Local slow-wave activity in regular sleep reveals individual risk preferences

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Background

- Human risk-taking is characterized by a large amount of individual heterogeneity.
- Previous research has shown that the manipulation of total sleep time affects risky decision-making[1,2].
- Slow-wave activity (SWA, a physiological marker for sleep depth) and its scalp topographical distribution shows large inter-individual variation, remarkable stability within an individual across nights, and is unique to each person.[3,4] Due to these trait-like characteristics, SWA provides an ideal neural trait marker to investigate interindividual differences in risk-taking.

Do individual, temporally stable neural sleep characteristics (the topographic distribution of SWA) during a night of sleep under normal conditions relate to individual differences in risk preferences.

Methods

Participants. 54 healthy good sleepers (mean age ± SD = 21 ± 2.04 years, 42 females).

Study protocol

Regular sleep-wake rhythm, activity-monitoring and sleep- & consumption diary for 7 days

Risk-taking task

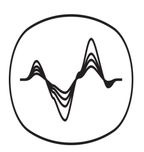
How many meters do you want to drive on a 50-meter road?
A wall will appear at a random distance, every meter driven earns you 0.1MU.
If you drive more meters than the distance to the wall you will crash and loose the start-fee (5MU) and the payment for the driven meters (1MU = 1CHF).

High-density sleep EEG

Portable polysomnographic system at participants' home, 61 electrodes

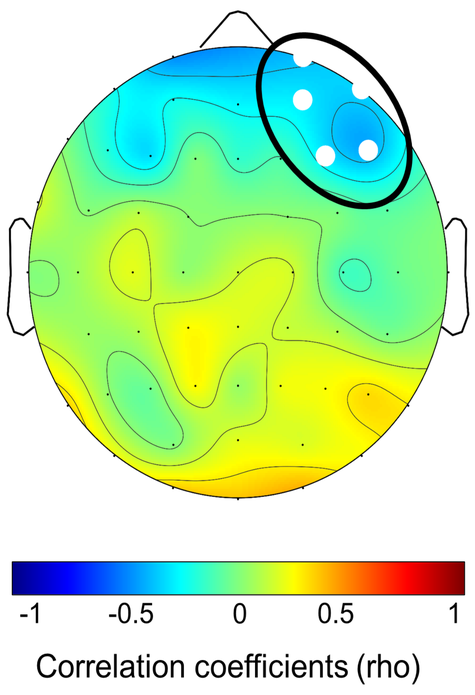
Normalized SWA (0.8-4.6Hz)

Computed in deep sleep (N2 and N3)



Results

- Spearman's rank correlations between normalized SWA distribution map and risk-taking revealed robust and significant negative associations in a cluster of five electrodes placed on the right PFC (corrected for multiple testing, **Fig. 1A**).
- The correlation between mean SWA in the significant cluster and risk-taking behavior resulted in a rho-correlation coefficient of -0.38 (df = 52), p = 0.004, R^2 = 0.14 (**Fig. 1B**).
- Partialling out participants' total sleep time did not affect the relation between SWA in the right PFC and risk-taking behavior. (rho(51) = -0.39, p = 0.004, R^2 = 0.15). Thus, the negative correlation between SWA in the right PFC and risk-taking behavior is independent of sleep quantity.



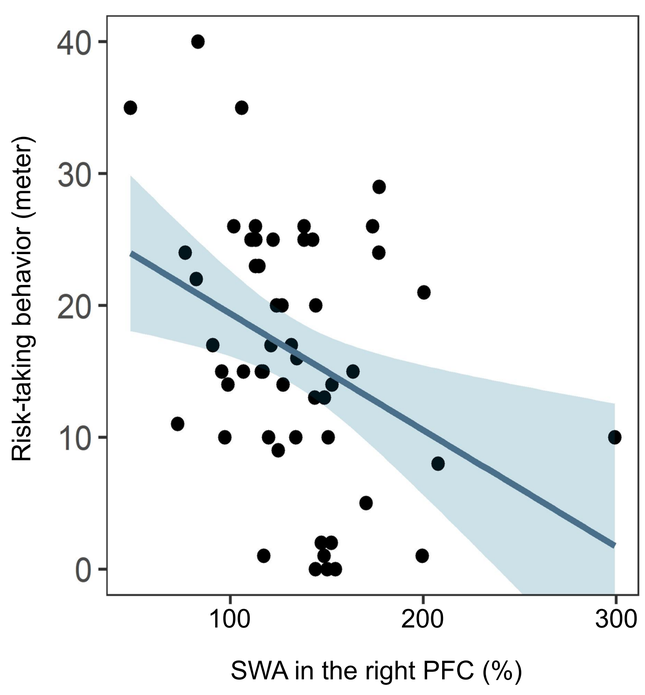


Fig. 1. (A) Statistical topographical distribution of rho-coefficients between normalized SWA and risk-taking behavior. **(B)** Scatterplot of the negative correlation between mean normalized SWA in the significant cluster over the right PFC and risk-taking behavior.

Discussion

We found that normalized SWA over the right PFC is associated with an individual's propensity to engage in risk-taking behavior: Individuals with a high-risk preference showed less SWA in the right PFC than those with a low-risk preference. A large body of research indicates that higher levels of both baseline and task-related activation in the lateral PFC correlates with increased self-regulation, inhibitory control, or executive functions in general.[5,6] Hence, it seems reasonable to assume that higher SWA in the lateral PFC during sleep is critical for restoring self-regulatory abilities, which are fundamental not only in mitigating risk-taking but also in other important decision-making processes. Our results could inspire targeted interventions during deep sleep (via TMS, tDCS, or auditory closed-loop stimulation)[7,8] to boost the functioning of the right PFC to improve self-regulatory abilities and consequently functional decision-making.

Conclusion

- Individual fingerprints in sleep EEG topography relate to individual differences in risk preferences.
- Individuals with a high-risk preference showed less SWA in the right PFC than those with a low-risk preference. These findings were highly specific to the right PFC.
- SWA over the right PFC might be a dispositional indicator of self-regulatory ability.

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