Electrophysiological underpinnings of the cognitive map within egocentric and allocentric reference frames

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Introduction

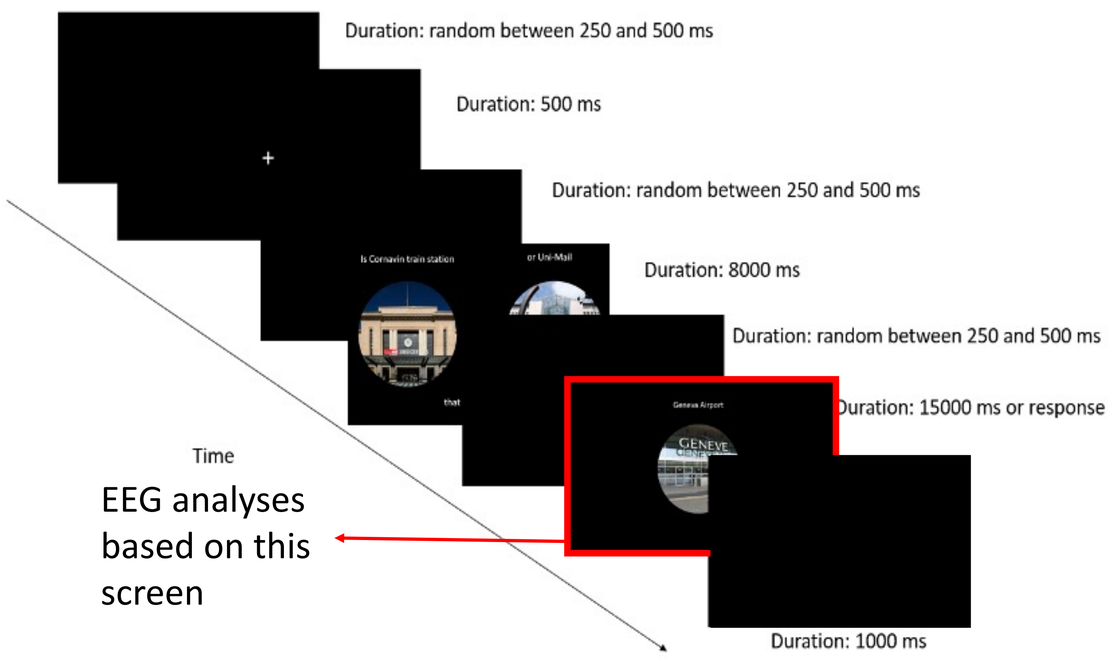
- All human behavior happens within a spatial context, hence the importance of studying spatial cognition.
- Two main reference frames (RF): **egocentric** (object location according to self); **allocentric** (object location according to other objects, independent from self) (Klatzky, 1998, as cited in Possin, 2010); use different brain structures. *Ego* RF is acquired first during development; seems to be better preserved during aging (Ruggiero et al., 2016)
- **Cognitive map**: representation of the environment containing information about the most important landmarks and distance and direction linking them (Tolman, 1948).
- Previous EEG studies mostly show differences for theta and gamma bands and from 200 ms post-stimulus onwards (Moraresku et al., 2023)
- **Main aims**: gaining new perspective on *ego* and *allo* RF (main literature focuses on MRI) using a clinically validated neuropsychological task to assess the cognitive map; using EEG to better define cognitive processes related to both RF using time-frequency (TF) and ERP approaches.

Method

50 healthy adult participants (half female; aged *M* = 24.56; *SD* = 3.99); modified version of the Cognitive Map Recall Test (CMRT, Descloux & Maurer, 2018), a validated neuropsychological test for the assessment of topographical disorientation; 132 trials in total, in two separate blocks (*allo* and *ego*, no switching)

Example of an allocentric trial

Chronology of a trial



EEG settings:

- Continuous 64-electrode EEG recording during task: ERP, TF and power analyses
- FIR filters (0.5-80Hz); Notch filter (50Hz); bad channels interpolation; artifacts correction with ICA; manual visual inspection and selection of the epochs; average reference
- 38 subjects (the rest were dropped due to low accuracy and/or bad EEG signal) kept for EEG analyses (the behavioral ones were conducted on all 50 participants), analyzed using MNE Python and Permuco4brain
- Statistics:
  - Behavioral analyses: Repeated-measures ANOVA
  - TF: cluster-based permutation test (-200ms– 6000ms)
  - ERP: Threshold-free cluster enhancement test (-200 – 900ms), which automatically corrects for multiple comparisons at a cluster level using permutations
  - Power: generalized linear mixed models

References

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4. Ruggiero G, D'Errico O, Iachini T. (2016). Development of egocentric and allocentric spatial representations from childhood to elderly age. *Psychological Research, 80*(2), 259-72.
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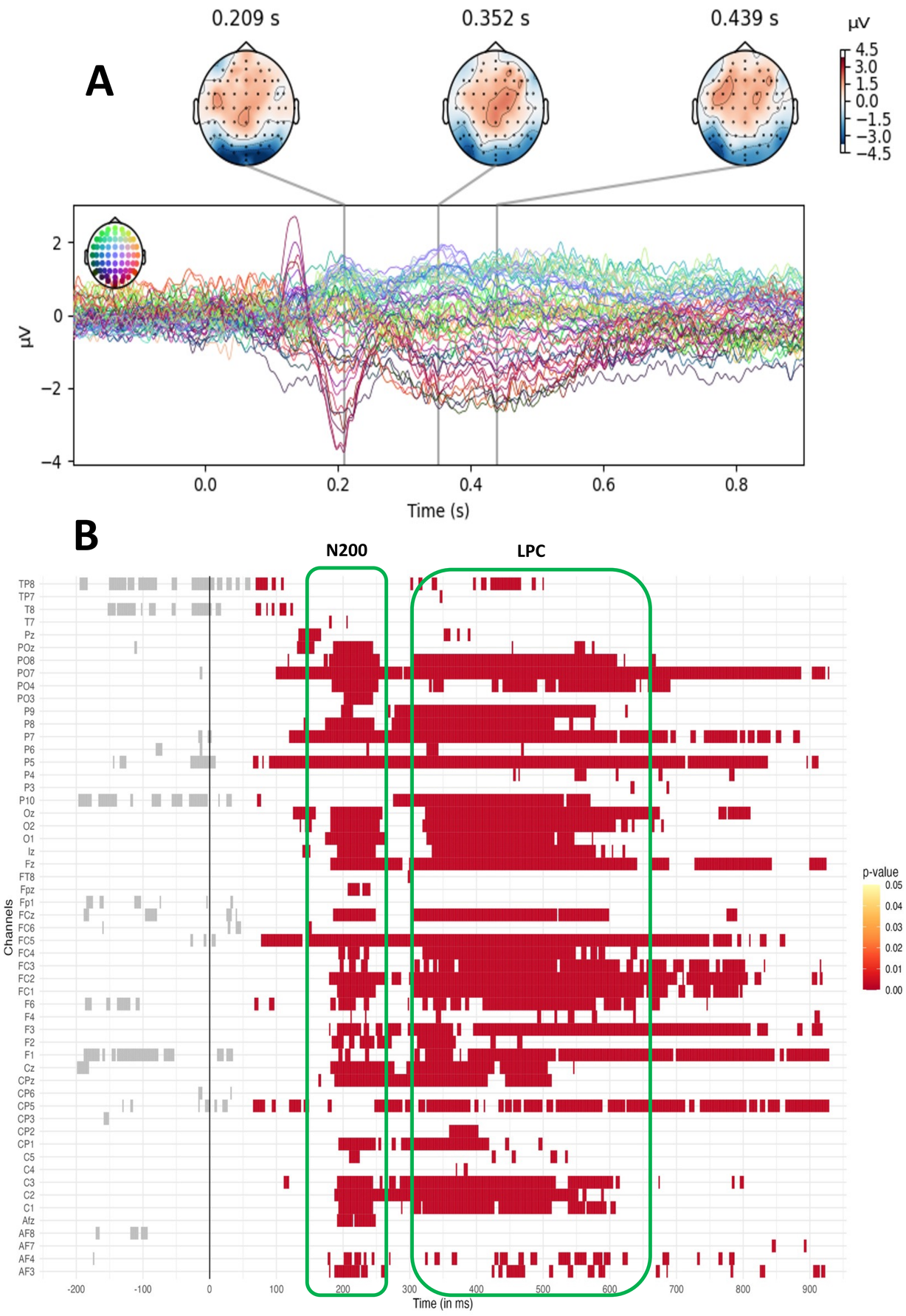
Hypotheses

- Theoretical: we expect better performances for *ego* than *allo* RF as well as different electrophysiological activation for the two RF.
- Behavioral expected results: higher ACC and lower RT for *ego* than *allo*.
- EEG expected results (exploratory):
  - TF: higher Power Spectral Density (PSD) for all frequency bands for *allo* overall, and more particularly around 200 ms and 400-600 ms post-stimulus for theta and gamma bands;
  - ERP: higher amplitudes for the N200 component (attention + executive processing) and LPC (recall and manipulation of spatial information, mainly) for *allo* than *ego.*

Results

- **Behavioral:**
  $ACC_{ego} > ACC_{allo}$ (0.705 > 0.652) but $RT_{ego} = RT_{allo}$
- **EEG:**
  No significant differences for TF and power analyses

A. Combined ERP signal components (P100, N200, LPC) and topographic differences between conditions (Allo - Ego). Blue colors indicate negative differences; red colors indicate positive differences. **B.** Results of the threshold-free cluster enhancement test (-200 – 900 ms)



Discussion

- Higher ACC/performance for *ego* RF, confirms its advantage on *allo*.
- N200 (attention + executive processing) → possible allocation of more attentional resources for *allo* as it may be a less automatic RF (Moraresku et al., 2023)
- LPC (recall and manipulation of spatial information, mainly) → possibly deeper recall and manipulation of spatial information for *allo* than *ego* RF (+ increased memory judgement for decision making)

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