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Spatial Cognition

March 6th, 2025

Presenter: Tzu-Yen, Yang

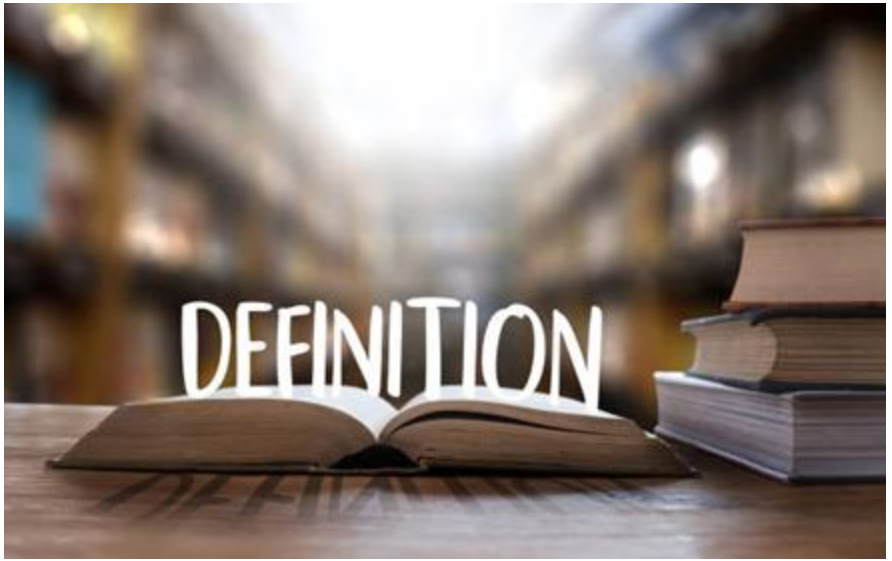
Agenda

- Spatial Cognition
  - Self-localisation
    - Reference frames
  - Navigation
  - Spatial cognition develops with age and experiences

Reminders & Announcements

1. Optional quiz 3 this Friday

Spatial Cognition



Spatial Cognition

- The use of internal knowledge about the layout of the world and the body's relationship to it in order to organise spatial actions like reaching, ***self-localisation*** and ***navigation***.

How is Spatial Location Represented?

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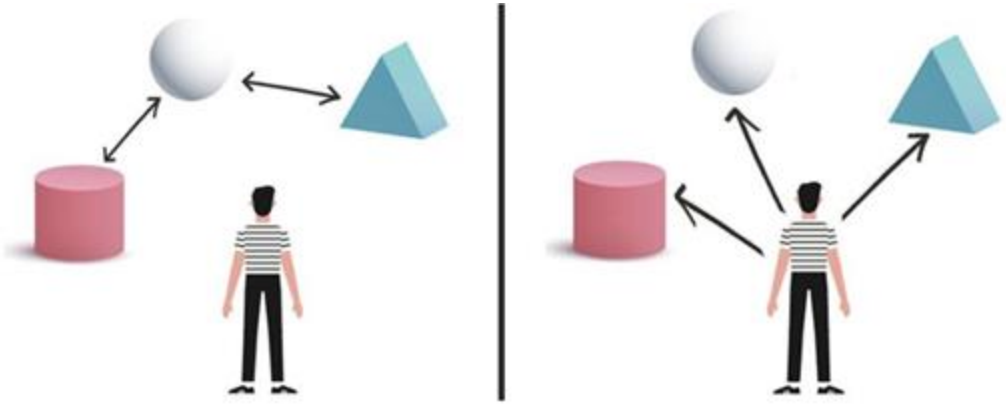
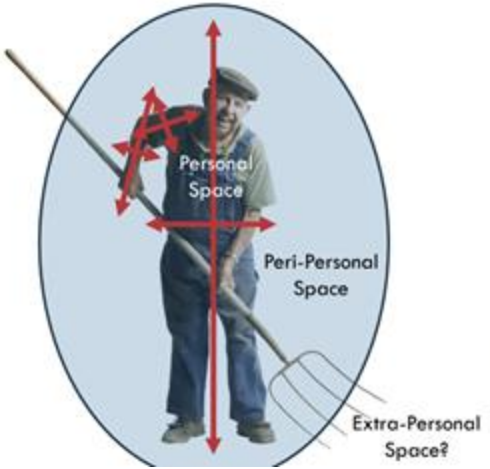


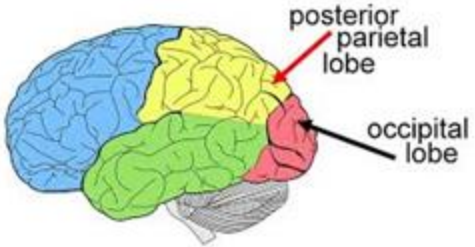
Mirino, et al. (2022).

Allocentric: Spatial information based on the navigator's perception of relative landmark positions (left).
Egocentric: Bases spatial representations from the point of view of the navigator (right)

How is Spatial Location Represented?

Egocentric Reference Frames
- Relative to self ● Body-centered ● Limb-centered ● Head-centered ● Eye-centered
- Relevant for ● personal space ● peri-personal space
- Posterior parietal lobe





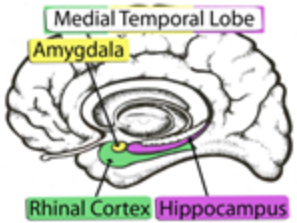
How is Spatial Location Represented?

Allocentric Reference Frames

- Centered on
  - Environment
  - Objects

- Both peri- and extra-personal space

- Medial temporal lobe



Egocentric Reference Frames

- Taylor Swift - ME!

I promise that you'll never find another like me

I know that I'm a handful, baby, uh

I know I never think before I jump

And you're the kind of guy the ladies want

(And there's a lot of cool chicks out there)

I know that I went psycho on the phone

I never leave well enough alone

And trouble's gonna follow where I go

(And there's a lot of cool chicks out there)

But one of these things is not like the others

Like a rainbow with all of the colors

Baby doll, when it comes to a lover

I promise that you'll never find another like

Me-e-e, ooh-ooh-ooh-ooh

I'm the only one of me

Baby, that's the fun of me

Eeh-eeh-eeh, ooh-ooh-ooh-ooh

You're the only one of you

Baby, that's the fun of you

And I promise that nobody's gonna love you like me-e-e

I know I tend to make it about me

I know you never get just what you see

But I will never bore you, baby

(And there's a lot of lame guys out there)

And when we had that fight out in the rain

You ran after me and called my name

I never wanna see you walk away

(And there's a lot of lame guys out there)

'Cause one of these things is not like the others

Livin' in winter, I am your summer

Baby doll, when it comes to a lover

I promise that you'll never find another like

Me-e-e, ooh-ooh-ooh-ooh

Egocentric Reference Frames

- Taylor Swift - ME!

Spatial Cognition

- The use of internal knowledge about the layout of the world and the body's relationship to it in order to organise spatial actions like reaching, ***self-localisation*** and ***navigation***.

Navigation

- Can be done in different ways
- Rely on different types of knowledge
- Egocentric to allocentric
- Orient self relative to world, landmarks; landmarks relative to each other

Cue

"To get to Uris Library, first walk toward the tower."

Route

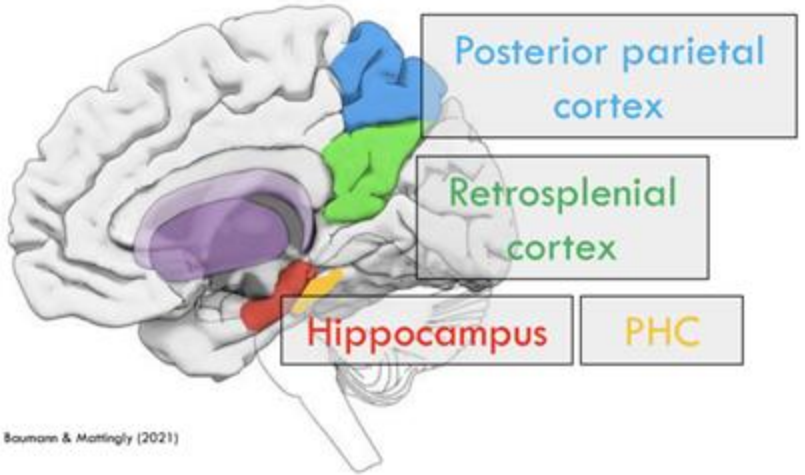
"To get to Uris Hall, turn left at the intersection."

Map

"Mann Library is east of GSH."

Navigation

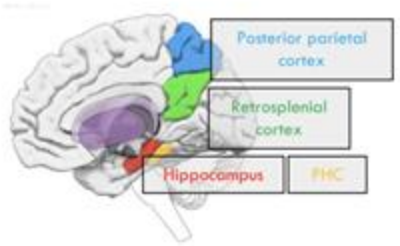
- Parietal to medial temporal lobe
  - Code multiple elements of space
  - Integrate dorsal and ventral



Representing places

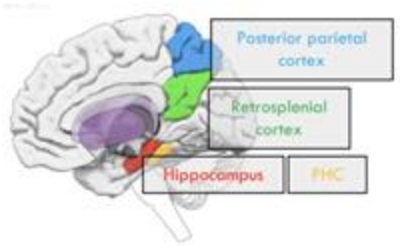
Representing places

- Parahippocampal place area (PPA)
  - Represents familiar locations (“places”)



Representing places

- Parahippocampal place area
  - Represents familiar locations (“places”)
  - Abstract: similar patterns for interior and exterior



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Representing places

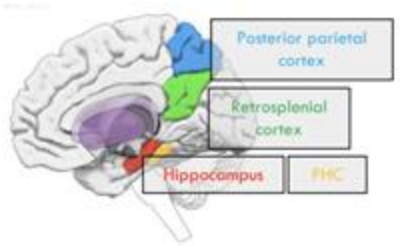
Abstract: similar patterns for interior and exterior

The PPA doesn't just respond to specific places like rooms or buildings; it also processes places in a more abstract way. It activates similarly for both **interior** (inside) and **exterior** (outside) environments, meaning the brain recognizes different types of spaces in a similar fashion.

Ex. the brain might process the interior of a house and the exterior of a park in a way that is functionally similar, based on their features and familiarity, rather than focusing on the exact details of each setting.

Representing places

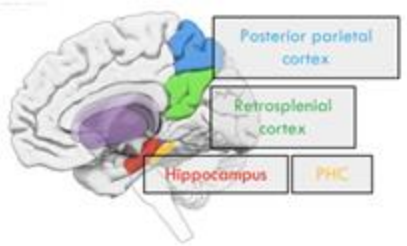
- Parahippocampal place area
  - Represents familiar locations (“places”)
  - Abstract: similar patterns for interior and exterior
  - Multimodal: Auditory and visual places



Allocentric Maps

Allocentric Maps

- Hippocampus & Entorhinal cortex
- Place cells
- Head direction cells
- Combination



Translating Allocentric and Egocentric

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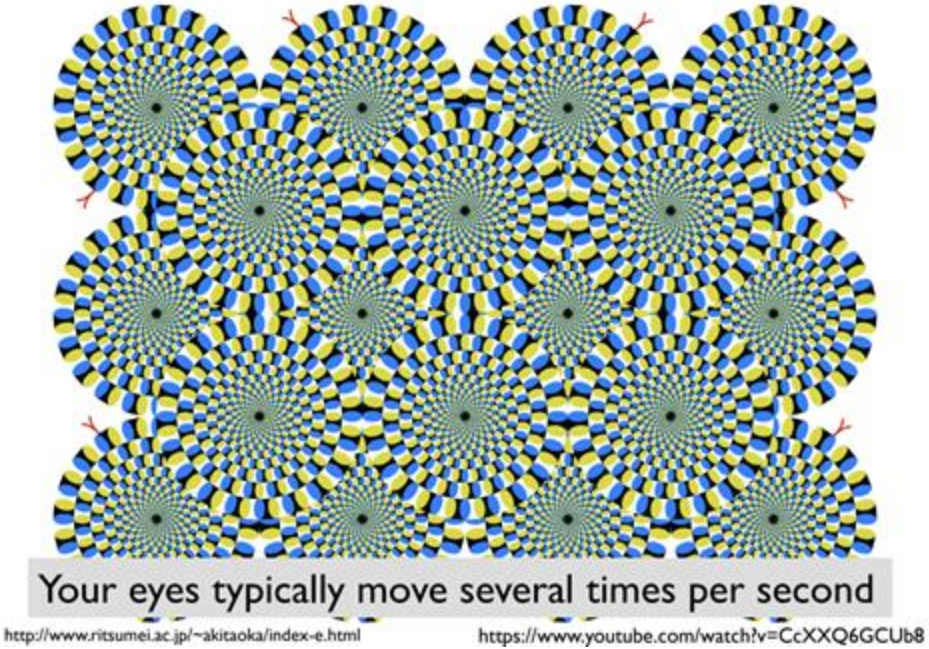
- Retrosplenial cortex
- Both allocentric and egocentric
- “Route-centric”

Eye movement

Your eyes typically move several times per second

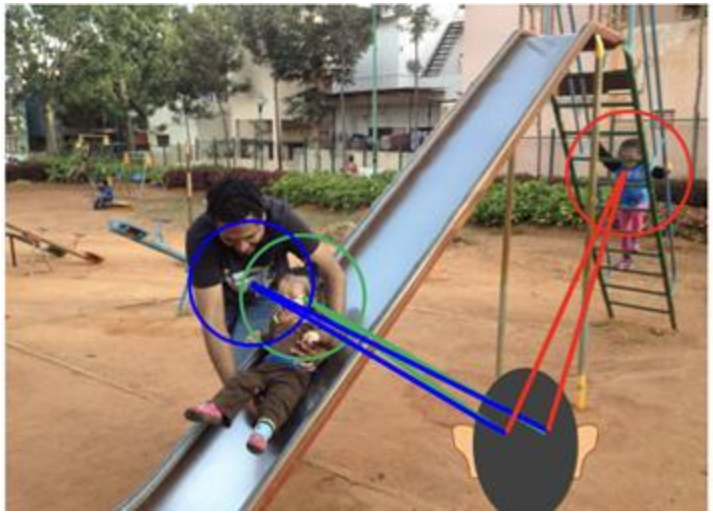


Eye movements complicate things

- The eyes move several times a second
- Therefore, the image on the retina changes just as often

Eye movements complicate things

- Where things are relative to the eyes changes
- Where the eyes are pointed changes relative to the head, body



How can we possibly know how to act on visual information?

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- Challenge
  - Space & movement need to be coded relative to lots of things
  - These need to be coordinated

- Parietal cortex
  - Integrates information across modalities
  - Segregate representations for different effectors

How can we possibly know how to act on visual information?

- Eye-tracker
- Eye-tracking young children study

Eye tracking

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Research in My Lab

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PI
Dr. Marianella Casasola

Dr. Aaron Beckner

David Tompkins

Tzu-Yen Yang

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SPatial cognition And Children's Exploration (SPACE)

- Aims to document how perceptual, cognitive, motor, and language abilities relate to spatial skill development throughout infancy and childhood.
- Employs a short **eye-tracking** task, puzzle-like games, and interactive tablet play.
- Consists of 2 visits 5.5 months apart.
- Children are 24 - 42 mo at Visit 1 and are as old as 48 mo at Visit 2.

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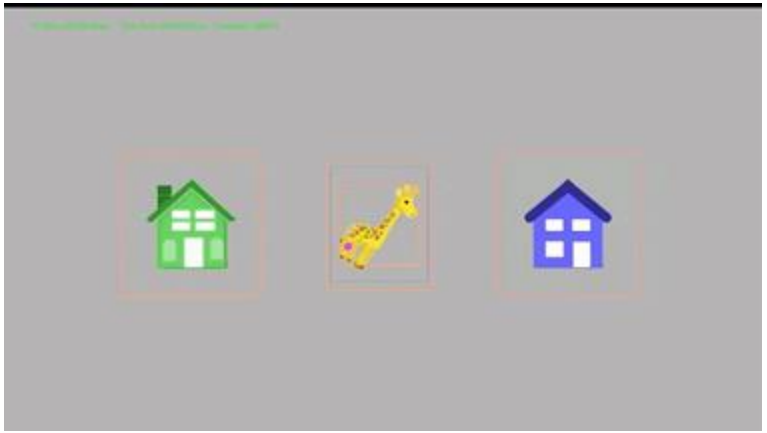
Eye-tracker

Eye-tracker: Protocol

GIMeR (Giraffe Infant Mental Rotation)

- Children are shown a rotated giraffe between two landmarks (houses) and their mental rotation is measured from their anticipated looking to the houses.



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Characterizing the development of mental rotation during the first few years of life

Mental rotation was measured based on children's ability to execute an eye movement to a landmark based on the face-direction of a cartoon giraffe

Beckner, Katz, et al. (2023)


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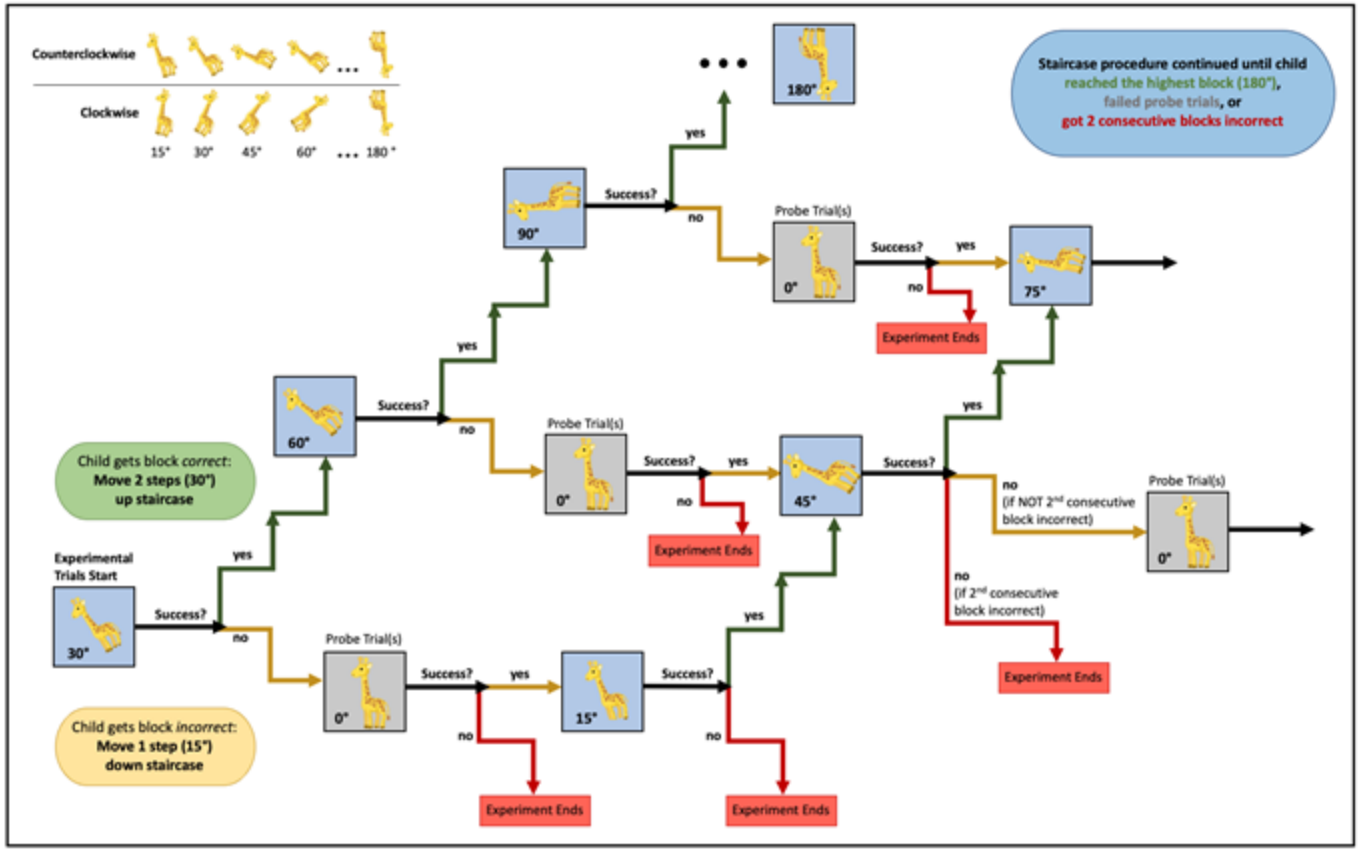

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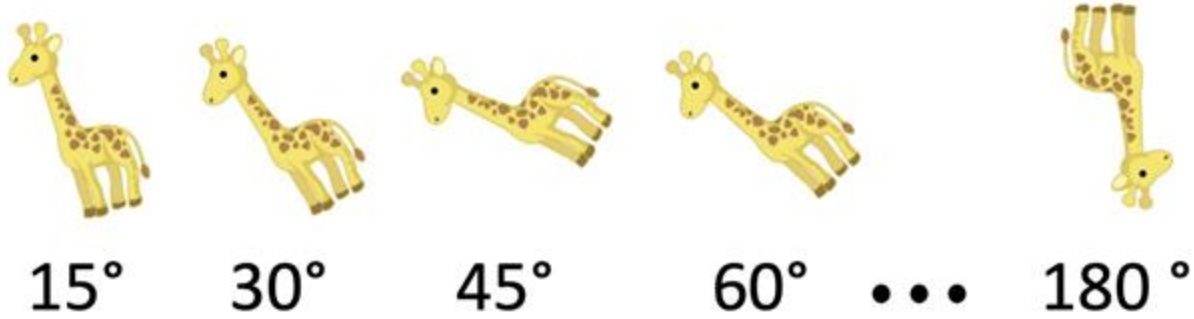
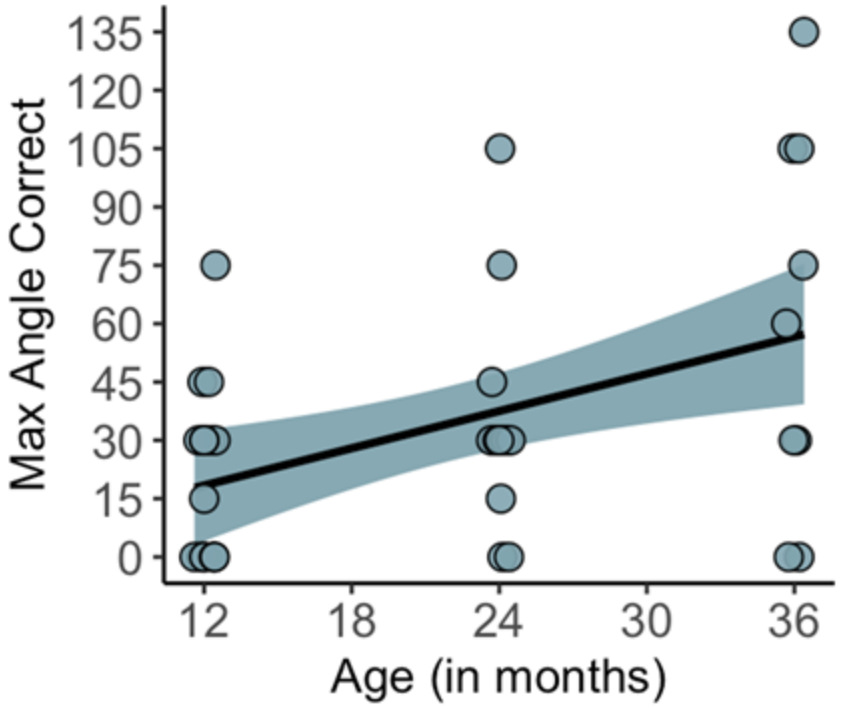
Children would progress through angles based on their accuracy matching the giraffe to the house



This repeated until a max angle correct, or threshold, is obtained

Results



12 months

24 months

36 months

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Beckner, Katz, et al. (2023)

Conclusions

- Children show evidence of mental rotation as early as 12 months
- Older children's mental rotation ability is better than younger children

Beckner, Katz, et al. (2023)

Recap

- Spatial Cognition
  - Self-localisation
    - Reference frames
  - Navigation
  - Spatial cognition develops with age and experiences

Questions?

THANK YOU!