

Seminar Presentation

Vestibular involvement in cognition:
Visuospatial ability, attention,
executive function, and memory

Bigelow, RT, Agrawal, Y. *Journal of Vestibular Research* 25 (2015) 73-89

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Group 7: A Cognitive Training Quiz Application

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Project: A Cognitive Training Quiz Application

- Web application for visuospatial cognitive training and testing
- Based upon an existing pen-and-paper set of exercises and exams.
 - Paper exam designed to be taken with assistance from clinician
- Electronic format allows for accessibility, data collection & interactivity
 - Measure per-question response latency
 - Instant feedback

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Paper Selection

“Vestibular involvement in cognition: Visuospatial ability, attention, executive function, and memory”

- Review paper
 - Studies investigating the contribution of the inner ear vestibular system on cognitive function
- Relevance: background & motivation
 - Overview of visuospatial cognitive functions
 - Methods for assessing visuospatial cognitive ability

Background

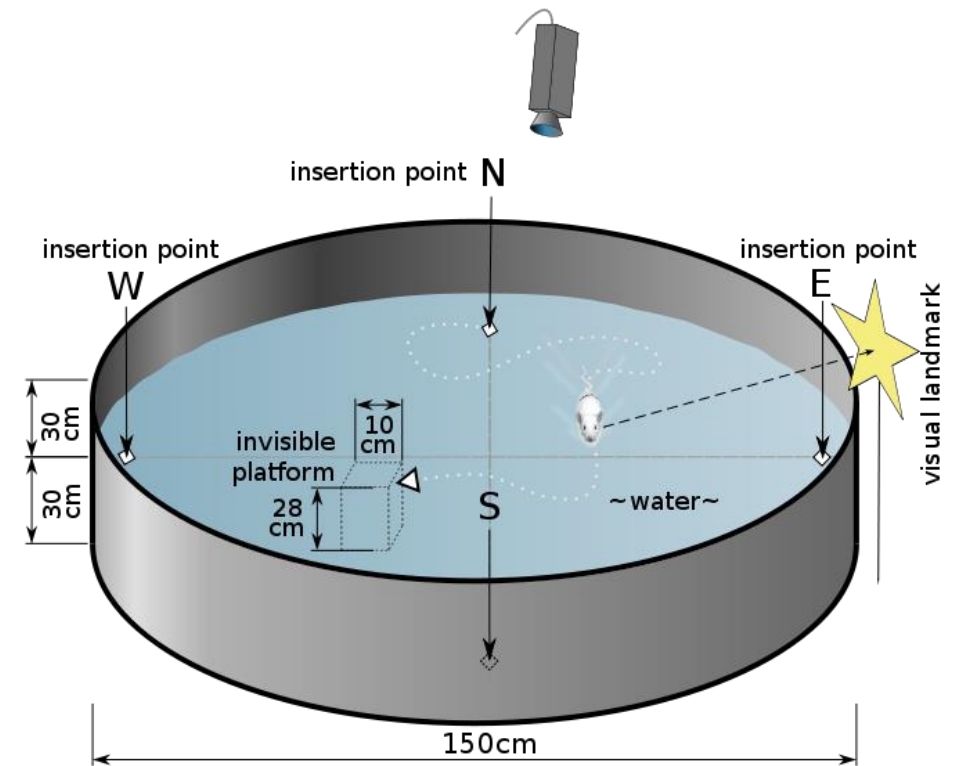
Visuospatial ability: the ability to comprehend and organize space

- Spatial memory
 - The ability to retain certain types of information about the environment:
 - Geometry
 - Relative positions and distances
 - Size
 - Orientation
- Navigation
 - The ability to move purposefully through the environment
- Mental rotation
 - The ability to determine whether similar objects at different orientations are identical

Assessing Spatial Memory

Morris Water Maze Task

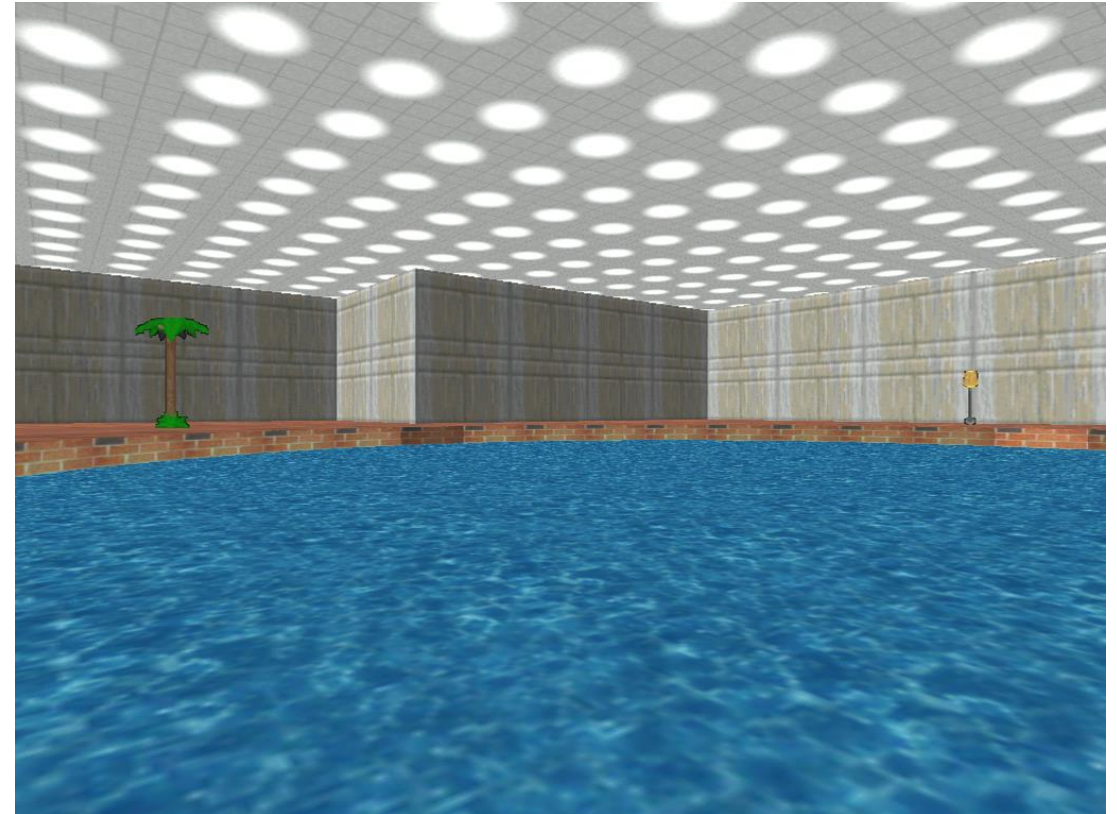
- Primarily for animals (lab rats)
- Participants repeatedly dropped into pool
- Navigate to invisible platform
- External visual cues for reference



Assessing Spatial Memory (cont'd)

Virtual Morris Water Maze Task

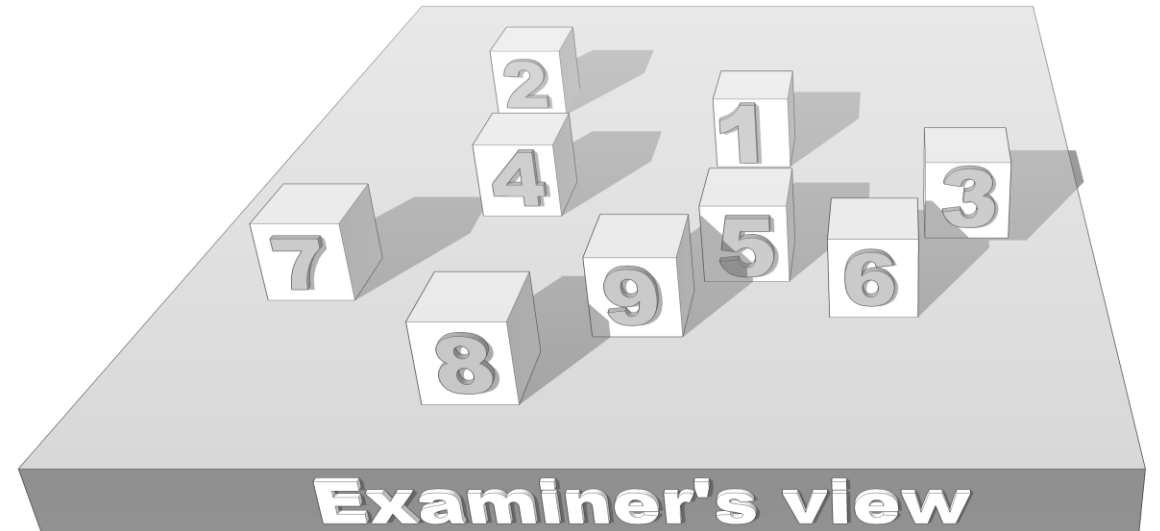
- Electronic analog for humans
- Patients with bilateral vestibular dysfunction perform worse
 - Longer path length
 - Less time spent in correct quadrant



Assessing Spatial Memory (cont'd)

Corsi block test

- Participants are shown sequence tapped on blocks
- Must repeat sequences
 - Sequences grow progressively longer
- Vestibular deficit leads to poorer performance

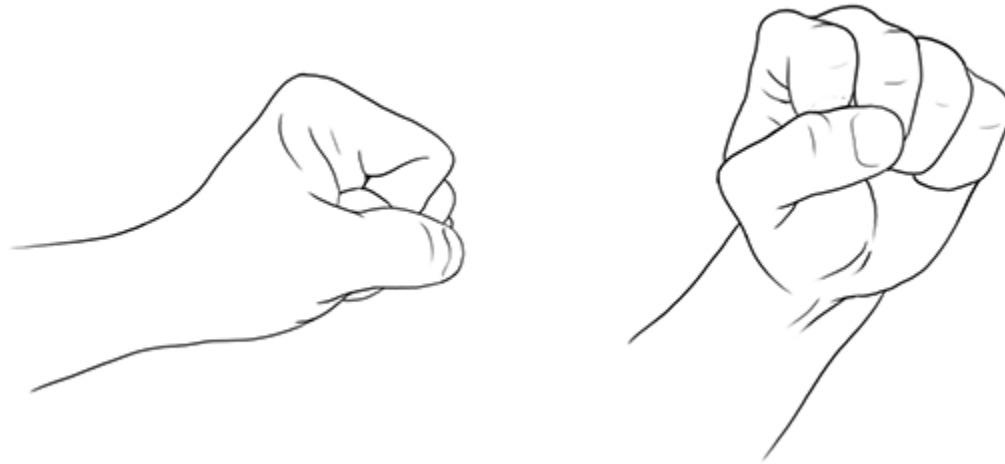


Assessing Navigational Ability

- Movement along memorized paths or towards memorized targets
- Patients with vestibular function have impaired navigational ability
 - Particularly when blindfolded
- Compensation occurs after loss of vestibular input
 - Visual and somatosensory cues allow for maintained balance
 - Cognitive visuospatial deficit persists

Assessing Mental Rotation Ability

- Two similar objects in different orientations:
 - Identical or not?



- Patients with vestibular deficits perform worse

Summary of Results

- Patients with vestibular deficit do worse on cognitive tasks that don't require vestibular input
 - Tests taken seated, stationary
 - Findings suggest vestibular input important in forming a mental representation of 3-dimensional space
- Explanation?
 - Kahneman's Capacity Model of Attention
 - Limited pool of attention and cognitive resources
 - Brain allocates to mental tasks
 - Balancing is harder for individuals with vestibular deficit, requires more cognitive resources

Interesting Digressions/Additional Review Topics

- Vestibular experiments... in space
 - Reduced visuospatial ability and attention in astronauts
- Vestibular stimulation
 - Attempting visuospatial tasks while being physically rotated
 - Mental rotation is easier in the direction of physical rotation



Significance

- Methodology for assessing cognitive visuospatial ability
 - Analogous assessments: coverage (somewhat inherent by design)
 - Corsi box test for Spatial memory
 - Navigation
 - Rotation of objects
 - Prior attempts at translating these tests into electronic format
 - Validation studies compare effectiveness

Assessment

- Review spans many independent studies; results indicate fairly decisively that a vestibular deficit causes cognitive deficit
- Some studies have small sample sizes - ~10 patients, 10 control
- Does Kahneman's attention model really explain why this happens?
 - In all likelihood, yes. However:
 - 2002 Yardley et al. dual-task study – statistically significant
 - Hypothesis testing: merely shows a difference in distribution in the populations
 - Patients with vestibular deficit tend to perform worse on cognitive tests of all sorts, even under regular testing conditions

Conclusion/Application

- Assessment is only part of our project; we also attempt to provide cognitive training that can help patients improve their visuospatial abilities.
- We assess the same major components of cognitive visuospatial ability:
 - Spatial memory, navigation, mental rotation
 - Fairly analogous assessments to those in wide usage