USING VISUAL SENSORY ENTRAINMENT FOR MODULATING SPATIAL NAVIGATION IN VIRTUAL REALITY ENVIRONMENTS

Torralba Cuello, M [(1)], Fuentemilla Garriga, L [(2,3,4)], Blat[(5)], J, Marti-Marca, A [(1)], Pápai, MS [(1)], Soto-Faraco, S [(1,6)]

(1) Center for Brain and Cognition, Departament de Tecnologies de la Informació i les Comunicacions, Universitat Pompeu Fabra, Barcelona, Spain; (2) Cognition and Brain Plasticity Group, Bellvitge Institute for Biomedical Research, Hospitalet de Llobregat, Spain; (3) Department of Cognition, Development and Educational Psychology, University of Barcelona, Barcelona, Spain; (4) Institute of Neurosciences, University of Barcelona, Barcelona , Spain; (5) Information and Communication Technologies Department, Universitat Pompeu Fabra, Barcelona, Spain; (6) Institució Catalana de Recerca i Estudis Avançats (ICREA), Barcelona , Spain.

RATIONALE

Spatial Navigation (SN) skills integrate several basic cognitive processes such as working memory, episodic memory, spatial positioning, sensorimotor coordination and, executive control, among others[1]. SN abilities have huge inter-individual variability, although they often decline in elderly populations, especially in association to other age-related clinical conditions[2] (MCI, AD) impacting negatively the quality of life of elderly population.

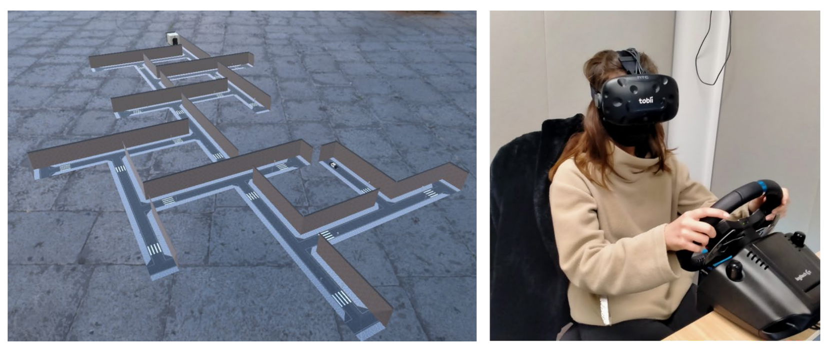
A number of studies (in rodents and, more recently in humans) have highlighted the relevance of brain oscillatory activity in the Theta range (4 to 7 Hz) for SN[3,4]. Interestingly, Theta oscillations also correlate with the ability of maintaining sequences of elements in working memory[5]. Different theories relate Theta, SN and memory. For instance, Theta-Gamma Neural Code theory proposes that Theta cycle duration determines the number of items that can be sustained in working memory[6]. This result is backed up by non-invasive causal studies using brain stimulation[5]. Therefore, according to this theory the impact of Theta in SN could be mediated solely by its effect in working memory (a cognitive ability that is commonly accepted to be part of SN). Causal studies relating theta oscillations using sensory stimulation also have been found to improve episodic memory in humans[7].

The aim of current study is to modulate human SN skills during navigation in realistic Virtual Reality (VR) environments (T-junction mazes) using sensory (visual) stimulation to entrain Theta oscillatory activity and evaluate the effects of sensory stimulation both at short and long-term.

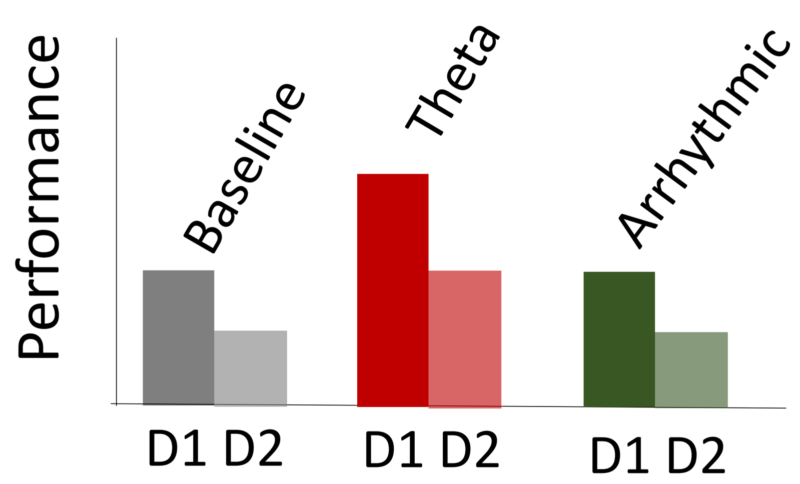
HYPOTHESES

- Theta is **causally related** to SN: facilitation during encoding and retrieval of new information.
- Facilitation in both **short and long term memory**.
- It is possible to entrain Theta activity relevant for SN using **sensory** (visual) **entrainment**.

PREDICTIONS



Realistic SN task + sensory entrainment



MATERIALS AND METHODS

DAY 1: EEG+Behaviour

Habituation → Training → Encoding → Short Term Test

6 mazes

Guided + up to 3 unguided repetitions

Unguided up to 3 repetitions

DAY 2: Behaviour

Habituation → Long Term Test + Fillers

- 8 junctions T-Mazes
- 3 conditions
- 2 sessions (consecutive days)

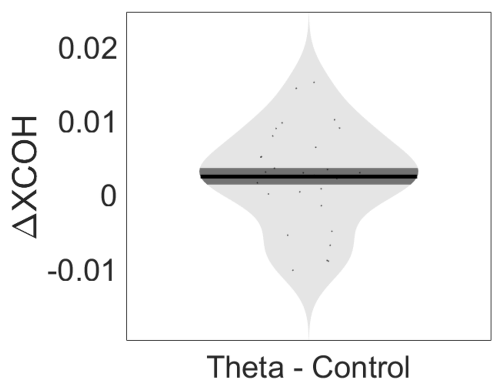
Pre-registered pipeline

- Behavior: number correct junctions x condition and repetition (ANOVA 2x3)
- EEG: cross coherence, SSVEP

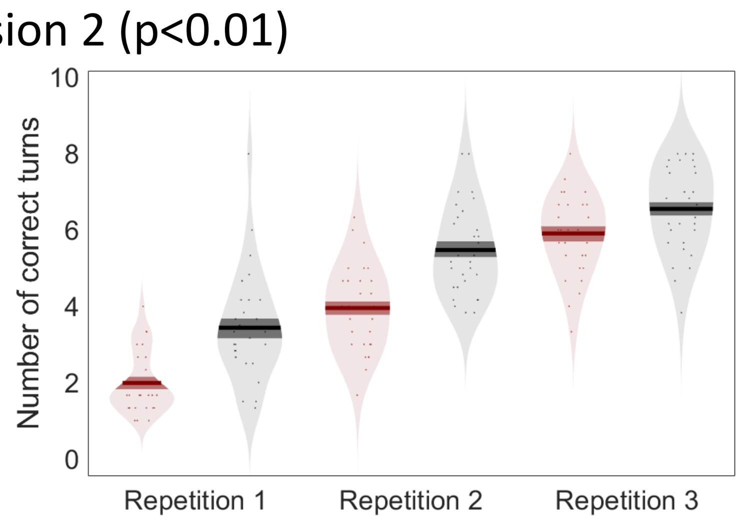
PRELIMINARY RESULTS

REALITY CHECKS

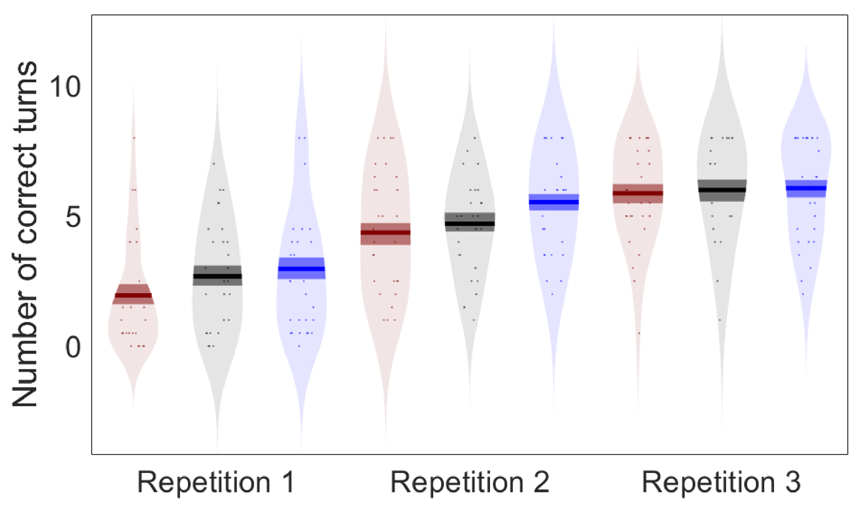
EEG: Cross coherence significantly larger for Theta than for control (p=0.03) but not significantly above chance (28 subjects)



Behavior: significantly better performance for trained mazes (black) than filler mazes (red) in session 2 (p<0.01)



REGISTERED ANALYSIS



Performance was not significantly different between Theta (black), Baseline (red) and Control (blue) conditions in either Session 1 (graphic) or 2 (not shown).

DISCUSSION

- Our results do not support a causal connection between theta and SN. Possible reasons:
  - There is no causal connection
  - Entrainment too faint → AV entrainment
  - Small effect masked by "noise" → Exploratory analysis.

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