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To cite this version:
Sara Pishdadian, Antoine Coutrot, Michael Hornberger, Hugo Spiers, Shayna Rosenbaum. Big data meet deep data: Characterizing spatial navigation in hippocampal amnesia. Cognitive Neuroscience Society, Mar 2021, Virtual Meeting, Canada. CNS 2021 Abstract Book. hal-03268852

HAL Id: hal-03268852
https://hal.science/hal-03268852
Submitted on 23 Jun 2021

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Big data meet deep data: Characterizing spatial navigation in hippocampal amnesia

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Background

New Spatial Learning & Hippocampal Damage

- The hippocampus is hypothesized to be critical to episodic memory and new spatial learning.1
- Individuals with hippocampal damage are generally impaired in new spatial learning.2,3,7
- Allocentric spatial navigation: navigation with a cognitive map of the environment in mind, hippocampally reliant.1
- Allocentric spatial navigation performance in hippocampal amnesia can be variable and it is possible patients with similar lesion profiles may be impaired for different reasons
- Path integration: referring to one’s starting location after navigating
- Combines both allocentric and egocentric (person-based) aspects of navigation.
- It has been shown to require the hippocampus but also heavily involves other brain regions.
- Given variability in spatial ability performance, research on these processes would be enhanced by large control samples and dynamic tests

Study Question

- What is the role of the hippocampus in new spatial learning and does episodic memory impairment correspond with task performance?

Results

Patient BL

- Overall trial performance for distance traveled and time taken was below controls
- Poor wayfinding performance (e.g. level 56, 11), was marked by a pattern of repeated travel down an incorrect path, including backtracking to starting location
- Trial performance (e.g. level 56, 9) were closed and without decision point

Patient DA

- DA’s severe anterograde amnesia resulted in more difficulty using technology
- Overall performance across trials is poor compared to peers, with longer duration and distance, with patterns of backtracking or continually staying in one area

Method

Sea Hero Quest (SHQ)

- SHQ is a mobile video game played by over 3 million worldwide and involves navigating a boat with both wayfinding & path integration tasks
- Task performance predicts both real-world wayfinding and is sensitive to country of origin.4,5

Experiment Method

- Patient testing was completed with research assistant available for technical assistance on 2 separate testing days
- Controls matched to patients by country of origin, sex, education & age (+/- 3 years) and similar practice trial performance (N = 7000-10,000)

Discussion

- Patient-Lesion Approach
- Findings suggest patients with hippocampal amnesia have below-average, but broadly normal, path integration performance on SHQ consistent with findings that path integration involves multiple brain regions, including outside the medial temporal lobe and despite the task length.
- Patients had significant difficulty with select wayfinding trials but also show ability to perform well
- Explanations include poor environment recognition, and/or forgetting areas traveled and/or not forming a cognitive map
- Performance broadly corresponds to cognitive profiles
- Further work will look at qualitative metrics of performance

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