Mind Blanking is Associated with a Rigid Spatio-Temporal Profile in Typical Wakefulness

Sepehr Mortaheb[1,2], Manousos A. Klados[3], Laurens Van Calster[4,5], Paradeisios Alexandros Boulakis[1], Kleio Georgoula[1], Steve Majerus[2,4,5], and Athena Demertzi[1,2,4,5]

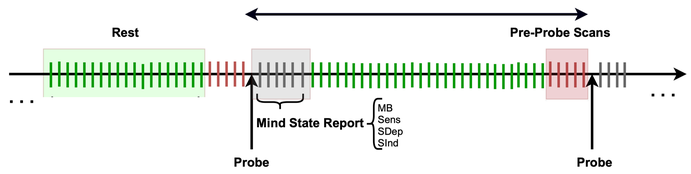
[1]Physiology of Cognition Lab, GIGA-Consciousness, University of Liège, Liège, Belgium,
[2]Fund for Scientific Research FNRS, Brussels, Belgium,
[3]Department of Psychology, CITY College, University of York Europe Campus, Thessaloniki, Greece,
[4]Psychology and Neuroscience of Cognition Research Unit, University of Liège, Liège, Belgium,
[5]GIGA-Cyclotron Research Center In Vivo Imaging, University of Liège, Liège, Belgium

Introduction

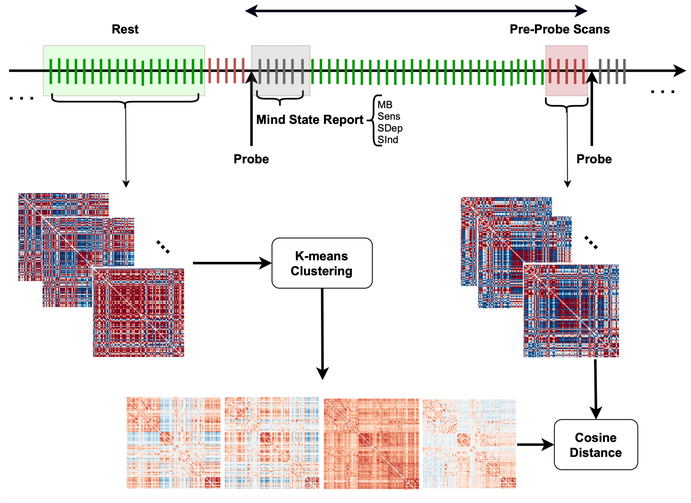
- **Mind Blanking:** Absence of any reportable mind content during spontaneous thinking[1].
- **Question:** How does our brain configure in this state?
- **Goal:** To characterize the behavioral and neural correlates of mind blanking instances.

Methods

- **Subjects:** 36 typical adults (27 F, Age: 23±3y)[2]
- **Paradigm:** Experience-sampling during rest inside the scanner (n=50)
  - Mind blanking (MB)
  - Sensory perception (Sens)
  - Stimulus dependent thought (SDep)
  - Stimulus independent thought (SInd)

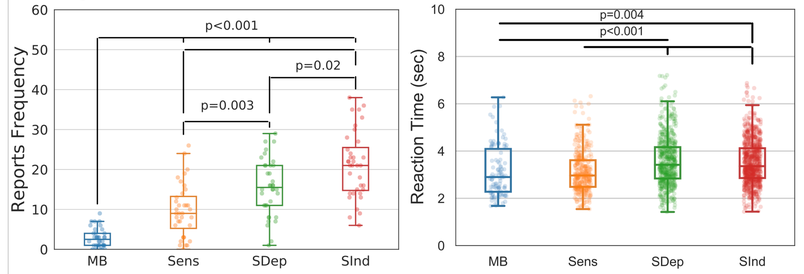


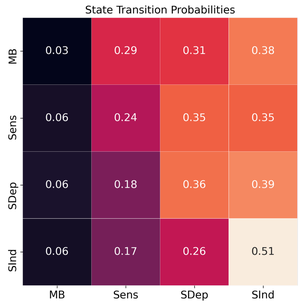
- **Behavioral Outcomes:**
  - **Report frequency**: paired t-test, FDR corrected
  - **Behavioral dynamics**: Markov model state transition probabilities
  - **Reaction times**: generalized linear mixed model (reports as fixed effects, subjects as random effects, sex and age as covariates, gamma distribution for responses, inverse link function, Tukey post-hoc test)
  - **Distribution across time** (Chi square uniformity test)
- **Neuroimaging :**
  - **Resting state functional configurations**: Phased-based coherency[3] and K-means
  - **Resting state patterns occurrence rate**: paired t-test, FDR correction
  - **Neurofunctional analysis**: Cosine distance between pre-probe scans and four main resting state functional connectivity patterns (generalized linear mixed model: reports as fixed effects, subjects as random effects, sex and age as covariates, gamma distribution for distances with an log link function, Tukey post-hoc test for pairwise comparisons)
  - **Integration/Segregation Profile**: Diffusion maps of averaged connectivity matrices[4], Decision tree classification of mental states based on diffusion maps: C4.5 decision tree classifier and 10-fold cross-validation)

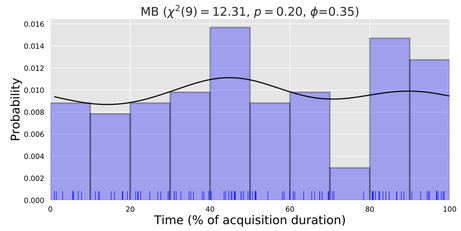


Results

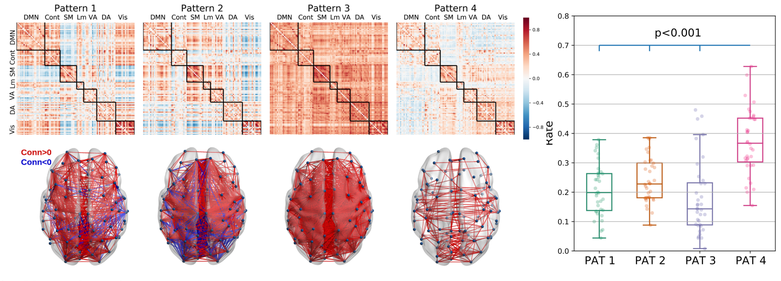
- **Behavioral Outcomes:** MB is characterized by low reportability, fast reaction time, and uniform distribution over acquisition time. MB has a **unique place** as a default mental state during spontaneous thinking.



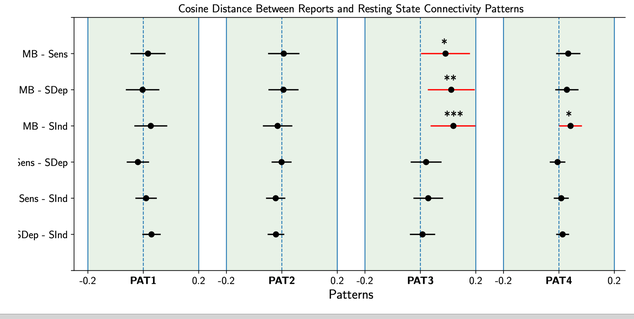




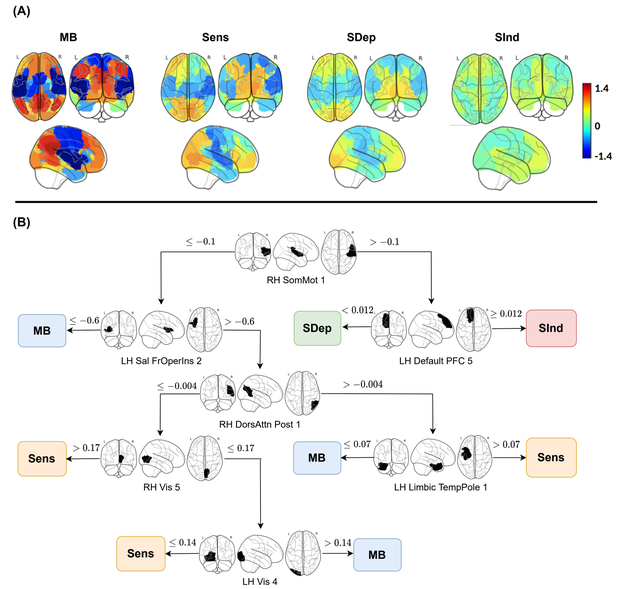
- **Resting State Functional Configurations:**
  - **Pattern 1:** Complex interaction between networks
  - **Pattern 2:** Anti-correlation between visual network and other networks
  - **Pattern 3:** Overal positive inter-areal connectivity
  - **Pattern 4:** Low inter-areal connectivity



- **Neurofunctional Analysis:**
  - Significant effect of reports on pattern 3 (p=0.001) and pattern 4 (p=0.032).
  - Significant similarity of MB scans to the pattern 3.



  - Pattern 3 (Global all-to-all functional connectivity):
    - ✓ Reflects **minimal neural firing**[5].
    - ✓ Can also happen during wakefulness: **slow-wave activity and local sleeps**[6].
    - ✓ Instances of local sleeps can be phenomenological counterpart of MB[7].
- **Diffusion Map Analysis:** DMN-Salience segregation in MB (A) and role of insula in classification of MB from other mental states (B).



  - DMN-Salience segregation in MB
  - Salience network is a switch between DMN and CEN to bring important stimuli into attention[8]
  - Insula might act as a gate for conscious access[9]

Conclusions

- While our mind tends to traverse different contents, there are moments that it is empty of any reportable content.
- MB is supported by an all-to-all functional connectivity pattern which can be interpreted as local sleeps during wakefulness.
- During MB, DMN and salience network are segregated and no stimuli is being fed to the focus attention.

References

[1]Ward & Wegner., Front. Psychology (2013), [2]Van Calster et al., J. Cogn. Neurosci. (2017), [3]Demertzi et al., Sci. advances (2019), [4]Coifman et al., Proc. national academy sciences (2005), [5]El-Baba et al., PloS one (2019), [6]Vyazovskiy et al., Nature (2011), [7]Andrillon et al., Nature Communications (in press), [8]Menon & Uddin, Brain structure function (2010), [9]Huang et al., Cell Reports (2021).

Contact and Project Info:
s.mortaheb@uliege.be
physiologycogn@uliege.be