Brain Networks Under Different Task Demands After Abrupt Awakening with Enriched Blue Light Exposure

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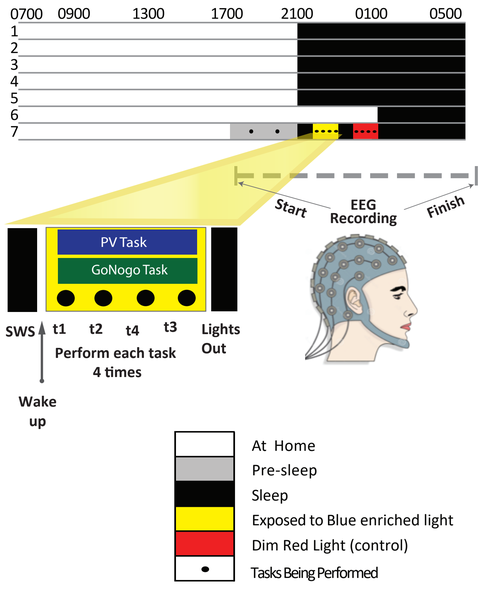
Background

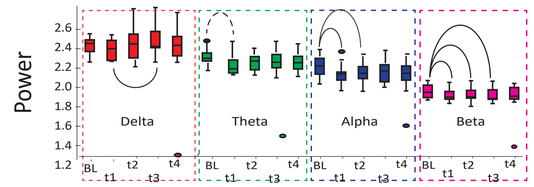
Sleep inertia refers to the state of transition between sleep and wake characterized by impaired alertness, confusion, and reduced cognitive and behavioral performance. While the neurobehavioral symptoms of sleep inertia are well-described, less is known about temporal evolution of brain network dynamics after waking, the impact of blue-enriched light on this profile, and the cognitive specificity of these effects. Here we explore the waking brain from a graph theoretical perspective. We assess two key network properties after abrupt waking: the clustering coefficient, which measures how likely two network regions are connected to one another, and average path length, which measures the average shortest path between pairs of regions. With this approach, we ask how exposure to blue-enriched light attenuates changes clustering and path length as subjects perform two different cognitive tasks to undertand how task demands interacts with these effects.

Methods

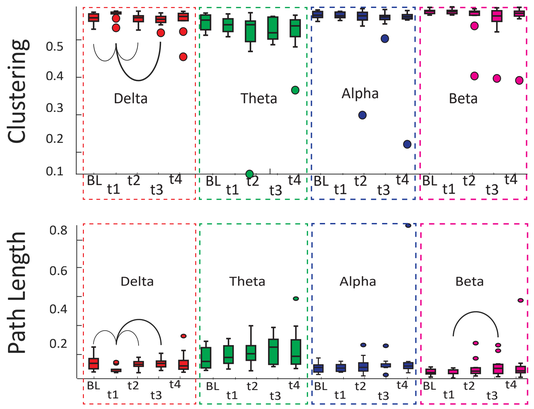


PV Task

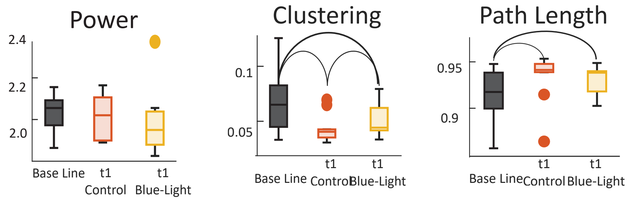
1 Performing a PV task immediately after waking is accompanied by a decrease in global theta, alpha, and beta power



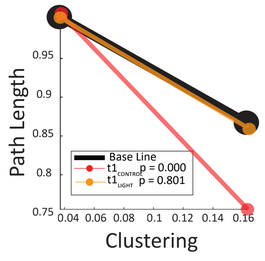
2 Furthermore, clustering in the delta band decreases and path length increases



3 Exposure to blue light after waking attenuates reductions in delta clustering while engaging in the PV task

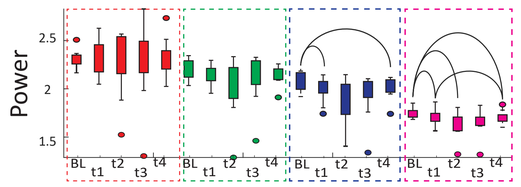


4 The slope between path length and clustering in the delta band steepens when performing the PV task during sleep inertia. Exposure to blue light prevents this change

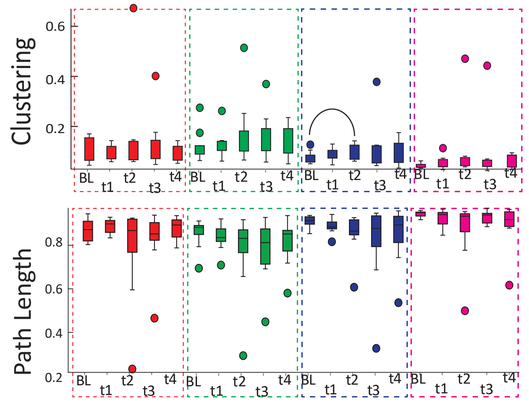


Go Nogo Task

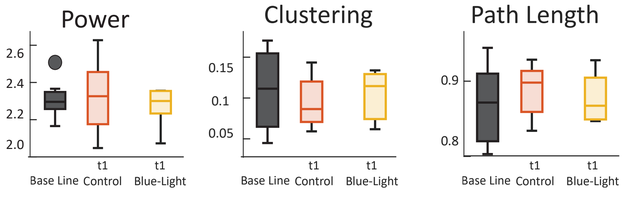
1 Similar to the PV task, performing a GoNogo task immediately after waking is accompanied by a decrease in global theta, alpha, and beta power



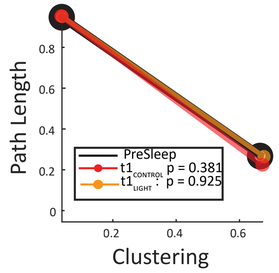
2 However, there are no changes in delta clustering or path length immediately after waking



3 Exposure to blue light after waking, while engaging in the Gonogo task, does not alter global power, clustering nor path length

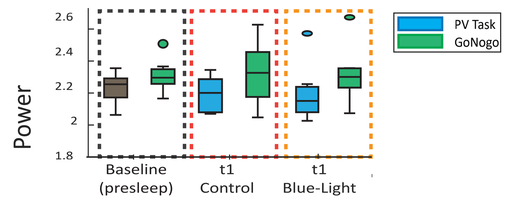


4 While performing the GoNogo task, the slope between path length and clustering in the delta band is same during presleep, after waking with and without blue-light exposure

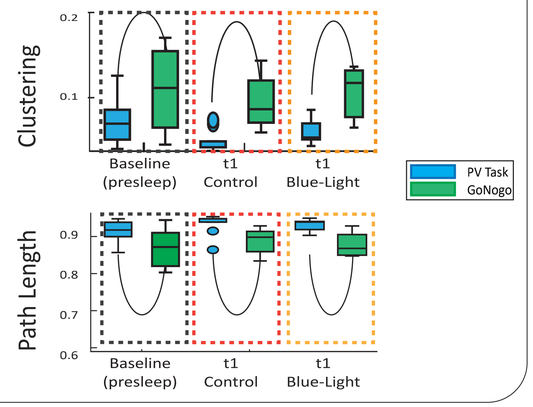


Comparing Tasks

1 Delta power is always the same regardless of the task being performed



2 Delta clustering is always larger, and path length is always shorter, when performing the GoNogo task



Discussion

1 Sleep inertia changes power during both tasks in the same manner. Blue light intervention does not alter these changes in neither task. This suggests the existance of ***a neural sceme that impacts all that we do under all types of task demands and environmental conditions***

2 Sleep inertia impacts network connectivity (Clustering and path length) during a PV task differently compared to a Gonogo task. Blue light intervention impacts network connectivity only during the PV task, but not during the Gonogo task. This suggests that ***the brain is sensitive to task and intervention, reconfiguring itself as new task demands and environmental conditions emerge.***

References

- Hilditch, Cassie J., et.al. "Rise and Shine: The Use of Polychromatic Short-wavelength-enriched Light to Mitigate Sleep Inertia at Night Following Awakening from Slow-wave Sleep." Journal of Sleep Research, January 31, 2022
- Bassett, Danielle Smith, and Ed Bullmore. "Small-World Brain Networks." The Neuroscientist (December 2006): 512–23.
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