The role of the dentate gyrus in the perceptual discrimination of complex, novel objects

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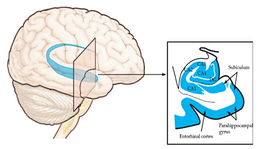
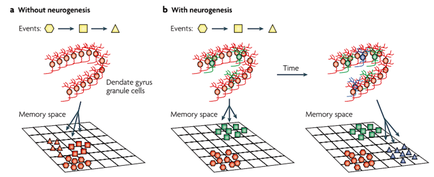
Elia Scholars Program

Introduction

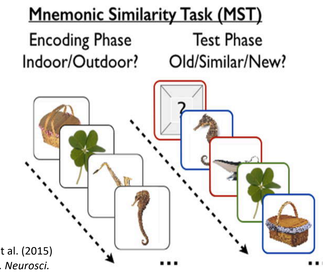
The dentate gyrus (DG) subregion of the hippocampus (HPC) is purported to function as a 'pattern separator', orthogonally representing similar information such that distinct memories are formed.



Deng et al., (2010) *Nat. Rev. Neurosci*

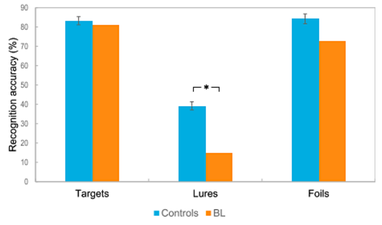


Research points to the HPC as playing a domain-specific role in spatial scene/configural processing, while other medial temporal lobe structures are specialized for item-specific representations of faces and objects. However, previous work in our lab has demonstrated that a unique brain-damaged individual, B.L., who has 50% cell loss in his DG, had poor discrimination of similar, everyday objects in memory.



Stark et al. (2015) *Behav. Neurosci.*

Baker et al., (2016) *Curr. Biol.*



Research Question

Does selective DG damage impair the ability to discriminate complex, novel objects perpetually and mnemonically?

Patients & Participants

DG-damaged patient - B.L.

- 58yo male, 13 years education
- Electrical accident leading to brief anoxia (25yo)
- ~50% cell loss along entire length of DG (Baker et al., 2016)
- poor discrimination of everyday objects (Baker et al., 2016)

MTL-damaged patient - D.A.

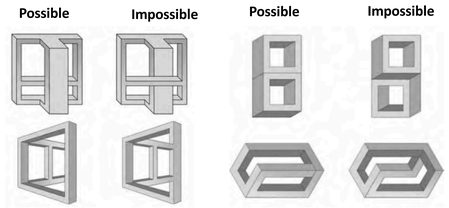
- 68yo male, 17 years education
- Herpes simplex virus encephalitis (middle age)
- Extensive damage to medial temporal lobe (MTL), including: HPC, perirhinal cortex, entorhinal cortex, parahippocampal cortex (Douglas et al., 2019; Rosenbaum et al.. 2008)

Controls

- N = 6; all male
- Matched controls: +/- 5yr; +/1 2yr education (B.L. two; D.A. two)
- Age range: 56-69; Education range: 14-17yr

Experimental Methods & Results

82 impossible and possible counter-part objects were used, as they are novel, contextually irrelevant stimuli. Computer-based tasks using these stimuli were taken from Freud et al., (2017). Controls are typically more sensitive to possible objects.



Freud et al. (2017) *Cerebral Cortex*

DV's and Statistics

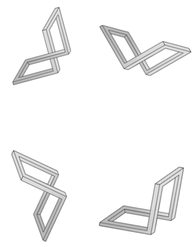
Accuracy – percentage correct

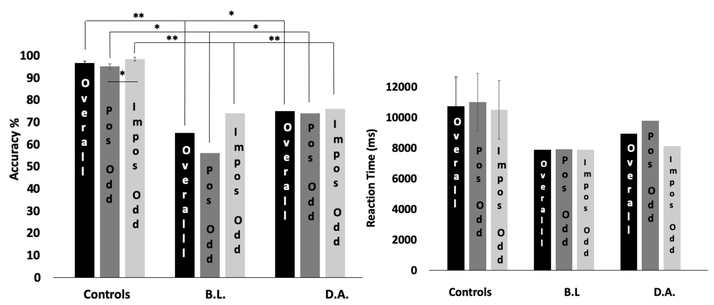
Sensitivity – D prime analysis [Z hits/Z false alarms] accounts for response bias

Reaction Time (RT) – average RT of only correct trials

Crawford's t-test – t-test for single case studies [$t_{n-1} = x - X/(SD)\sqrt{n+1/n}$]

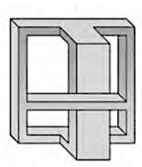
1 - Oddity Task

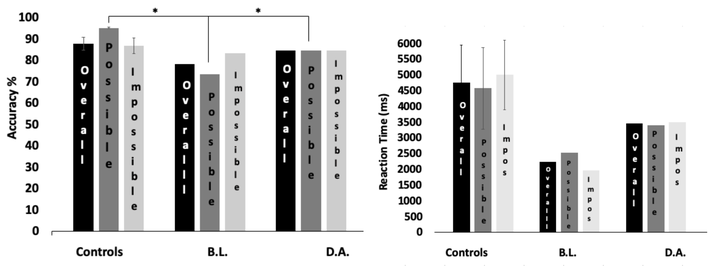




Patients were poor at determining the odd object amongst three identical counter-part objects (non-mnemonic). General perception of objects was intact (tasks 3, 4).

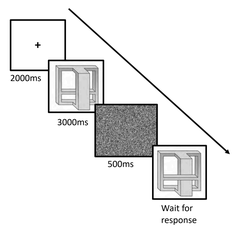
2 - Possibility Judgement Task

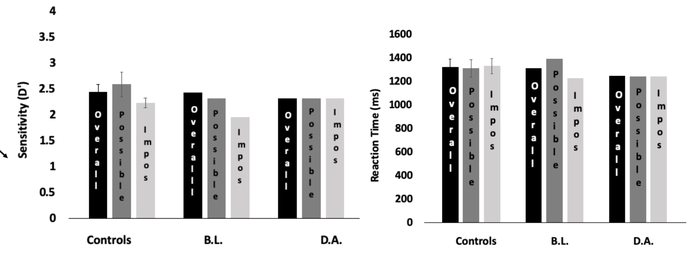




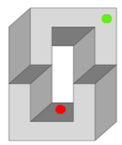
Patients were impaired at explicitly judging possible objects.

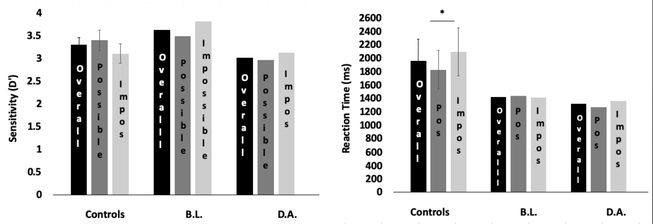
3 - Same Different Task





4 - Depth Judgement Task





Neuropsychological Measures & Results

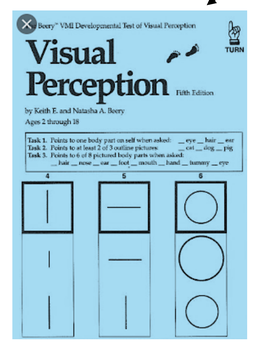
1. **Montreal Cognitive Assessment (MoCA)** – general cognitive screen
2. **WRAML-2 Finger Windows** – Spatial attention span (screen)
3. **Benton Judgement of Line Orientation** - Visual-spatial perception
4. **Beery Developmental Test of Visual Perception** - Visual perceptual discrimination of abstract designs (non-mnemonic; timed)
5. **Benton Visual Retention Test (Forms F & G)** - Visual perceptual discrimination of abstract designs (mnemonic; 10sec delay)

	1 - MoCA	2 - Finger Windows	3 -Judgement of Line	4 - Visual Perception	5 - Visual Retention
Controls	≥ 26 (cut-off)	37-99th	41-98th	66-97th	40-90th (one indiv. 20th)
B.L.	**23** (poor memory)	37th	19-28th	**14th**	**10th**
D.A.	**24** (poor memory)	50th	60-71st	77th	30th

Values are represented as percentiles based on the normative samples for each specific measure. The Average range is 25-74th percentile. The Low Average range is 9-24th. Values in red are below average.

B.L. is below average on tasks of visual discrimination of designs in both perception and memory.

4 - Beery VP – Easy practice items displayed



5 – BVRT Recognition

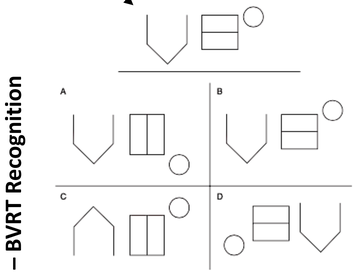


Figure 1 | An altered item from the multiple-choice format of the BVRT. The target stimulus is presented at the top, with the four possible choices (A–D) below.

Amieva et al., (2006) *Nat. Protocols*

Conclusions

- B.L. (DG-lesion) and D.A. (MTL-lesion) impaired on perceptual discrimination of complex, novel objects in an oddity task.
  - Impairment not due to perirhinal cortex damage in D.A
- B.L. and D.A. impaired on explicit judgement of possible, but not impossible objects. Lack of benefit towards possible??
- B.L. has low average performance on a mnemonic (BVRT) and non-mnemonic (Beery VP) visual perceptual discrimination task

These results suggest that the DG is necessary for fine-grained discrimination of objects in memory and perception.

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