Spatio-temporal dynamics of the attentional switch to autobiographical memory: an iEEG study

CUTTINGEEG 5th Symposium on cutting-edge methods for EEG research

Collected Data

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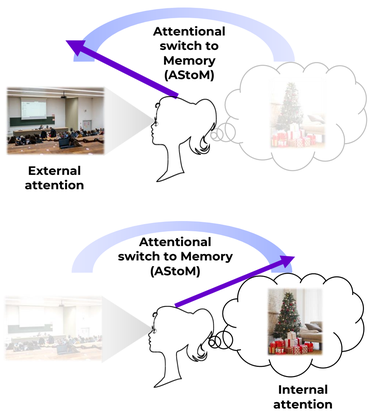
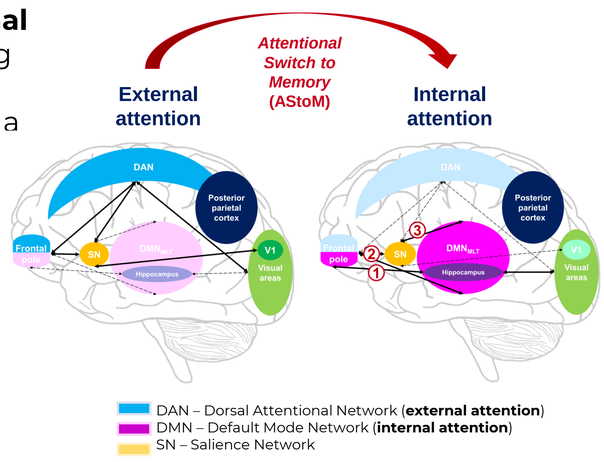
1. Rationale & Hypothesis



Autobiographical memory retrieval, i.e. remembering past personal events, requires attention towards our internal mental world[1]. As internal and external attention are in competition, they cannot occur simultaneously[2]. We call ***Attentional Switch to Memory* (AStoM)** the brief moment when attention switches from the external to the internal world in early stages of memory retrieval.

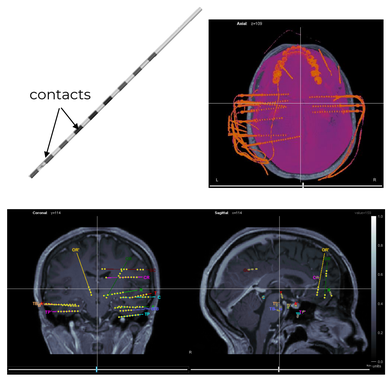
The brain is organized into two anticorrelated functional networks, one showing coherent activation during attention to external stimuli (dorsal attention network, DAN), the other showing coherent activation during internally oriented attention (default mode network, DMN)[3].

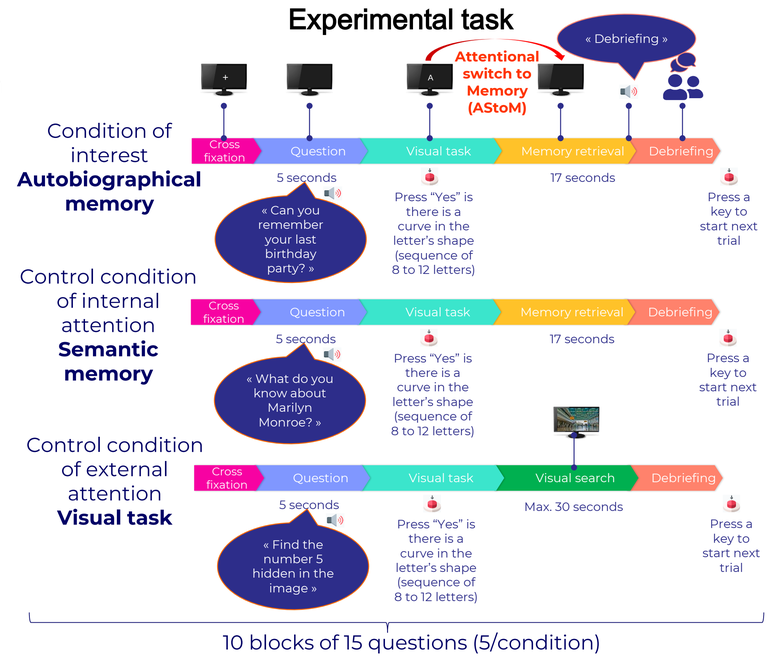
We hypothesize a **rapid, major, functional brain reorganization** taking place during AStoM, allowing the transition between these two distinct brain states. Based on a review of previous studies, we suggest **early activation of the hippocampus**[4], highly connected with the lateral frontal pole. It should act as a "supervisory attentional gateway" to deactivate the DAN and activate the DMN[5]. In parallel, t frontal pole should be connected to the SN[6] allowing the maintenance of the attentional focus on the relevant stimuli (external or internal depending on the ongoing task).



2. Material & Methods

Intracranial EEG in epileptic patients (N=8). The signal of each patient is recorded with 11-15 electrodes and >100 contacts.





Preoperative MRI and postoperative CT scan are fused and normalized to the MNI atlas to identify in which brain region each contact is located (AAL).

We use bipolar montage between adjacent contacts to ensure that the signal has a local origin. For each trial, an epoch is extracted from 5 sec before the reflection phase to 8 sec after. The 5 sec period of fixation cross preceding the trial is used as a baseline for normalization (z-score).

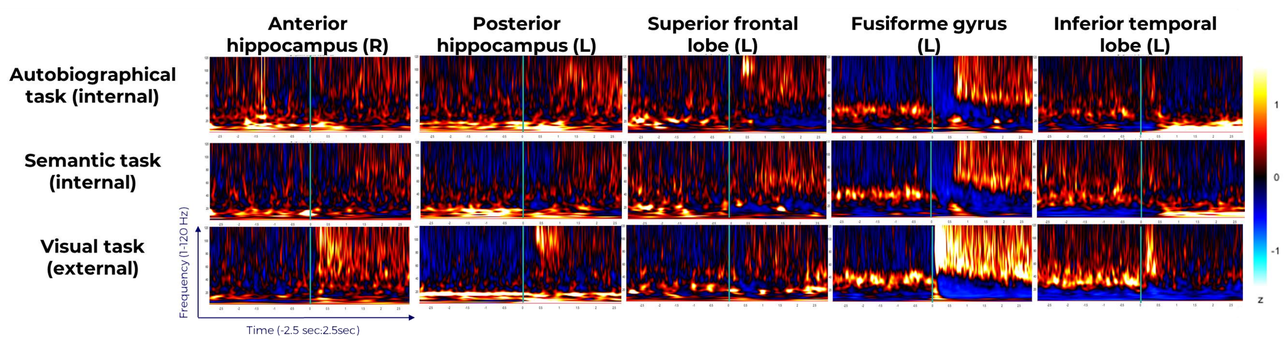
Brainstorm

Analyses are performed with Brainstorm (Tadel et al., 2011).

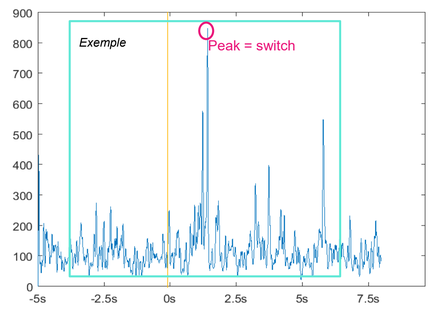
3. Analyses & preliminary results

Analyses conducted on one patient. A right-handed 47 year old man suffering from drug resistant epilepsy (seizure onset zone in the left temporal lobe). A total of 12 electrodes (9 in the left hemisphere) were implanted for intracranial EEG recordings with overall 119 contacts among which 41 are selected after excluding contacts located in white matter. He completed 9 blocks, i.e. 45 questions per condition out of which we kept 33 autobiographical, 29 semantic and 26 visual trials after manual artefacts rejection.

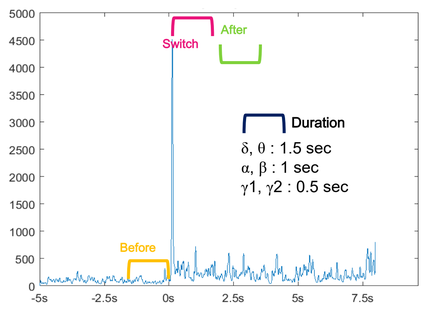
1 – ERSP visualization (average on trials, one electrode contact per region of interest). ERSP are normalized (z-score) on the baseline (Fixation cross preceding the trial).

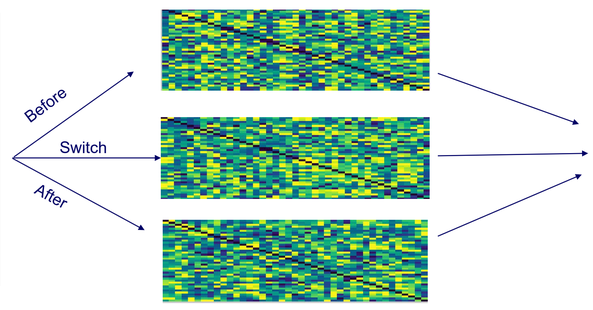


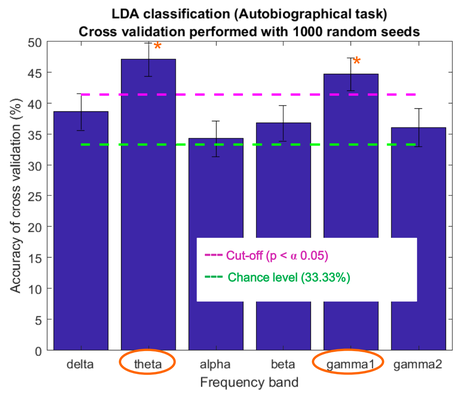
2 – Using Wasserstein distance (WS) to identity the moment of the switch (trial-based). Wasserstein distance is calculated on the ERSP map of each trial for each contact. The switch is considered as the time where there is a peak of WS. Per trial, the switch is the median of peaks through contacts. If peak before -500ms, reject of trial (only 1 rejection has been done).



3 – Computation of Phase Locking connectivity matrices. For each trial, the phase locking matrix is calculated for each frequency band (δ, θ, α, β, γ1, γ2) and for 3 periods of time (before, during and after the attentional switch). Connectivity matrices are computed on normalized epoch (z-score on baseline, fixation cross preceding the trial). Per frequency band, a **linear discriminant analysis (LDA)** is conducted on the connectivity matrices from the 3 periods of time. Cross validation result show that the classification is statistically higher then level of chance for the theta and low-gamma frequency bands. We'll focus the analysis on these 2 frequency bands.







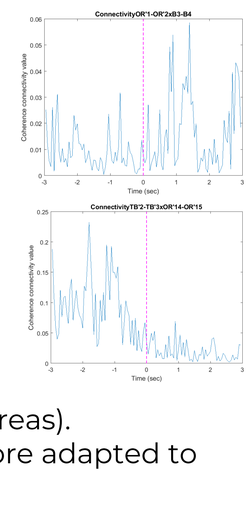
4 – What's next? We want to analyze if there are significant differences before and after the switch in terms of connectivity. But, we are currently facing 2 issues:

- Before running statistical tests, we need to reduce the number of variables because the very high number of variables (3 conditions * 3 periods * 2 frequency bands of interest * 861 connectivity values) decrease our statistical power. → We want to identify on which brain regions (electrodes' contacts) we should focus. We tried to conduct LDA but the accuracy is poor because of the small number of trials.
- From the averaged connectivity maps of before and after the switch. No obvious difference is visible. Is the time-window too large?

5 – Dynamic coherence connectivity analysis (Time-resolved coherence from Brainstorm Toolbox with sliding window of 100ms and overlap 50% for high frequency bands and 1000ms for low frequency bands). Time-resolved coherence matrix was averaged cross trials (for autobiographical condition until now). Region by region, we run a t-test comparing connectivity before and after the switch (-3 sec : +3 sec) and do FDR correction according to the number of tests. We observe changes in connectivity before and after the switch in a certain number of brain regions.

ONGOING WORK...

A few examples



5. Conclusion & perspectives

ERPS show transient activity in various brain region when the attention switches to our internal world (hippocampus, temporal lobe, frontal lobe, visual areas). How to understand the dynamic brain reorganization which takes place with brain connectivity analyses? The time-resolved coherence values seems more adapted to capture the dynamic change of connectivity happening during the attentional switch to memory. The pipeline of analyses is in construction...

What are the best methods for connectivity analyses?

Any idea?

You're welcome!

3 conditions * 3 periods * 6 frequency bands * 861 connectivity values =

How to reduce the number of variables to deal with statistics?

References

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