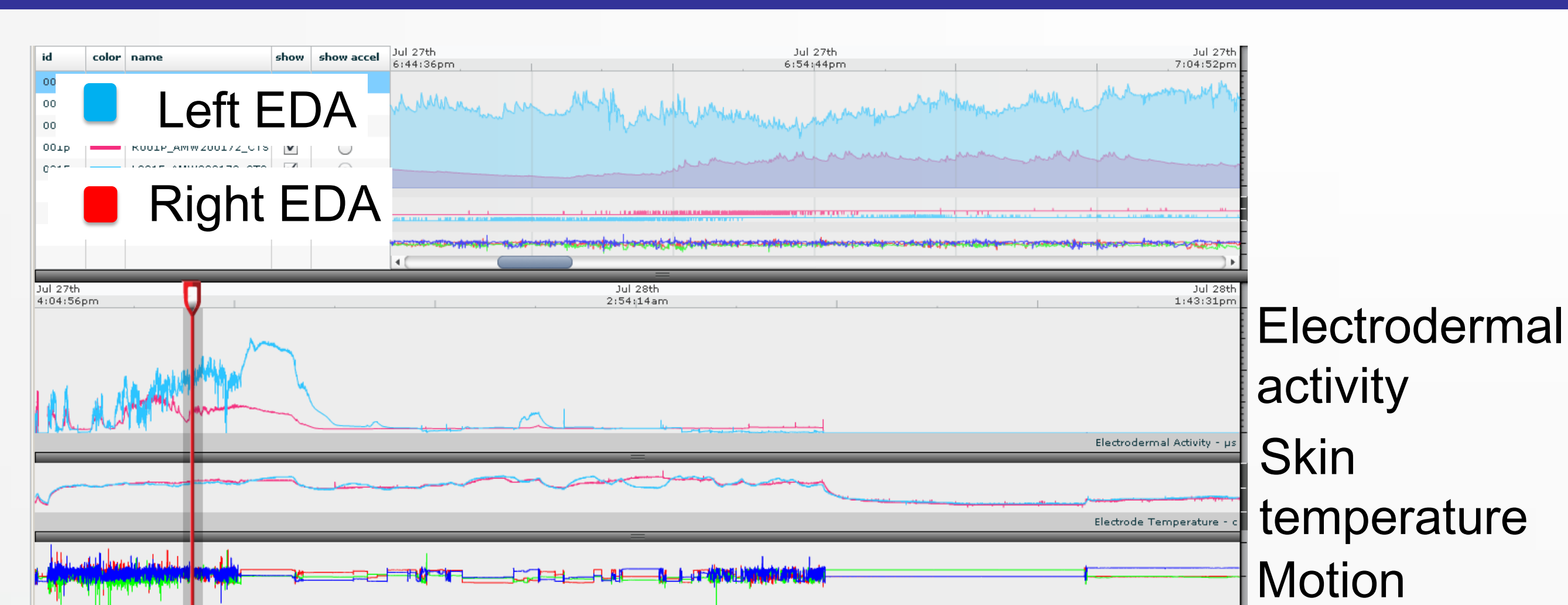


Fig. 1: EDA on the right wrist vs. on the left wrist. The bottom graph shows the full night of sleep; the top graph shows a detailed view of the section highlighted in grey. Note that the EDA is not correlated with temperature.

The data is analyzed as follows:

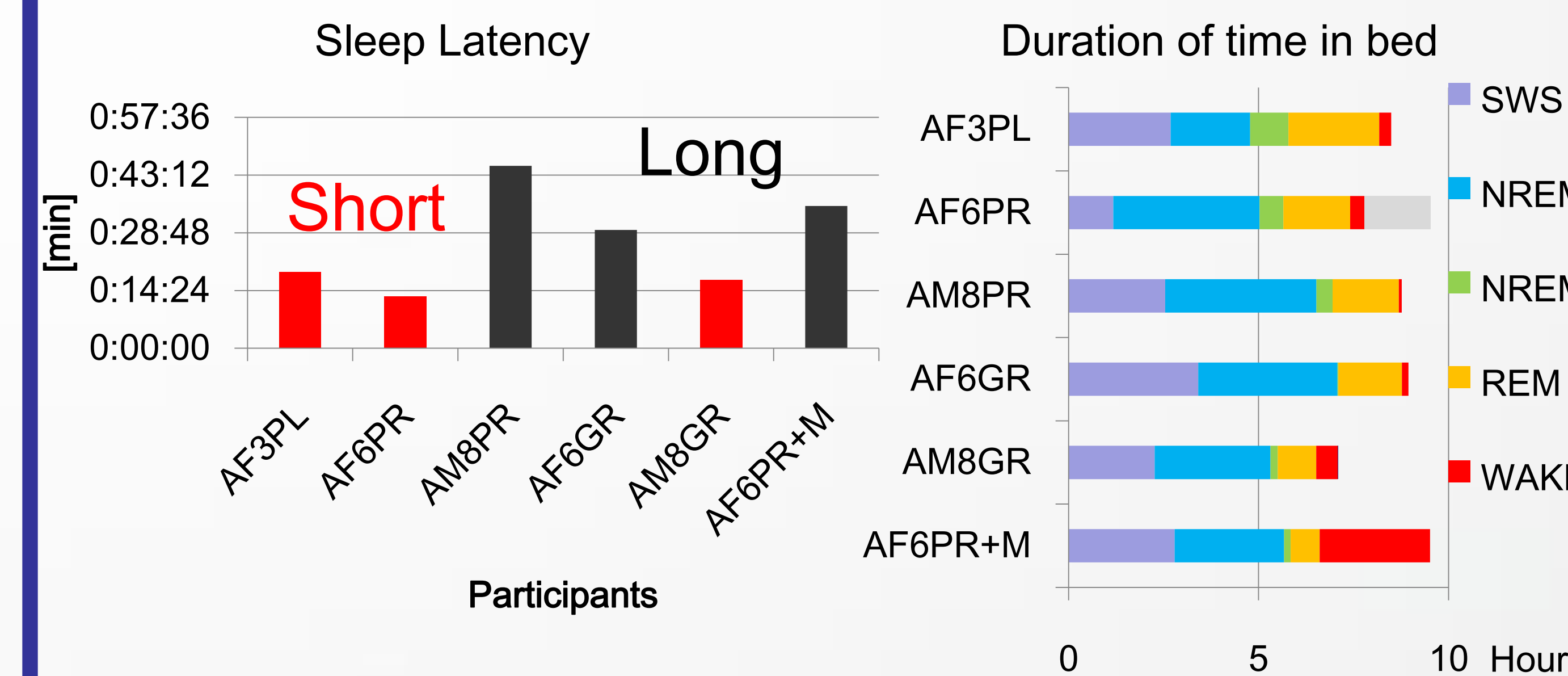
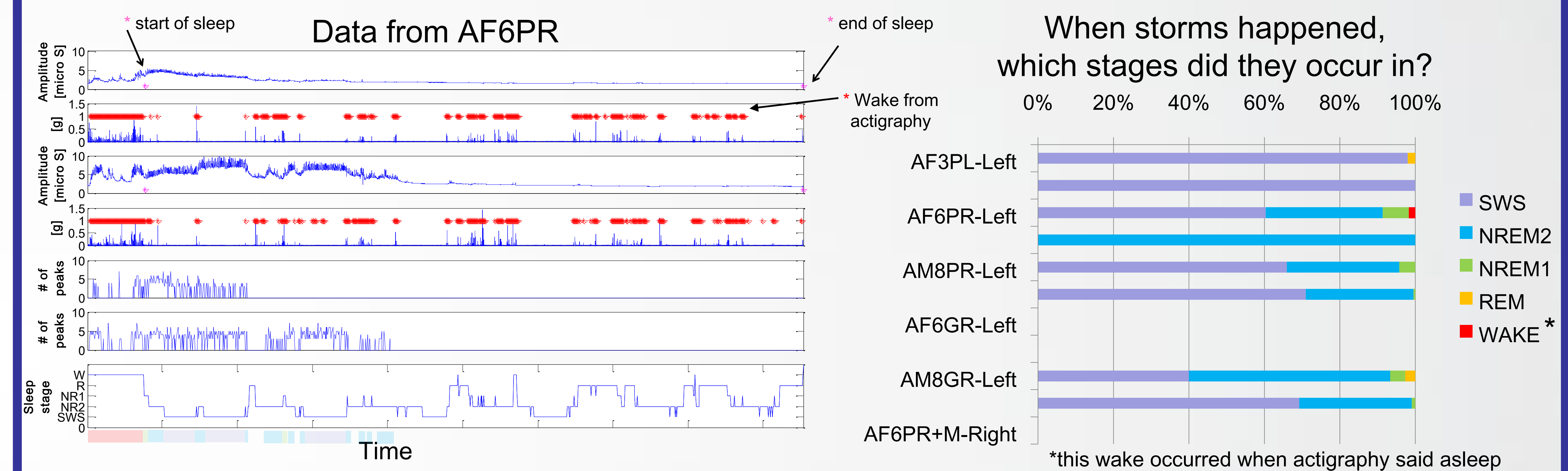
1. Pre-processing: Standard zero-crossing and Cole's function applied to the accelerometer data was used to discriminate between sleep and wake. EDA data was low-pass filtered (cutoff frequency 0.4 Hz, 32nd order FIR filter).
2. We detected EDA "storm" regions, where "storm" (first described by Burch) 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, we defined "storm epochs" as a 30 second epoch with a minimum of three GSRs/30s. If storm epochs are adjacent or within five minutes of each other, they are combined into a "storm".

Results

(1) Do children tolerate this new sensor? YES, all 5 subjects tolerated the new sensor.

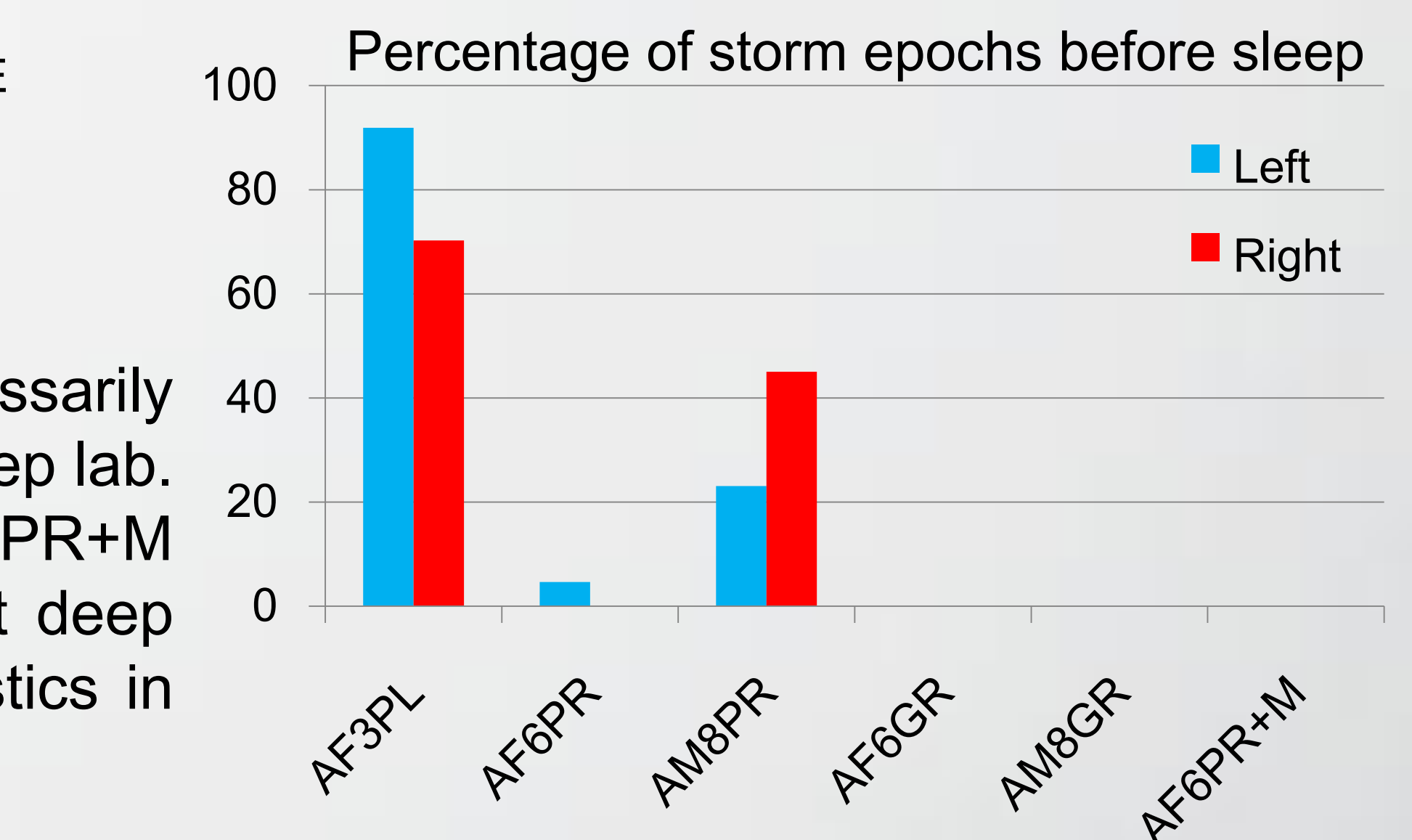
(2) Does EDA give rich data beyond actigraphy?

YES, EDA storms occurred in the early night, mostly during SWS and N-REM2. 4 in 6 nights showed at least one EDA storm: 3 of them occurred in poor sleepers (parental questionnaires) with short sleep latency. Out of 5 participants, two showed similar EDA storm patterns for both wrists. 4 of 5 showed larger responses on the left.



(3) Does EDA show more arousals pre-sleep for children who had difficulty falling asleep?

YES, children labeled by parents as poor sleepers showed a larger percentage of storm epochs both before and during sleep.



Good sleepers based on the parental questionnaires did not necessarily show shorter sleep latencies or better objective sleep quality in the sleep lab. Moreover, AF6PR showed shorter sleep latency than AF6PR+M. AF6PR+M showed a larger percentage of SWS and shorter latency to the first deep sleep. We need to monitor long-term data to confirm the characteristics in detail.

Conclusions

We measured continuous EDA, actigraphy and skin temperature on children diagnosed with ASD with a comfortable wearable sensor and evaluated the relationship between EDA characteristics, laterality, and sleep stages from simultaneously recorded PSG. The comfortable wearable sensor showed new sleep characteristics on children diagnosed with ASD that could be measured easily at home. About 70 % of the EDA storms occurred during SWS. We will continue analysis with a larger number and long-term data monitored at home.