An at-home, wireless, soft electronics sleep monitoring system for long-term, reliable sleep assessment in young and older adults

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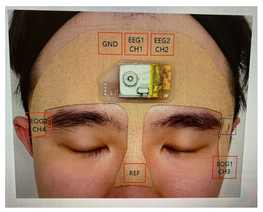
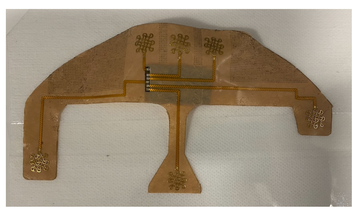
Introduction

- Constraints of **"gold standard" polysomnography**, including bulky, wired, rigid, expensive, and uncomfortable equipment either in an unfamiliar lab or at home, make collecting multiple nights of sleep data prohibitive.
- **In the current study:** we designed a portable, skin-like, wearable EEG monitoring patch, a sleep patch that was deployed at home over 7 nights
- We include young and old participants to assess typical age-related patterns
- **Aim:** to validate the age-related differences in microarchitecture and macroarchitecture observed in polysomnography literature using our sleep monitoring system

Methods





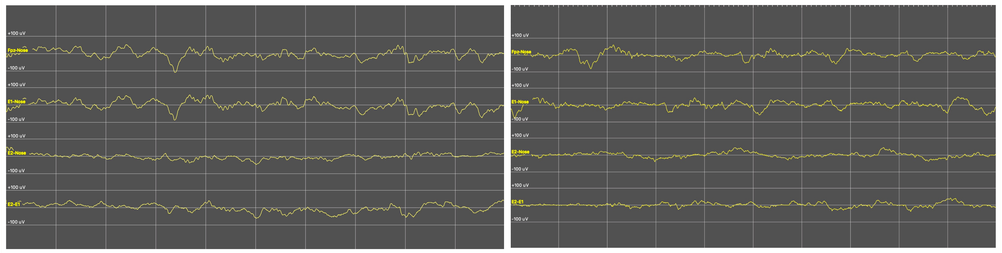
1. **Participants:** 12 old, 14 young healthy adults (age 18-36 and ages 60-74)
2. **Measures:**

- Sleep Patch
  - Gel-free, nearly weightless, sleep monitoring patch that uses soft, silicone elastomer in which the laser-cut electrodes are embedded, self-applied to the face for optimal usability and comfort.
- Bluetooth tablet-based data acquisition software
  - Captures the signals from the sleep patch.

Results

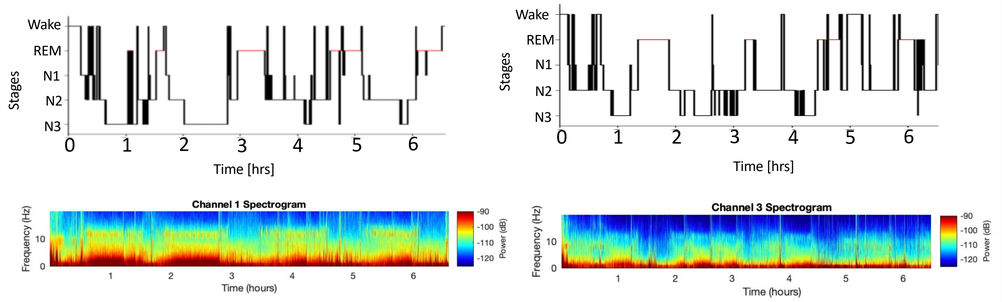
1. Raw sleep data: Raw sleep EEG data is measured in both young and old adults capturing the four channels' signals.

Young **Old**



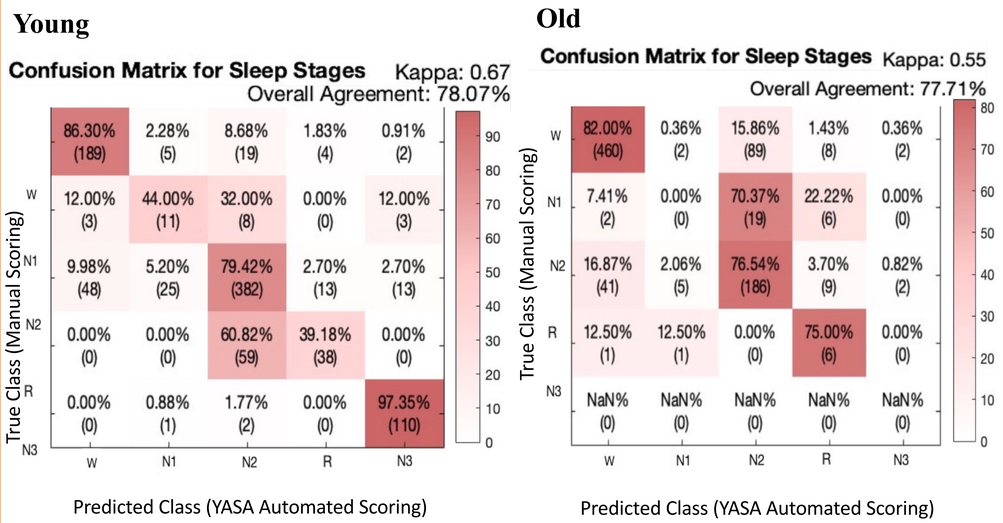
2. Hypnogram and spectrogram of a healthy subject showing sleep/wake cycles. Captures the characteristics for each sleep/awake stage, including alpha, REM, and slow wave sleep.

Young **Old**



3. Confusion matrix: Manual scoring and YASA automated classification-based scoring showed good agreement across all sleep stages.

Young **Old**



Results (Continued)

4. Table: Comparison between older and younger adults across different features.

	YA-Average[Standard Deviation]	OA-Average[Standard Deviation]	*p*
Average SNR (dB)	28.587[sd=2.154]	27.830[sd=1.898]	0.350
Change in SNR over time (dB)	2.008[sd=4.286]	-0.657[sd=3.543]	0.096
Total sleep time (min)	215.591[sd=84.002]	267.217[sd=117.725]	0.220
N1 of TST (%)	3.065[sd=1.655]	2.930[sd=1.792]	0.844
N2 of TST (%)	73.894[sd=12.925]	77.652[sd=9.887]	0.410
N3 of TST (%)	13.661[sd=7.981]	9.293[sd=5.842]	0.122
REM of TST (%)	9.370[sd=5.418]	10.124[sd=5.912]	0.739
spindle density_N2	1.259[sd=1.408]	0.755[sd=0.641]	0.245
spindle density_N3	0.212[sd=0.278]	0.156[sd=0.176]	0.539

5. Debriefing: Participants reported being easily able to self-apply the reusable sleep patch and operate the Bluetooth tablet-based data acquisition software throughout seven nights.

Survey Question	YA[sd]	OA[sd]
Would you wear this mask if your doctor wanted to see if your sleep indicated a sleep disorder? (1=unlikely, 7=likely)	6.300 [sd=0.823]	5.889 [sd=1.965]
How much did the mask interfere with your sleep, if it did? (1= none, 7= a great deal)	2.615 [sd=0.870]	2.182 [sd=1.250]
Overall, how easy was the mask to use (1=difficult, 7=easy)	5.000 [sd=1.118]	5.111 [sd=1.900]

Conclusion

- This study validates that the high comfort, wearable patch can measure physiological sleep data in adults across the lifespan.
- By utilizing this sleep patch with gel-free electrodes that can be worn at home, it would enable participants to engage in the study more naturally and over an extended period.
- Future work will use this system to assess sleep-dependent consolidation across ages from the comfort of one's home and measure sleep variables longitudinally to identify those most indicative of cognitive decline.

Acknowledgement

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