**The effects of auditory landmarks availability in goal-oriented behavior**

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**Introduction:**

The brain integrates a variety of sensory signals to build its representation of place [1]. In the hippocampus, place cells integrate excitatory signals arriving through entorhinal cortex (EC) projections [2]. Because EC encodes internal [3] and external [4] types of sensory information, one could expect that environmental sensory richness modulates the hippocampal spatial representation and affects performance during goal-oriented navigation. To access the relationship between the environmental density of sensory cues and performance during goal-oriented navigation, we conducted an experiment with humans performing a treasure hunt task within a sensory controlled environment. Auditory landmarks served for spatial navigation as a strategy to control localized sensorial stimuli.

**Materials and Methods:** 23 subjects were recruited and requested to perform a 5 minutes navigation within a 3x3 meters arena where sounds were coupled to spatial locations. The subject’s position was tracked via a Kinect sensor and sensory cues were delivered accordingly with the experimental protocol. Subjects were blindfolded and could not assess visual cues. Wireless headphones were provided so that subjects could assess auditory sensory cues. Eight conditions defined the amount of auditory cues scattered over the arena (1 to 14 sounds). Each sound was designated to a non-overlapping random location and was active when the subject was closer than 30cm from it. After the free-exploration, subjects were requested to reach a specific sound source location.

**Results:** We accessed performance through the main spatial components of navigation, namely: absolute distance; angular offset; and distance offset. Results revealed a threshold for the efficacy in spatial encoding. Best performance in reaching a target-location occurred when either one or twelve sensory cues were scattered along the exploration arena, and more than twelve cues highly compromised performance.

**Discussion:** Our results suggest that the density of environmental sensory cues, which might reflect the accuracy in representing ones surroundings through hippocampal activity, modulates spatial encoding. Within our experimental setup, we have found a bimodal state of performance optimality. A single target-cue environment might reinforce the unique grid-to-place-cells perforant pathway and avoid the accumulation path-integration error. Alternatively, we have identified a bifurcation point in the trade-off between hippocampal spatial representation optimality and density of sensory cues for the 12 cues condition, where more than 12 cues drastically affected navigational performance.

**Conclusion:** How does the density of sensory cues affect the internal representation of space through the hippocampal circuitry? We found that humans display a threshold for environmental richness where little sensory information degrades navigational performance and above optimality ratio proper encoding is drastically abolished. Our results predict that sensorial configuration modulates the strength of internal and external inputs arriving to proper hippocampus.

**References:**

[1] O'Keefe, John, and Jonathan Dostrovsky.  *Brain research* 34.1 (1971): 171-175. [2] Rennó-Costa, et al., *Neuron* 68.6 (2010): 1051-1058. [3] Hafting, Torkel, et al., *Nature* 436.7052 (2005): 801-806. [4] Deshmukh, et al., *Front Behav Neurosci*5 (2011): 69.