9.85 Cognition in Infancy and Early Childhood

Navigation

Ancient questions

- Where does knowledge come from?
  - Rationalism and empiricism
- How does the mind work and how is it to be studied?
  - Modularity? Not?

- We will use navigation as a way into these questions

Where does knowledge come from?

- Rationalism: some of it, or the means for deducing it, is innate
  - Plato, *Meno*: purports to demonstrate that all knowledge is inherited; learning is recall

Where does knowledge come from?

- Empiricism: all knowledge comes from experience
  - Aristotle via Aquinas: "Nothing is in the intellect which was not first in the senses."

How does the mind work?

- The mind is difficult to study (in part) because it's difficult to break into pieces; everything seems to be connected to everything else
- Modularity: not so! Some parts of cognition can be separated into 'black box' systems. These systems are amenable to study.
  - Fodor, *The Modularity of Mind*

How does the mind work?

- Fodor also argued that while so-called low-level systems may be modules, higher level systems could not be

- Corollary: we shall never understand higher-level human cognition!

- At least, this is Fodor's claim.

What is navigation?

- Very simply: getting somewhere you want to go (but not locomotion; rather, guides locomotion)

- Not the same thing as (although connected with) intuitive geometry – e.g. cognitive map

Navigation as a candidate module

- Navigation is:
  - Something that (almost) all animals need to do to survive – quite sophisticated systems in e.g. ants
  - In some animals, present from birth, or innate
    - Indigo buntings
  - Not high-level, at least subjectively – is automatic, unconscious; *intuitive*
- Thus, navigation would seem to be a great domain for testing modularity

What is navigation? – part 2!

- Very simply: getting somewhere specific
- It's not trivial! Roomba video

- And yet, most animals can navigate - some very well

Image: Wikimedia. Fir0002/Flagstaffotos. CC BY-NC.

What is navigation? – part 2!

- Very simply: getting somewhere specific
- It's not trivial! Roomba video

- OK, so we've seen that it's not so easy to navigate. What strategies could an animal or robot use?

How could navigation work?

- Path integration
  - Keep track of positional and velocity cues, add them up to get an estimate of current velocity
  - Some ants can do this very well

How could navigation work?

- Landmark system
  - Keep track of where we are with respect to some other object

How could navigation work?

- Place system
  - Represents the global geometric shape of the environment; for natural scenes, which are usually quite non-symmetric

Navigation systems

- Landmark
- Place
- Illustration
- Are they separate systems? How do we know?

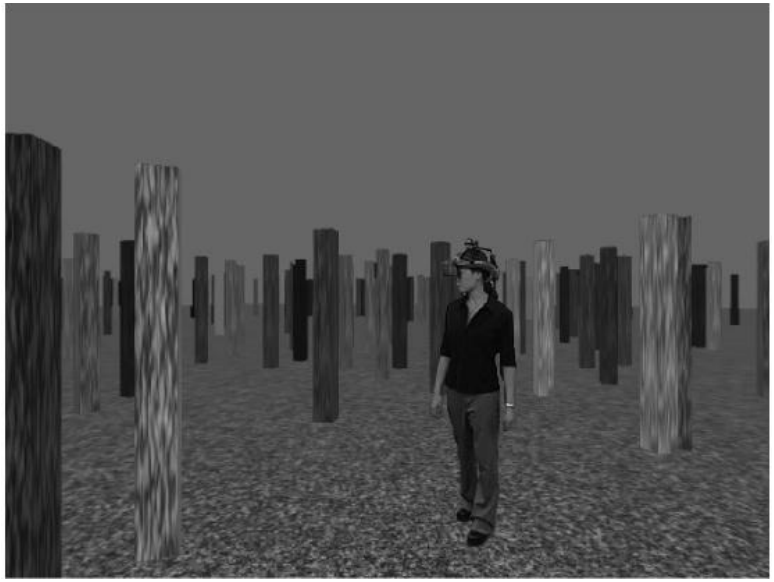
How can we probe systems for navigation/geometry?

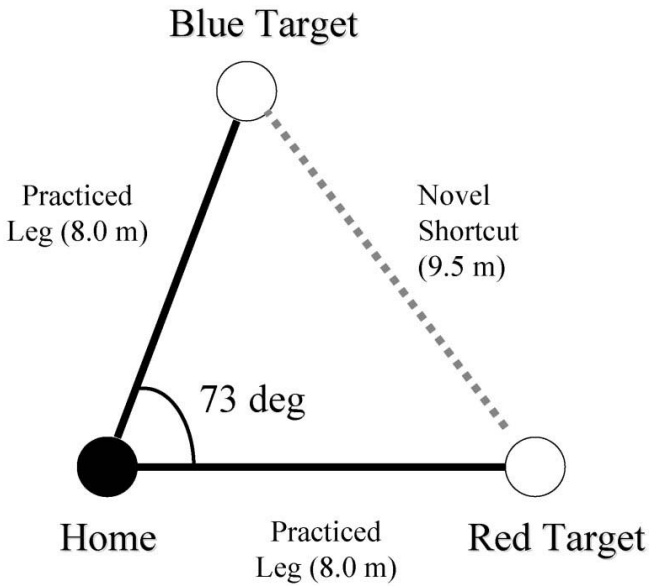
- Ask people to navigate, and manipulate the available environmental cues

- So: let's review evidence for existence of these systems

Evidence for landmark system

- Put subjects in virtual reality, with landmarks
- Have them learn to walk two legs of a triangle:



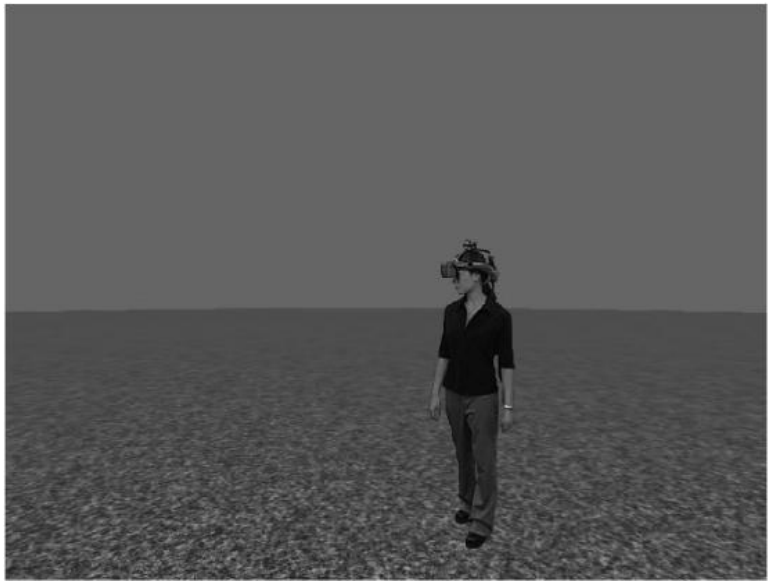


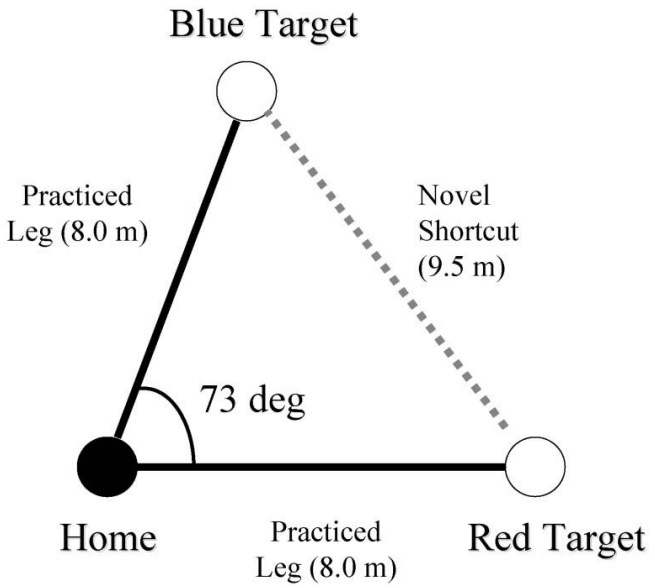
- Then, have them walk from the blue target to the red target

Foo et al., 2005

Evidence for landmark system

- Control (key because they could be using path integration): same task, but no landmarks!





- Subjects are significantly worse!

Foo et al., 2005

Evidence for place system

- First, rats: place rat in box, show it food in a particular corner. Then remove rat and bury food

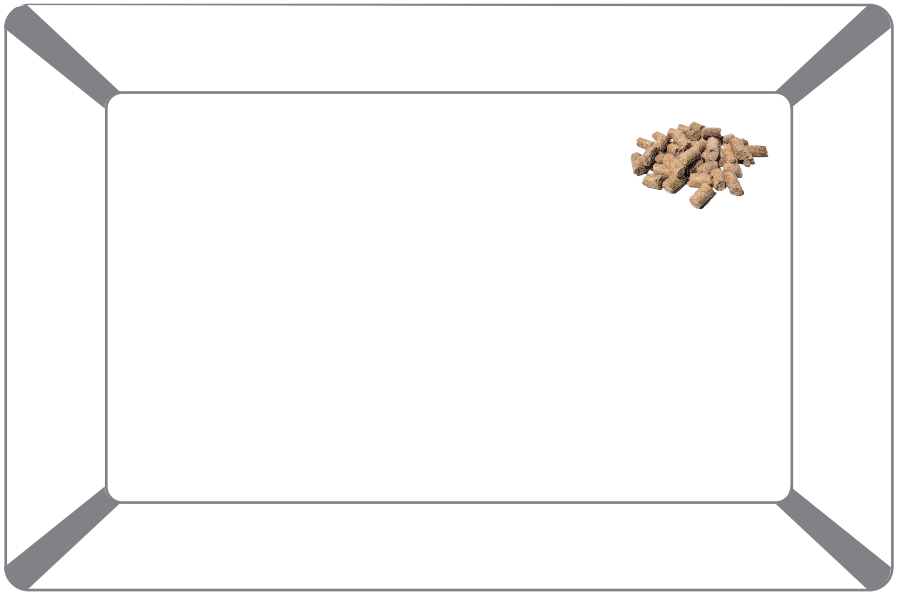
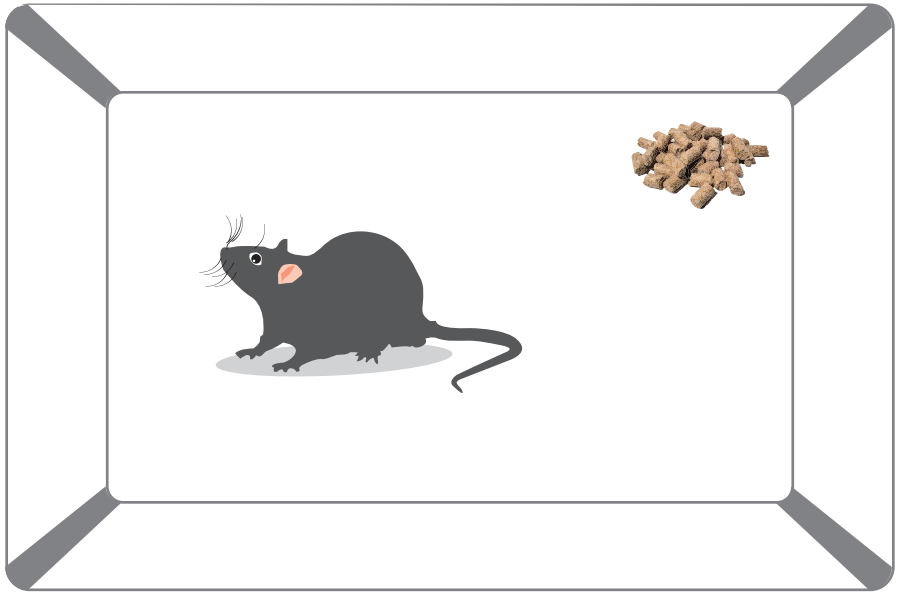


Image by MIT OpenCourseWare. Based on Cheng, Ken. "A purely geometric module in the rat's spatial representation." Cognition 23, no. 2, (1986): 149-178.

Evidence for place system

- For test, return rat back to the box. See where it digs for food



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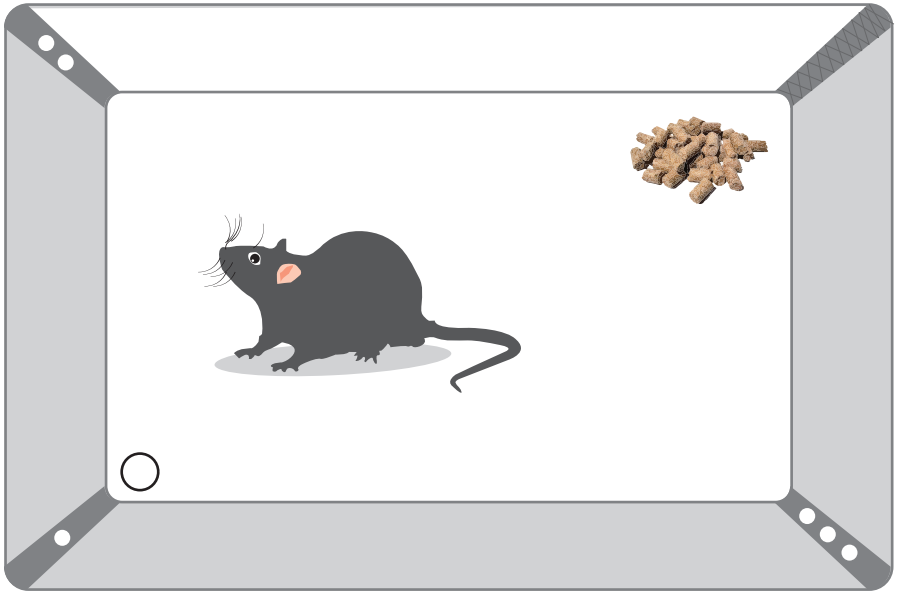

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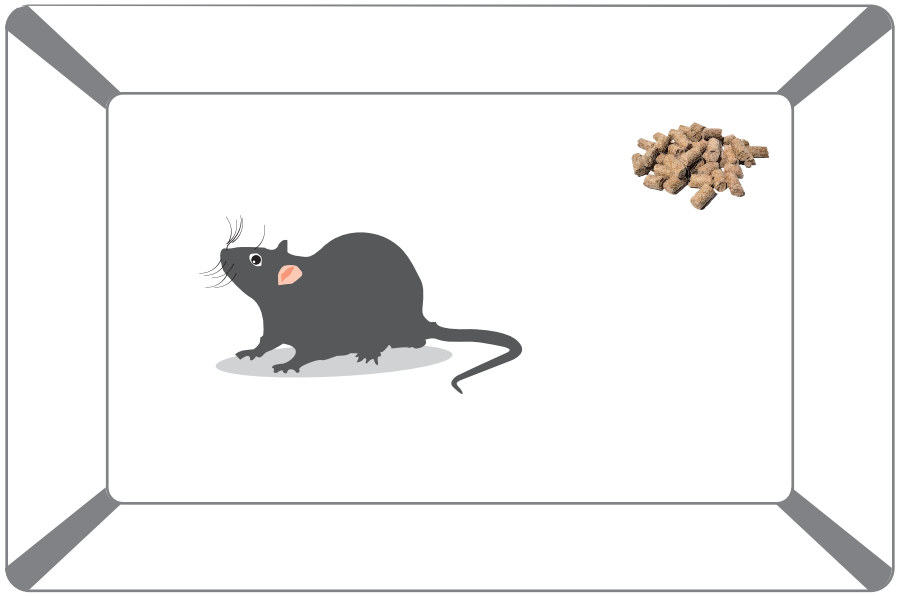

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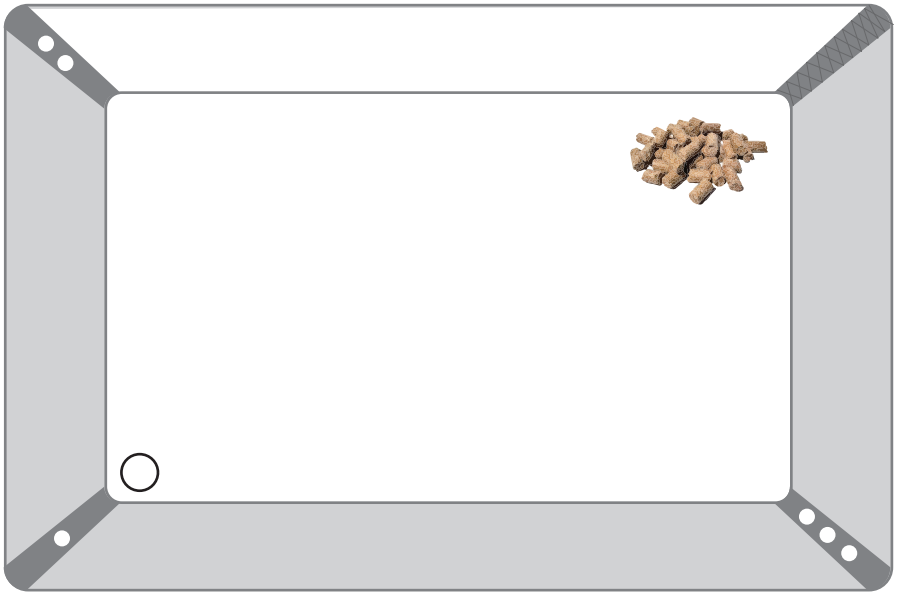
- Digs equally in appropriate corners
- But: SURPRISE TWIST!

Curiosities of place system

- The place system does not care about features!
- Strange figure from before



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Curiosities of place system

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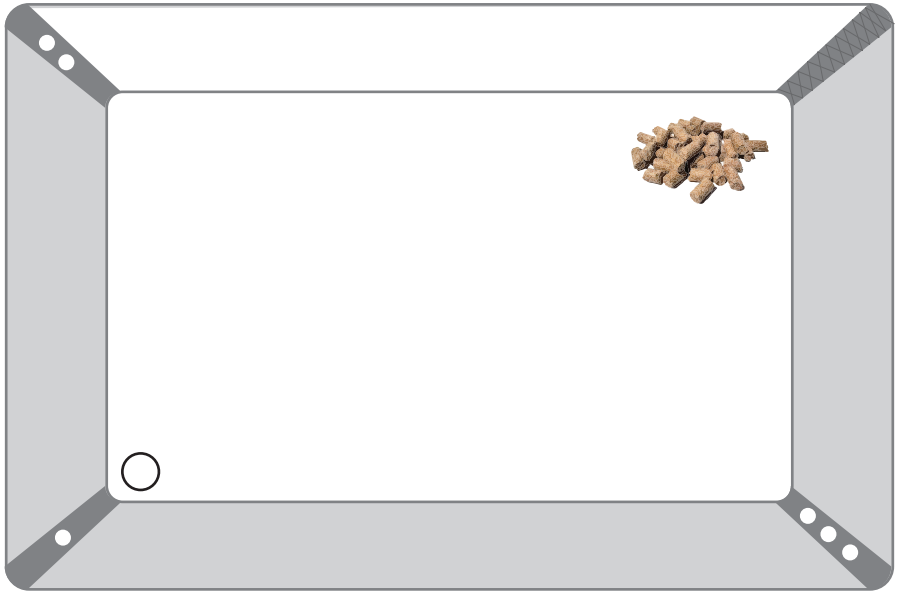

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- Rats ignored the cues on the walls!
- This leads us to surprise twist #2

Curiosities of place system

- Children show the same pattern!
  - Spelke & Hermer, 1994

- Surprise twist #3 (probably less of a surprise):
  - Adults can use features for navigation.

Two systems

- Okay, so we have two systems. Are they really separate?
  - Can evidently have place without landmark
  - Can have landmark without place (recall VR experiment)

- Shocking surprise twist

(untrained) Children don't use landmarks for reorientation!

- Spelke & Hermer 1994

Figure removed due to copyright restrictions.
Figure 3a. Hermer, L., and E. S. Spelke. "A Geometric Process for Spatial Reorientation in Young Children." *Nature*, 370 (2004): 57-9.

(untrained) Children don't use landmarks for reorientation!

- Lee & Spelke

Figure removed due to copyright restrictions.
Figure 1 Lee, Sang Ah and Elizabeth S. Spelke. "A Modular Geometric Mechanism for Reorientation in Children." *Cognitive Psychology* 61, no. 2 (2010): 152–76.

Two modules for navigation

- Navigation
- Place
- Recall: Fodor's modularity thesis
  - If we can split off parts of cognition, then we can start to understand them

Two modules for navigation

- Problem: adults use landmarks and geometry!

- How to resolve this? One proposal is language
  - Language is the glue that connects modules

Conclusion

- Two (maybe more; path integration) modules for navigation
  - Landmark system uses spatial landmarks
  - Place system uses geometry of surroundings

- They are as close to modular as any other systems that we know about

Conclusion

- Rationalism vs. empiricism:
  - Some things are cross species, probably innate
  - Some things depend on experience (landmark system..)

- As usual, it seems to be a mix of both

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