Space it Up! Days Florence 2026

Psychophysiological alterations in Space-Simulated conditions: EEG cortical connectivity in Head-Down Bed Rest and Sensory Deprivation

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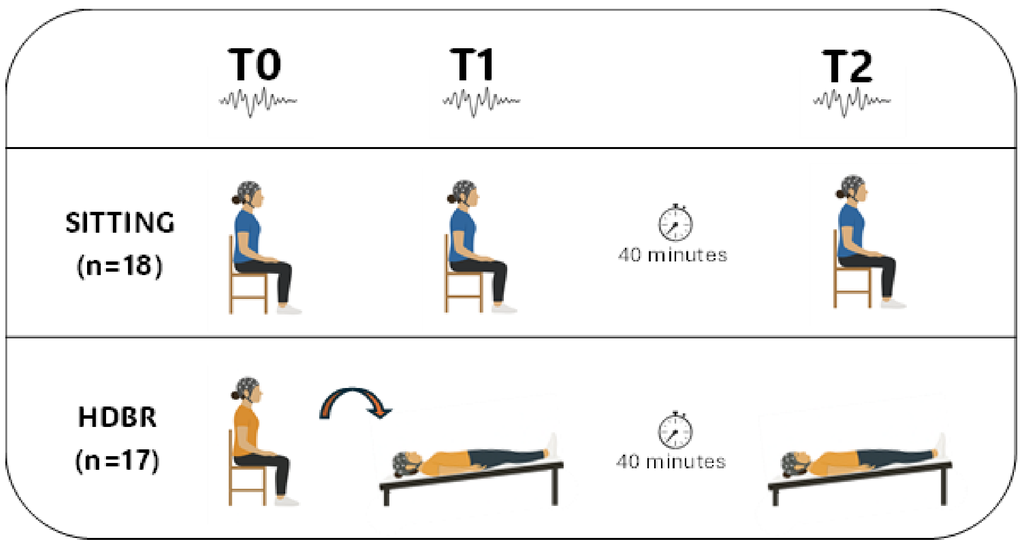
INTRODUCTION

Space missions expose astronauts to unique stressors, such as microgravity and sensory deprivation, which can disrupt cognitive performance and neurophysiological homeostasis. While space-analog research has predominantly focused on male participants, this study investigates brain alterations in an understudied female adult sample. We employed two Earth-based analogs, Head-Down Bed Rest (HDBR) and Sensory Deprivation (SD) induced in a silent, dark cabin, and focused on the Default Mode Network (DMN), a system involved in self-referential processing and mind wandering. Using two randomized controlled experiments with 64-channel EEG, we examined how these environments modulate resting-state activity and functional connectivity. Given the association between DMN alterations, depression, and anxiety, these findings are relevant for evaluating the risk of mood disorders and brain impairment during long-duration space missions.

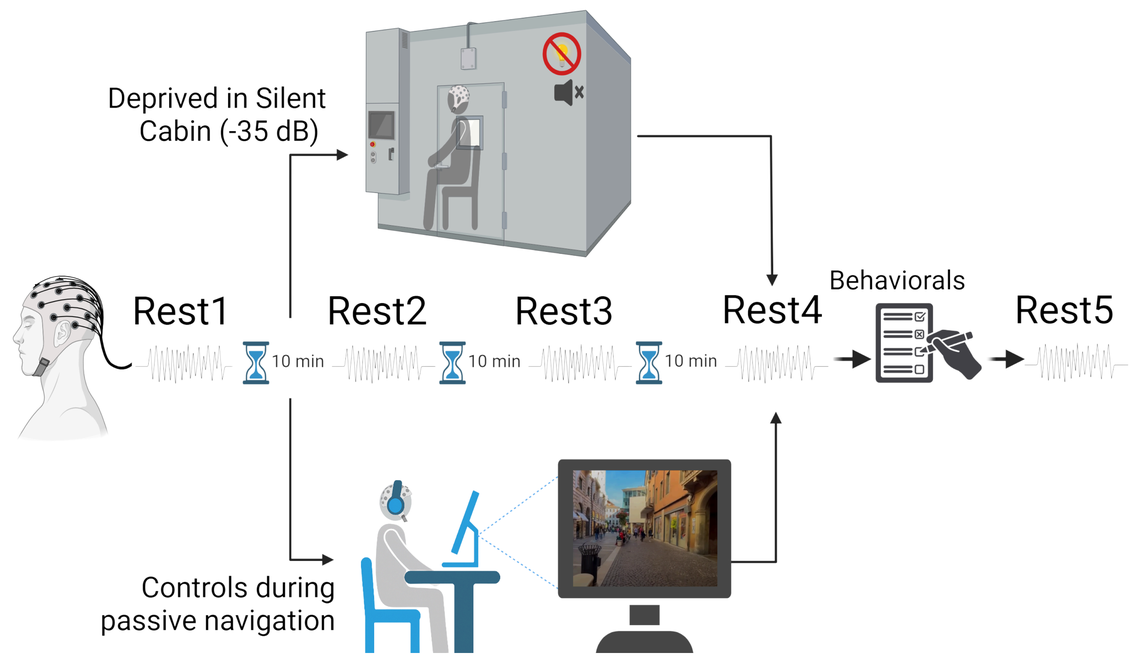
SIMULATED MICROGRAVITY

35 healthy young adult females were randomly assigned to either a Sitting (N = 18) or HDBR group (N = 17). Resting-state EEG was recorded using a 64-channel cap across three timepoints (5 minutes each). We analyzed DMN oscillatory activity and functional connectivity within alpha (8–13 Hz) and beta (13–30 Hz) frequency bands.



SENSORY DEPRIVATION

A sample of **47 healthy female** participants was randomly assigned to one of two conditions: Sensory Deprivation (SD, N = 24) or Control (CG, N = 23). In the SD condition, participants spent 45 minutes in a completely **dark and soundproof cabin** (–35 dBA), whereas in the control condition, participants watched a first-person naturalistic video depicting a passive walk through an urban environment.



RESULTS

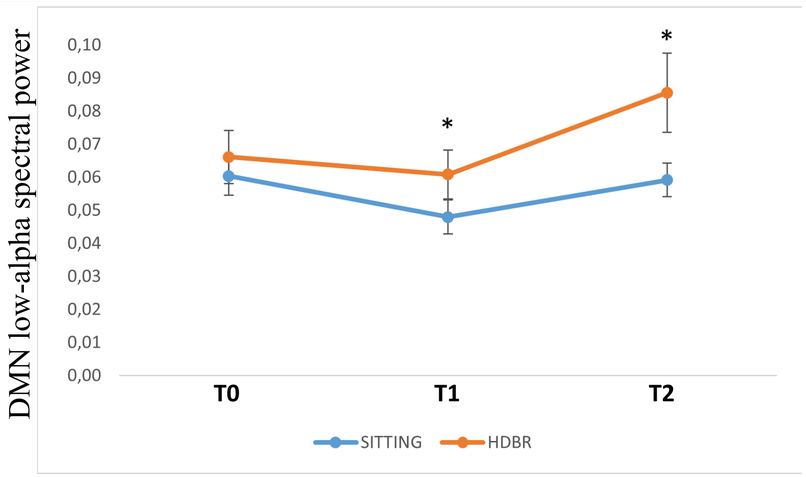


Fig.1. Group differences in global DMN low-alpha power. A significant increase in HDBR (vs. Sitting) was observed at T1 and T2. Values represent raw low-alpha power (mean ± SE).

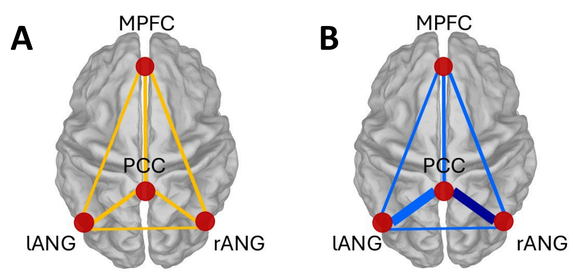
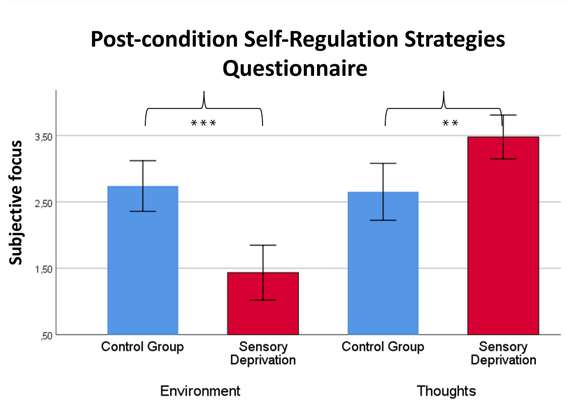
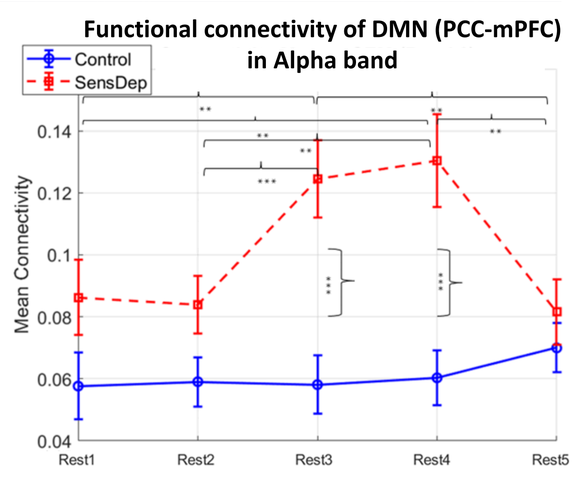
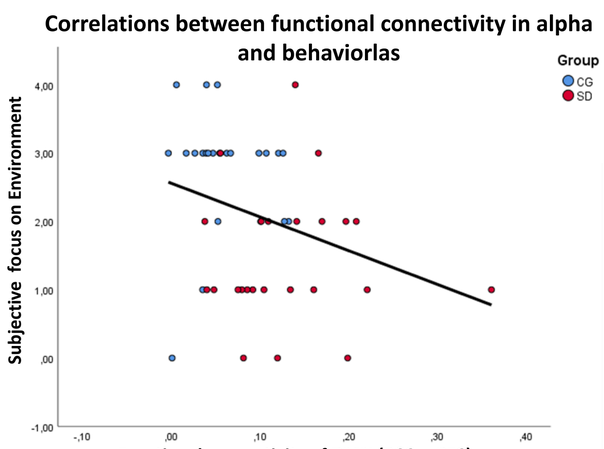


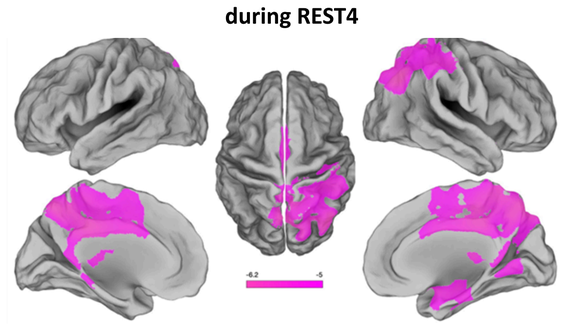
Fig. 2. Within-group changes in low-alpha DMN intra-network connectivity over time. (A) The HDBR group showed no significant connectivity change over time; (B) The Sitting group showed a significant increase over time, especially between T1 and T2; this change was driven by a significant increase in PCC–rANG connectivity.

RESULTS









Functional connectivity of DMN (PCC-mPFC)

CONCLUSION

Short-term HDBR in young women led to increased global low-alpha power in the DMN, possibly reflecting greater internal focus, mind-wandering, or reduced external sensory engagement. Unlike the sitting group, which showed a progressive increase in DMN connectivity, the HDBR group exhibited no significant change. This suggests that HDBR may reduce the brain's typical flexibility in adapting to environmental conditions, potentially representing a neurophysiological vulnerability during long-duration space missions.

CONCLUSION

During SD, participants showed increased internal attention compared to the externally oriented focus of the control group. Short-term SD induced a transient **increase in intra-network DMN functional connectivity** (alpha, beta, and gamma bands), particularly involving the PCC. In the absence of external input, the brain appears to **shift resources toward self-referential processing**, as supported by both functional connectivity and behavioural data. Although temporary, this mechanism may be potentially maladaptive, given links between altered DMN connectivity and psychopathology, and has implications for understanding isolation and stimulus-deprived environments.

ACKNOWLEDGMENTS

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