# WHAT, WHEN AND WHERE IT HAPPENED? A virtual reality study.

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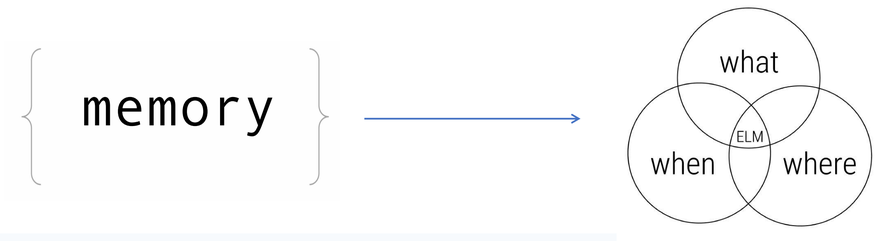
## INTRODUCTION

Episodic memory (EM) allows us to recall episodes from past events [1]. Each memory is saved in a particular contextual information at minimum of three basic characterizations: what, when and where the episode happened [2] – bases of the episodic-like memory (ELM) model, testable both in animals [3,4,5] and humans [6].




## PILOT STUDY 1 | When? Where?

*Aims:*

- to design vEMT in 3D VE based on the 2D desktop version of the task [6]
- study temporal and spatial components of ELM in two different VE in short-term memory paradigm

Material and methods: A working memory paradigm – immediate recall of positions (spatial component) and order (temporal component) of items in 5 trials with increasing difficulty (3,5, 7, 9 and 11 items).


**Figure 1.|** Illustration of VE: OFFICE (1) and HOUSE (2). Each trial consisted of Acquisition phase (A1, 2) - a yellow arrow showed direction to each item and Recall phase (B1, 2) - required to return all items.

Healthy volunteers (n= 72, University degree) were tested in two virtual environments (see Figure 1):

A) open space OFFICE (n= 41; $age_{avg}$: 26.9 (±6.84))

B) smaller well-structured family HOUSE (n= 31; $age_{avg}$: 26.5 (±7.15))

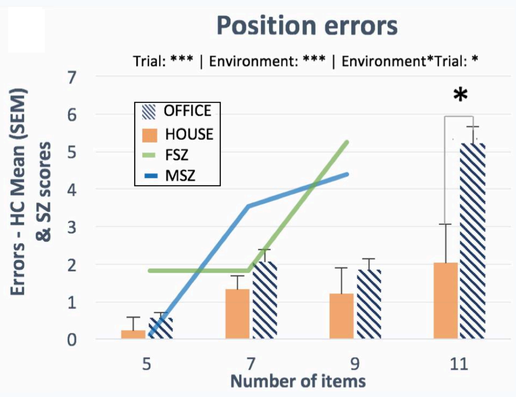



**Figure 2.** | Position errors (spatial) in both VE.

Results:

- Number of errors increases with growing task difficulty in both VE (ANOVA with repetition measures, Trial effect: $p < 0.001$, see Fig.2).
- Superior ability to remember positions ($p < 0.001$), but not order in "House" VE ($p > 0.05$). VE*Trial interaction in position errors (11 items - post hoc Newman-Keuls test, $p < 0.05$).
- No effect of previous experiences with virtual games.

## PILOT STUDY 2 | What? When? Where?

*Aims:*

- to test: 1) additional component - object's identity „what"; 2) a long-term memory (5' delay); and to categorize strategies used during the vEMT

Material and methods: A long-term ELM task (5 min delay filled up by spatial distractor task). vEMT was extended by **Item recognition phase** (selection of items from 2x bigger set) testing the 3rd ELM component (Fig. 2). Based on previous results we performed vEMT in HOUSE VE with 4 trials (3, 5, 7, 9 items).


**Figure 3.** Illustration of vEMT both phases. 3 components – what, where, when.

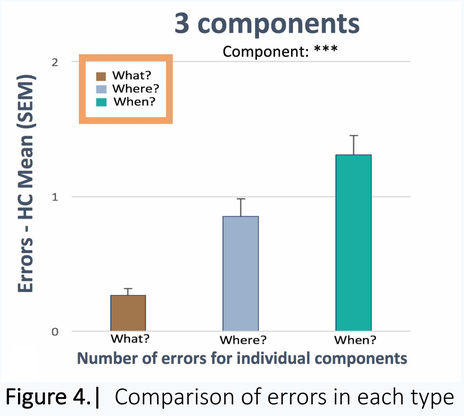



**Figure 4.|** Comparison of errors in each type of ELM component.

Healthy volunteers (n=30; 15 females; $age_{avg}$: 27.23 (±3.9), University degree).

Results:

- Temporal component "when" is the most difficult in structured VE, in contrast to the most simple item identity component "what".
- Frequent strategies are memorizing, story creating and spatial visualization.

*The virtual Episodic-like memory task (vEMT) requires each player:*

1. To collect several items in specified order from various location in the virtual environment (VE) and remember identity, order and position of individual items (Acquisition phase).
2. To return all collected items to their original position in the same order (Recall phase).

## fMRI STUDY PROCEDURE (*in progress*)

*Aims:*

- to study 4 components of ELM (item identity, temporal, spatial and contextual)
- to map functional brain areas during the recollection of the episodes experienced in VE

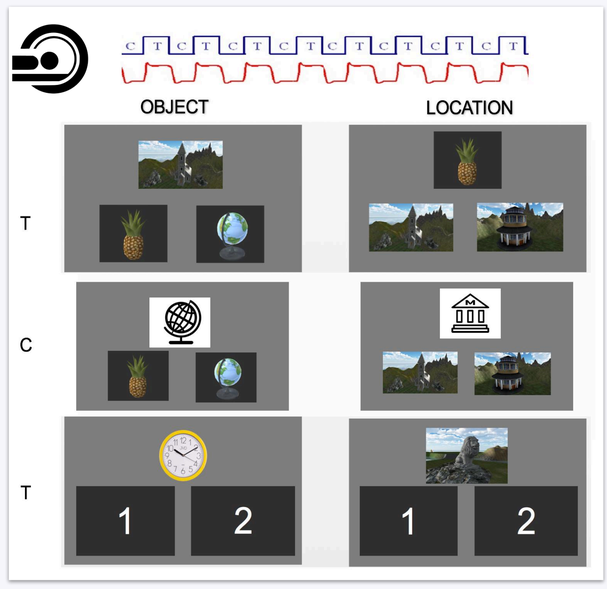
VE of five small islands with 5 separate spatial locations is designed with additional contextual information (variable weather conditions and/or day time) as following:

1. **Psychological examination** – WMS-III (subtest - Logical memory)

2. **Training in VE** – instructions and game control

3. **Acquisition phase** – locations of all 5 islands are visited consecutively with 30 min delay between islands.

4. **fMRI paradigm** – a block design – images depicting items or locations from VE in association with each other: time, or context.

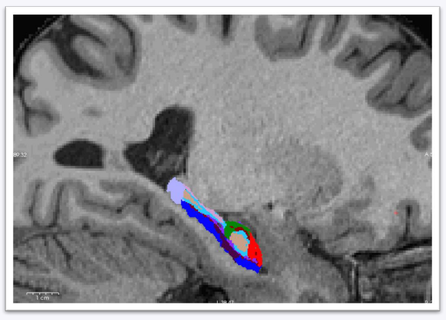




5. **Recall phase** – 5 trials starting with selection of the island (order of contexts), collected items are then identified and returned to original locations.

6. **Structured interview** of each participant.

Data analysis:

1. Performance in the open space and house VE.
2. fMRI analysis of vEMT (activation of brain areas and functional connectivity).
3. Analysis of the surface based volumetry of hippocampus (including HPC parcelation into 13 subfields).



Hypothesis:

- Recollection of episodes will activate both, hippocampus and prefrontal cortex.
- Individual conditions will activate a partially different neural network.
- vEMT performance will positively correlate with HPC volume.

Future directions:

Application of vEMT in Alzheimer dementia and schizophrenia (assessment and training).

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