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

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Background

New Spatial Learning & Hippocampal Damage

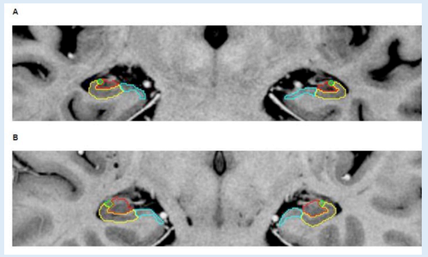
- The hippocampus is hypothesized to be critical to episodic memory and new spatial learning [1]
- Individuals with hippocampal damage are generally impaired in new spatial learning [2,3,7]
- Allocentric spatial navigation: navigation with a cognitive map of the environment in mind, hippocampally reliant [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[6,7]
- Given variability in spatial ability performance, research on these processes would be enhanced by large control samples and dynamic tests

Study Question

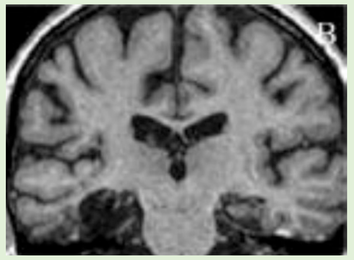
- What is the role of the hippocampus in new spatial learning and does episodic memory impairment correspond with task performance?

Participants

Patient BL



Patient DA

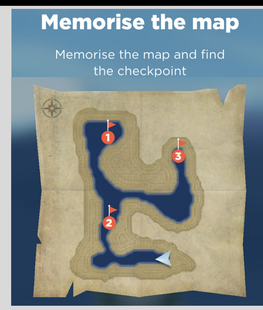


Patient	Age	YOE	Etiology	MTL Damage	Beyond MTL Damage	Clinical Profile
BL	59	13	Anoxia after electrical accident	bilateral loss of the DG/ CA3 in hippocampus	left hemisphere volume loss in the superior parietal lobule right hemisphere loss in the precuneus	Mild anterograde amnesia, weaknesses in complex attention and inhibition IQ: Average
DA	68	17	Herpes encephalitis	Bilateral MTL damage, more severe in right hemisphere	left hemisphere damage with volume reduction in the posterior temporal, ventral frontal, occipital regions, anterior cingulate and posterior thalamus.	Graded retrograde amnesia, severe anterograde amnesia and intact other domains IQ: High Average

Method

Sea Hero Quest (SHQ)

- SHQ is a mobile video game played by over 3 million worldwide[4] 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)

Results

Patient BL

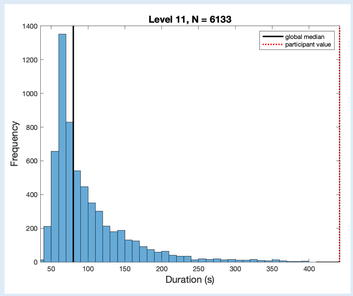
Map Levels

- Overall trial performance for distance traveled and time taken was below controls
- Trials with best performance (3) were closed and without decision point
- 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

	Percentile Distance	Percentile Duration	Number of Trials
All Map Trials	0.23 (0.68), Median = 0.13	0.19 (0.72), Median = 0.04	15
Level 11	0.01	0.01	
Level 56	0.01	0.01	

Note. Mean (SD)

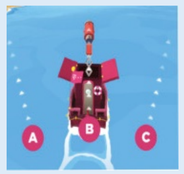
Level 56



Level 11

Flare Levels

- Missed 4-5/7 of trials (29-43% overall accuracy), with variability in performance across testing days
- Control performance across trials is 58.46% (SD = 0.07)



Patient DA

- DA's severe anterograde amnesia resulted in more difficulty using technology

Map Levels

- Overall performance across trials is poor compared to peers, with longer duration and distance, with patterns of backtracking or continually staying in one area

	Percentile Distance	Percentile Duration	Number of Trials
All Map Trials	0.37 (0.31), Median = 0.43	0.12 (0.81), Median = 0.02	14
Level 11	0.05	0.01	
Level 16	0.01	0.01	

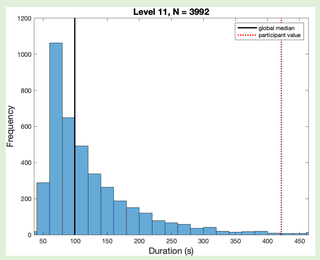
Note. Mean (SD)

Day 1 Testing

Level 11

Day 2 Testing

Level 11



Level 16

Flare Levels

- Missed 4-5/7 of the flare trials administered (29-43% overall accuracy)
- Control performance across trials is 51.49% (SD = 0.05)

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 [6,7]
- 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

References

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