Navigation 2: Path Integration In Humans & Scene Representations

Path integration in animals (yesterday)
Success using internal representations:
- Ants
- Bees
- Baby Goose
- Gerbil

Path integration in human adults?
Australian wanderers (Levinson) Good :)
Dutch mushroom collectors (Levinson) Bad :

Why is human performance so variable? 3 possibilities
1. Empiricist
   - in humans, the ability develops by experience when needed (so develops among Australians, not in Dutch)
2. Nativist with critical period
   - in humans, the ability is present early but atrophies in absence of use (NB: indigo bunting experiments & stereopsis!)
3. Nativist with input cues required
   - in humans, the ability is present throughout life but is not engaged in every context (NB: multiple object tracking)

Is path integration present early in development?
2-year-olds, blind kids & blindfolded kids are the same (Landau, Gleitman & Spelke)

“Here’s your basket” “Here’s your toy. Can you put your toy in your basket?”
Success!
Is path integration present early in development?
At 10 months (Acredolo)

Passive motion

Is path integration present early in development?
At 10 months (Acredolo)

Predicted failure
Blue = Egocentric
(keep looking to their right)

Predicted success
Red = Path Integration

Failure with passive motion! Child looks in wrong (blue) direction

Is path integration present early in development?
At 8 months with self-produced motion & immobile objects (Lepecq)

Success with active motion!

Is path integration present early in development?
Conclusion: path integration is present and functional as early as infants engage in self-produced locomotion. It may fail to operate reliably during passive locomotion for human infants (though it succeeds for goslings) (NB: the importance of activemotion in Kitten-Carousel, Prism Pointing Adaptation and here)

Path integration over human development
In natural tasks, adults do not always succeed (e.g. Dutch mushroom gatherers)

In laboratory studies like the ones with babies, adults succeed and show higher accuracy than children

Adults also succeed during passive locomotion.

Developmental changes begin in infancy.
Path integration in humans

Why is human performance so variable? 3 possibilities
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--in humans, the ability is present early but atrophies in absence of use (NB: indigo bunting experiments & stereopsis!)
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System 1: Path Integration
Conclusions
Existing data are not yet as complete as e.g. cliff avoidance, but they have the following suggestions:

Present in every mobile animal yet tested, including humans.
Like visual cliff avoidance, path integration emerges as soon as an animal is capable of independent locomotion (without flying or long-walk experience in geese).
Humans may fail to use our path integration abilities under some conditions (mushroom pickers, passive motion in babies).
Open question: Do all creatures use the same approximation?? (QALMRI write-up!)

Beyond Path Integration

Path integration allows animals and humans to navigate without forming any enduring representations of the surrounding layout.

But humans and animals do form enduring representations of our surroundings.

System 2: Scene Recognition

Today: Scene Recognition In Animals, Babies, and Adults (Behavioral Data)

Next time: (Brain Data)
A simple experiment on humans

Evidence:
Imagine you’re in the kitchen of the house you grew up in.

How many windows?
Face the refrigerator 
and point to the dining room.

A simple experiment on rats
The “water maze” (actually, more like milk: Morris)

Rats reliably learn to swim directly to the hidden platform, using 
remembered properties of the scene, not path integration.

Scene Recognition in Bees
Bees’ navigation is affected by visible landmarks that they have 
encountered on past journeys, with nearby cues controlling place 
recognition and distant cues specifying a more global map. 
(Collett & Wehner expts)

Training 
Near Landmark Defines Place 

Training 
Far Landmark Defines Navigation
Scene Recognition
More studies of bees: Near Landmark scene representations are view-dependent

Normal foraging:
N
Experiments with limited views:
Realese Red direction: Bee won’t land
N
Training
Release Blue direction: Bee lands

Scene Recognition
More studies of bees: Near Landmark scene representations are view-dependent

Train:
Test: make landmark bigger

Bee learns to search here
Bee now searches further away

View-dependent aspects of Scene Recognition in mammals
Rats in the water maze

With free access to all vantage points, rats learn to navigate to the platform from anywhere.
With blocked access to some vantage points, inconsistent navigating from novel vantage points when the barrier is removed

Simons & Wang: Do human adults form 3D cognitive maps or view-dependent scene representations?
View-Dependent Scene Recognition Processes in Humans?
Simons & Wang: Do human adults form 3D cognitive maps or view-dependent scene representations?

Task: what moved?

Method: Change Detection with a moving table and a moving observer
Table Rotates
Or Person Rotates
2 viewing windows
Question: Did something change?
Yes/No

Conditions:
1: no change in observer or table position.
View-Dependent Scene Recognition Processes in Humans?

Findings

<table>
<thead>
<tr>
<th>Condition</th>
<th>Corrected Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Change</td>
<td>0</td>
</tr>
<tr>
<td>Rotate Table, Viewer Same</td>
<td>10</td>
</tr>
<tr>
<td>Rotate Table, Viewer Different</td>
<td>90</td>
</tr>
</tbody>
</table>

Like bees, humans represent specific views of a scene and perform better with familiar than with novel views.
Moving human observers do not retain old “snapshots” of a scene—they compute new views.

How do we compute new views?

One possibility: dynamic updating of our relation to objects, just like ants and geese (path integration)

Prediction: if we use path integration processes to update the positions of objects like other animals, our ability should be affected by the same factors as that of other animals.
A test: effects of passive motion with and without vision.

Humans have two processes like those found in geese & rodents:
--a process for forming & using view-dependent representations of scenes. (Also found in Bees)
--a process for updating these representations by path integration. (This requires an interaction of Core System Space 1 “path integration” and Core System Space 2 “Scene-Recognition”)

--Next Time: Kid evidence and Brain evidence in rats and humans for both view-dependent representations and view-independent representations