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Electrophysiological markers of visuo-spatial processing decline during spatial orientation in aging

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Introduction:

Healthy older adults exhibit impairments in their capacity to navigate efficiently and reorient in unfamiliar environments, which significantly reduces their autonomy and mobility [1]. Given the predominant role of visual perception in human spatial navigation [2], there has been a substantial interest in visual cerebral regions and their contribution to reorientation processing [3]. In the context of aging, recent fMRI findings shed light on the involvement of the Occipital Place Area (OPA), a scene-selective region of the dorsal visual stream, in spatial behavior. We reported a preserved OPA connectivity with other navigational brain structures, and an increased OPA activation during landmark-based navigation in older adults [4,5]. However, the effects of aging on the temporal component of OPA responses and visuo-spatial coding remain insufficiently characterized. To address this issue, we used electroencephalographic (EEG) recordings to investigate how brain signal dynamics imputable to the OPA region were impacted by healthy aging during a reorientation task.

Methods:

Thirty young adults ($\mu=22.9$ years old, $\sigma=2.15$; 14F) and eighteen older adults ($\mu=72.3$ years old, $\sigma=5.81$; 10F) took part in a desktop-based virtual reality task. First, they were passively displaced in a Y-maze to learn the path towards a goal location. An array of three differently shaped objects at the center of the maze conveyed directional information (Figure 1). Second, during a reorientation phase, participants had to indicate the direction to the goal in briefly presented scenes, extracted from the learning phase. Third, during a control task, participants were passively presented images of the maze with three identical, spatially non-informative objects. We analyzed event-related potentials (ERPs) recorded from two regions of interest in the posterior parietal area encompassing OPA [6,7]. These regions correspond to electrodes P5, P7, PO7 in the left hemisphere and electrodes P6, P8, PO6 in the right hemisphere. Reaction times, accuracy as well as the mean peaks and latencies for the P1, N1, and P2 components in each hemisphere during the reorientation phase were analyzed.

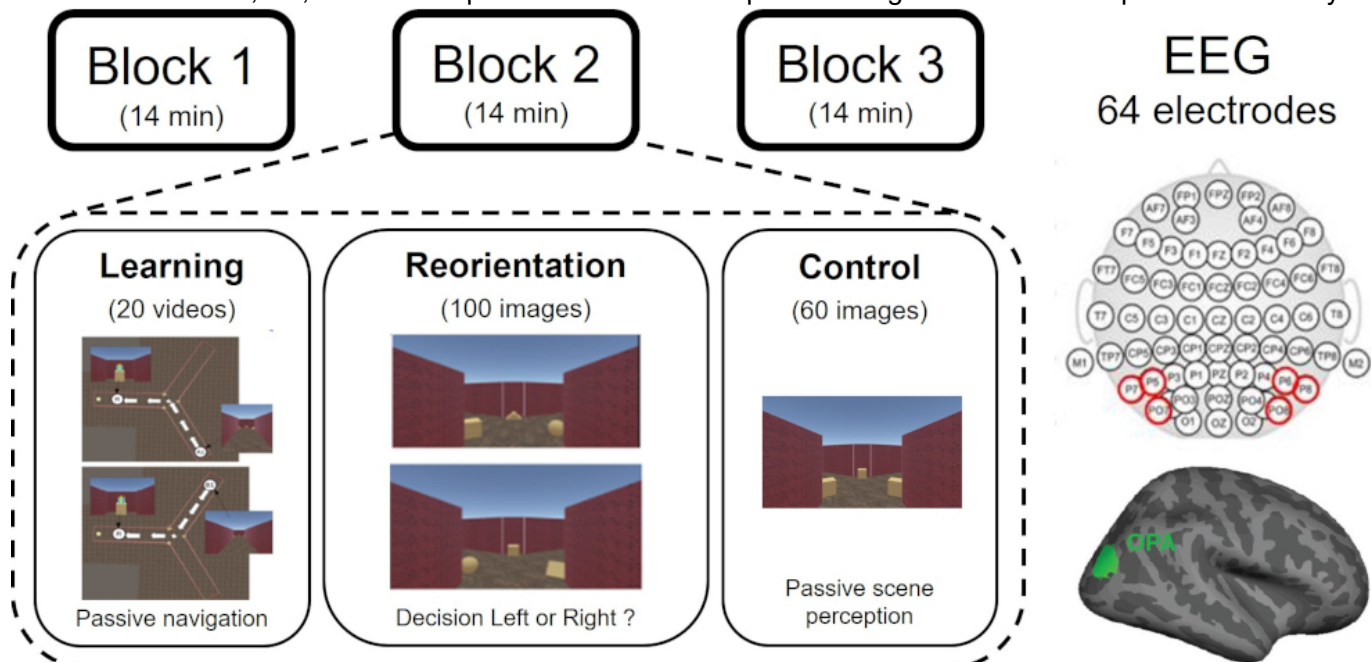


Figure 1. Description of the experimental paradigm, and examples of the visual stimuli used

Results:

Our behavioral results showed that older adults were slower to choose a direction ($844.27 \text{ ms} \pm 178.24 \text{ vs. } 1246.96 \text{ ms} \pm 291.71$; $p < 0.001$), and that they made more errors than young adults (accuracy: $96.91 \% \pm 2.0$ vs. $86.2 \% \pm 15.3$; $p = 0.009$). ERP results (Figure 2) showed that the peak latency of the posterior parietal P1 and P2 components was significantly delayed in older adults in both hemispheres ($p < 0.007$), and it was delayed only in the left hemisphere for the N1 component ($p = 0.01$). P2 amplitude was higher for young adults

in the right hemisphere compared to older adults ($6.05\mu\text{V} \pm 3.80$ vs. $5.27\mu\text{V} \pm 2.39$; $p = 0.002$), and higher in the right than the left hemisphere ($9.82\mu\text{V} \pm 4.49$ vs. $5.55\mu\text{V} \pm 2.79$; $p < 0.001$), in young adults only ($p = 0.83$). N1 showed greater amplitude bilaterally in older adults (RH: $2.49\mu\text{V} \pm 3.75$ vs. $-1.57\mu\text{V} \pm 2.99$; $p = 0.001$; LH: $0.58\mu\text{V} \pm 1.93$ vs. $-2.11\mu\text{V} \pm 3.18$; $p = 0.006$). Finally, we found no significant correlation between ERP parameters and behavioral performance.

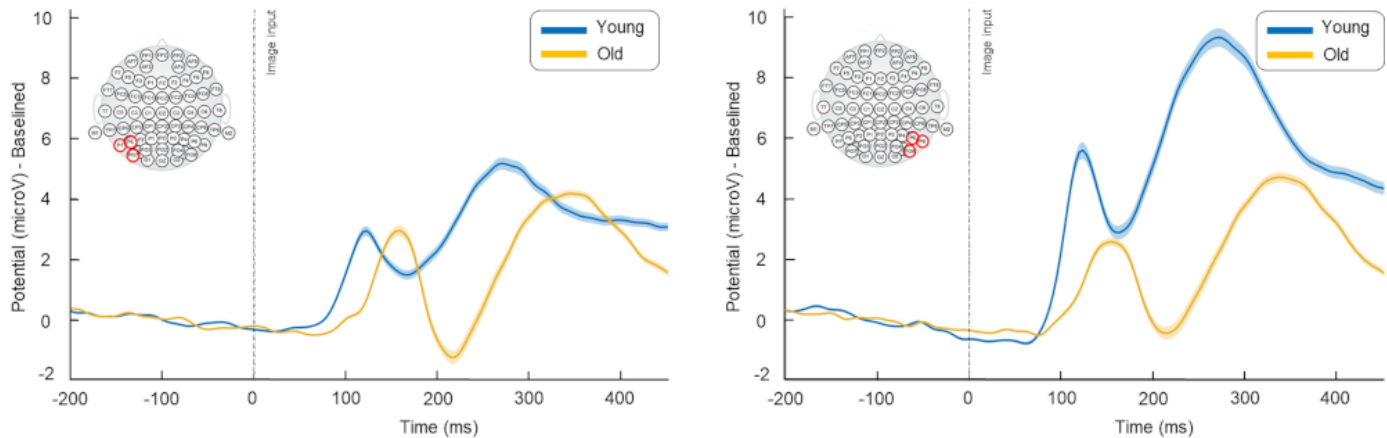


Figure 2. Group-averaged ERPs in young ($n=30$) and older adults ($n=18$) for the reorientation task from posterior parietal electrodes in left (P5, P7, PO7) and right (P6, P8, PO6) hemispheres.

Conclusions:

This EEG study extends previous knowledge of OPA on visual scene processing revealing also the involvement of this brain region in the early coding of visual information during a landmark-based reorientation task. It also provides new insights on an age-related decrease of the hemispheric asymmetry in posterior parietal areas during reorientation. This exploration of neural activity in the OPA, and the posterior parietal region more generally, calls for future studies to better characterize the role of this visual brain region in navigational performance during aging.

Higher Cognitive Functions:

Space, Time and Number Coding ²

Lifespan Development:

Aging ¹

Keywords:

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Cognition

Electroencephalography (EEG)

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¹²Indicates the priority used for review

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No

Please indicate below if your study was a "resting state" or "task-activation" study.

Task-activation

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

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Yes

Was any animal research approved by the relevant IACUC or other animal research panel? NOTE: Any animal studies without IACUC approval will be automatically rejected.

Not applicable

Please indicate which methods were used in your research:

EEG/ERP

Provide references using author date format

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