Finding your way in space

Daily routin:

- Special skills (e.g. finding cached food)
- General skills (e.g. finding the shortest rout)

Navigation during migration

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Finding your way in space

Simple orientation: taking up a particular bearing with respect to the current position, regardless of destination (go west!)

Goal orientation: heading towards a particular location (fly to nesting area!)

- Pilotage: finding the way to a known destination across a *familiar* area using local sources of reference ('landmarks')
- Navigation: finding the way to a known destination across *unfamiliar* territory using any of a number of possible mechanisms

Peter Kabai
www.behav.org
peter.kabai@gmail.com

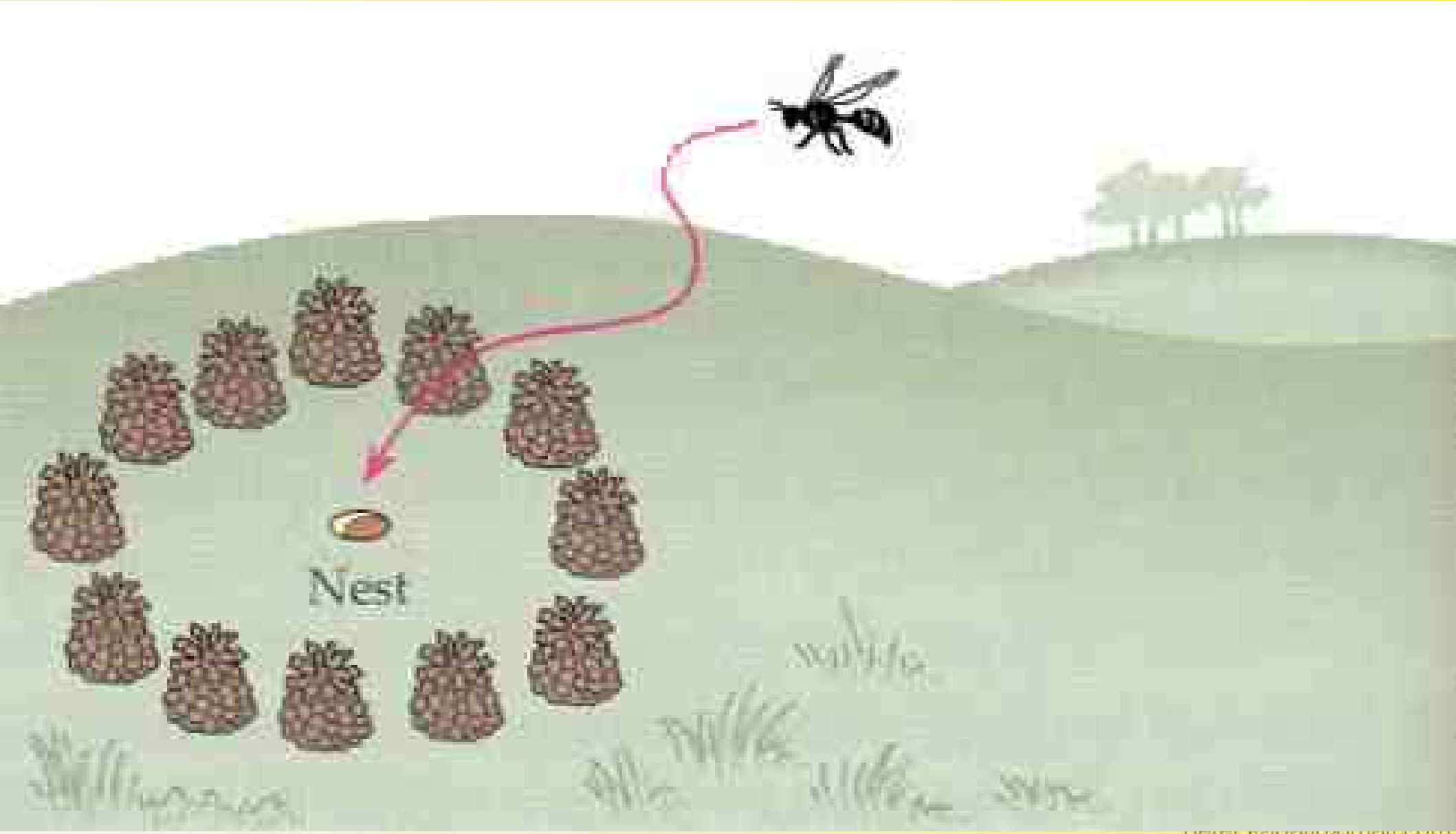
Orientation

Hynek Burda et al. (2008 PNAS) recorded orientation of 8500 cattle in 300 pastures by GoogleEarth

Most individuals oriented North – South

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Pilotage: landmarks (digger wasps)



Navigation

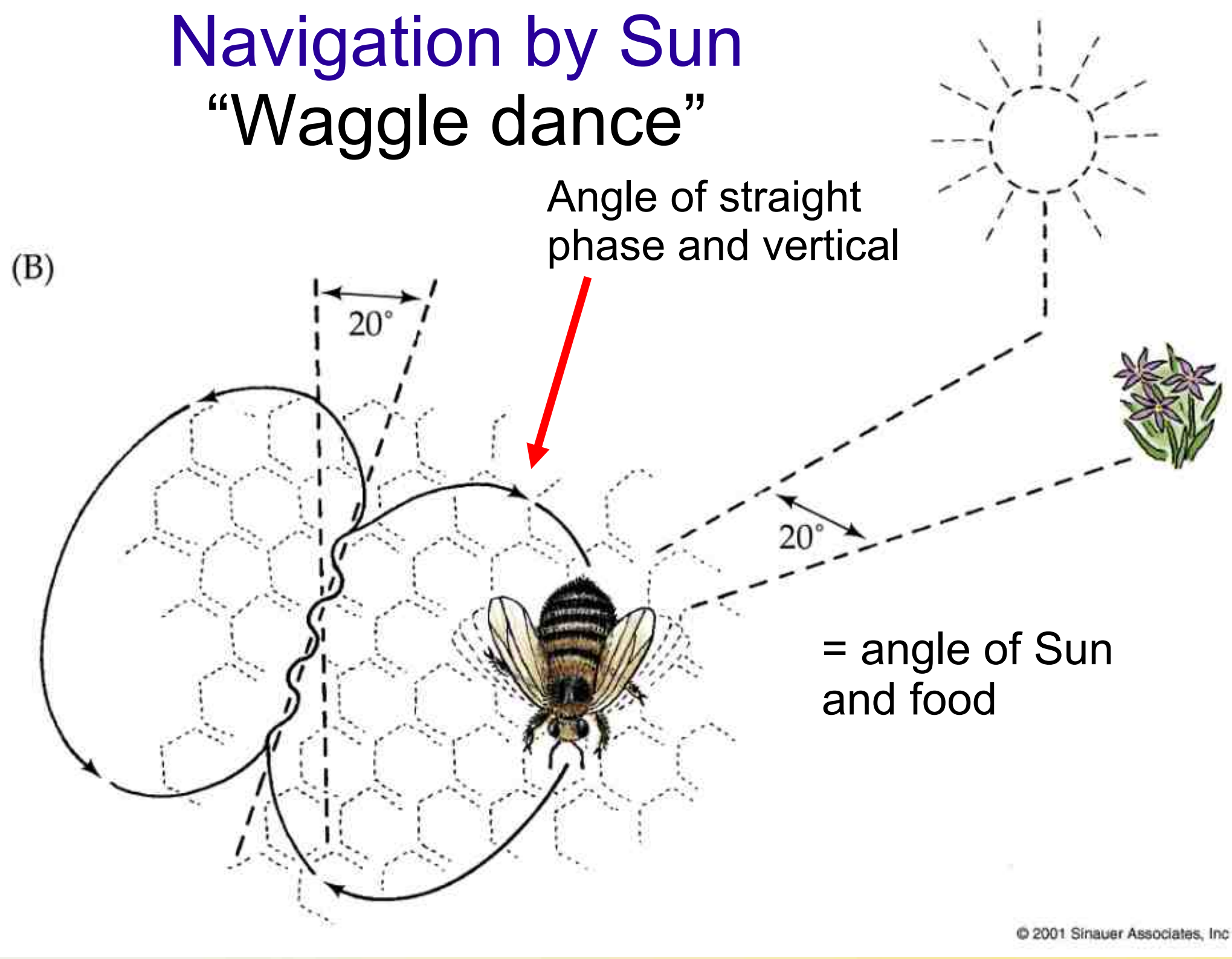
Navigation: finding the way to a known destination across *unfamiliar* territory using any of a number of possible mechanisms

- Direction: which way to go? (Sun, geomagnetic field)
- Position: where am I? (mental map, computation e.g. distance travelled)

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Navigation by Sun

"Waggle dance"



Navigation by Sun

Dancing for hours meanwhile the Sun „travels”

Can bees compansate?

- Bees marked at feeding station
- Let them fly back to hive
- Shut hive for 3 hours
- Hive relocated (no familiar landmarks)
- Hive opened, direction of flight measured

Bees flew in correct direction (as time passed dancers changed angle of straight phase and vertical)

Peter Kabai
www.behav.org
peter.kabai@gmail.com

In the news

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Loggerhead turtles have a magnetic sense for longitude

› 14:41 25 February 2011 by **Aria Pearson**
› For similar stories, visit the **Mysteries of the Deep Sea** Topic Guide

Newly hatched sea turtles can sense their longitudinal position – something that took sailors hundreds of years and many lost ships to figure out. Surprisingly, they do so using the Earth's magnetic field.

Recently, it was discovered that a handful of species – including older sea turtles and migratory birds – seem able to perceive longitude. But it was unclear what cues they could be using.

The Earth's magnetic field, which animals can use to gauge latitude, was considered an unlikely candidate because of how little it varies in the east-west direction around the globe.

However, in certain parts of the world at the same latitude there are subtle differences in the intensity and angle of the magnetic field. Could these be used by animals to figure out longitude?

PRINT SEND SHARE

It has been known that loggerhead turtles sense geomagnetic field for North-South orientation. New research shows they can detect and use it for longitudinal (East-West) orientation

Peter Kabai
www.behav.org
peter.kabai@gmail.com

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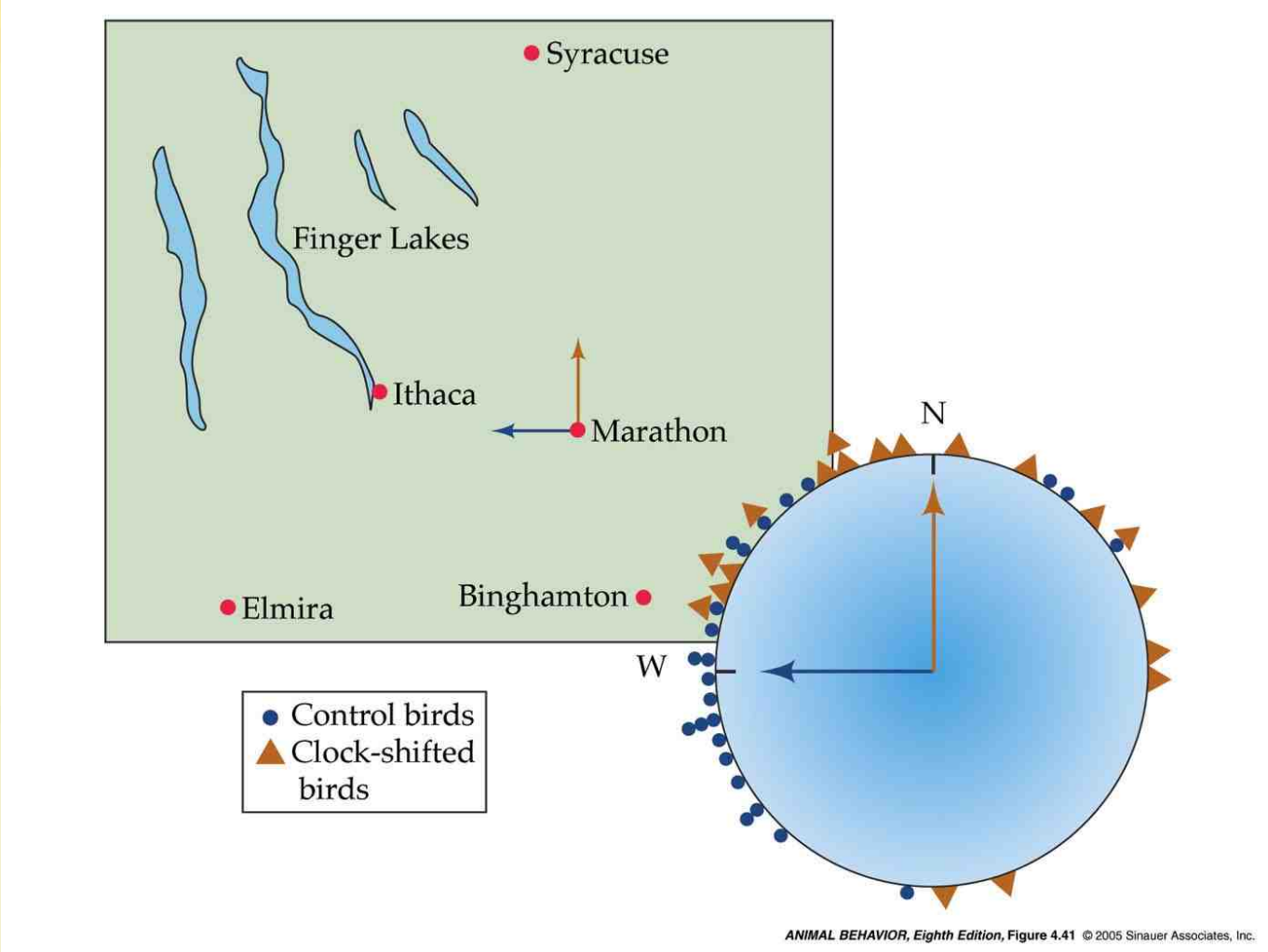
Navigation by Sun

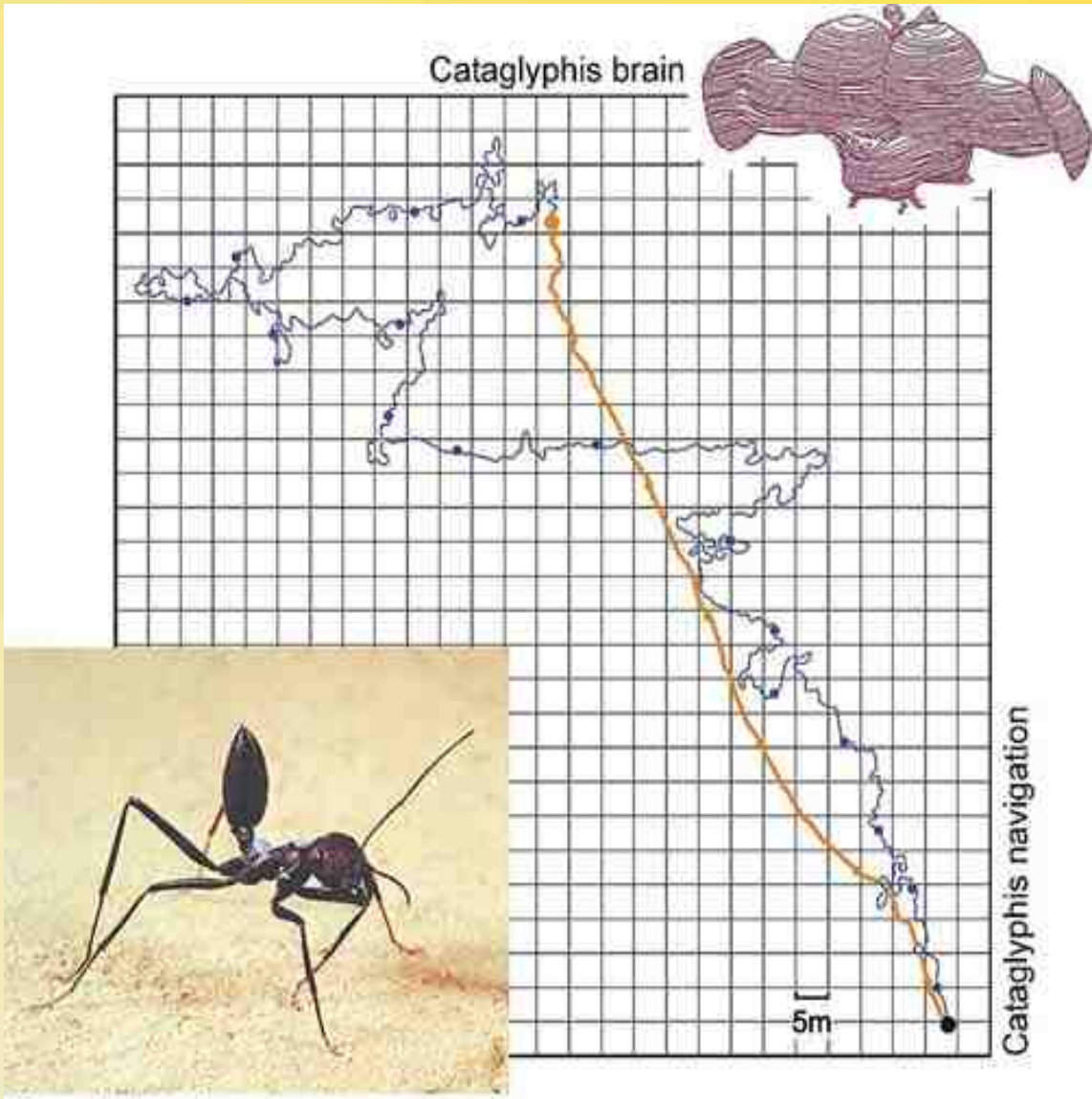
Inner clock of homing pigeons set back by 6 hours (artificial LD cycle for one week)



Navigation by Sun and path-integration

Despite the lack of landmarks, desert ants in the genus *Cataglyphis* can quickly and directly navigate back to their colony entrance after collecting food.

Ants can use information from the sun and the pattern of light reflected in the sky to orient themselves with respect to the direction of their colony.



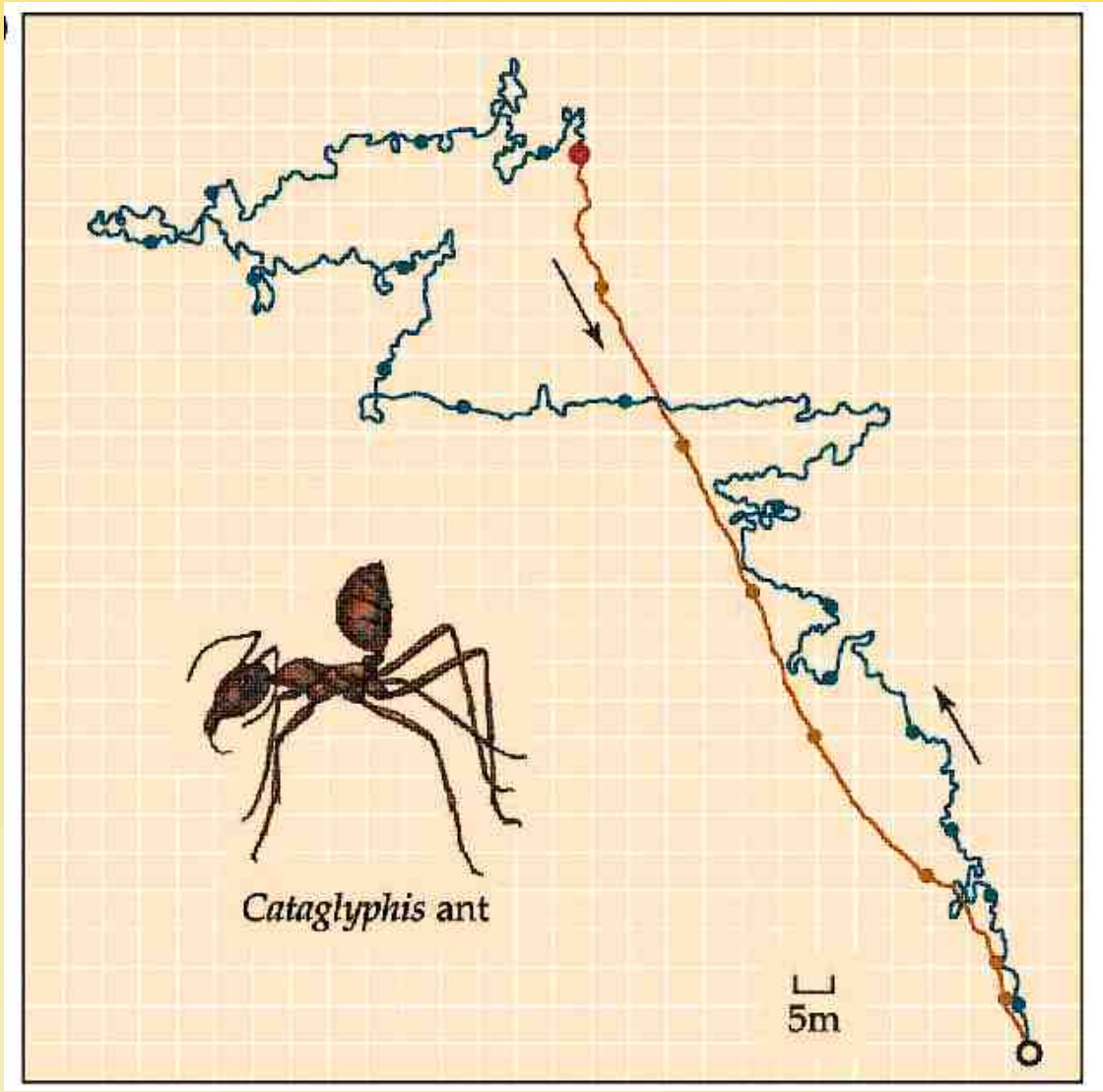
Navigation by Sun and path-integration

Desert ant species

- Leaves nest
- Searches prey (blue path, 592 m)
- Finds prey (red circle)
- Heads home
  (red line, 140 m)

Direction: Sun

Distance?
(few landmarks in desert)



Peter Kabai
www.behav.org
peter.kabai@gmail.com

Distance?

Pedometer

Wittlinger et al. (2006, Science)
manipulated length of legs
- elongated by attaching pig bristles
- shortened by cutting

100 m path is 10 000 times the body length

„Animals with elongated (‘‘stilts’’) or shortened legs (‘‘stumps’’) take larger or shorter strides, respectively. Travel distance is overestimated by experimental animals walking on stilts and underestimated by animals walking on stumps.”

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Food caching

Eurasian Jay: caches cca 30 000 acorn –
retreiving them through 10 months

Marsh Tit: 100 cashe – retrieving within a few hours

Food caching

Fallen acorn dries out

Cached acorn sprouts

Jays are the most significant propagator of oak trees

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Food caching

Clark's nutcracker

(Nucifraga columbiana)

Caches 33 000 nuts in cca 6,600 locations in autumn.

A single hiding lasts 20 sec.

Retrieving :

72% in spring

32-44% in summer

(Tomback, 1980)

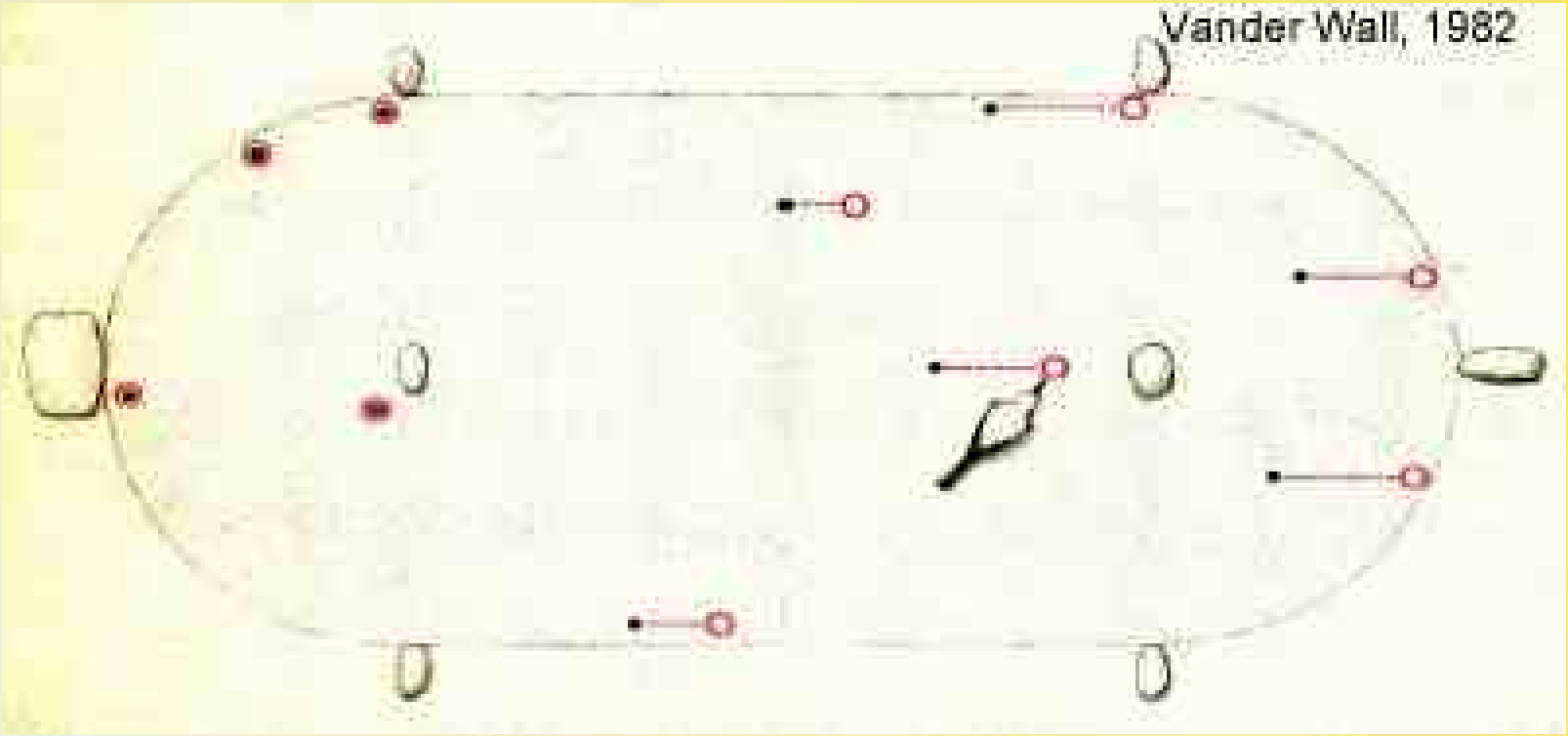
Retrieval. What is the trick?

1) Caches by simple rule?
   - Small brain capacity does it
   - Competitors can find it
2) Remembers every place?
   - Safe from competitors
   - 30 000 coordinates in memory?

? How can we test this ?

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Testing memory



Sandy arena, rocks, bird is provided with nuts

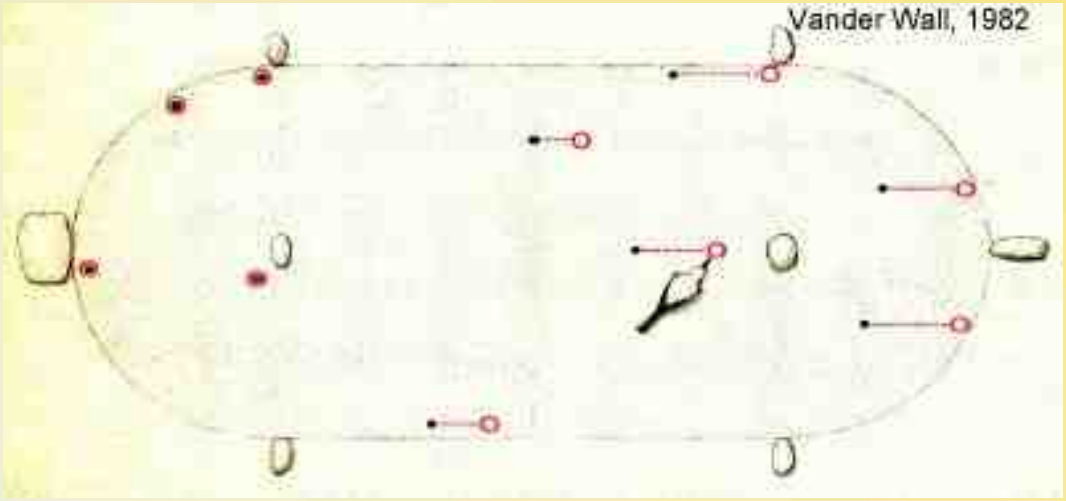
Caches them (black dots)

Rocks on the right are moved to the right by 20 cm.

Where would the bird search?

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Testing memory



Search

- on the left finds nuts
- on the right errs 20 cm

All in the memory? How is it done?

Caches close to large rocks (landmarks)

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Testing memory

Many experiments support the hypothesis that jays memorises locations by landmarks

Nutcracker memorises

locations of tens of thousands of objects.

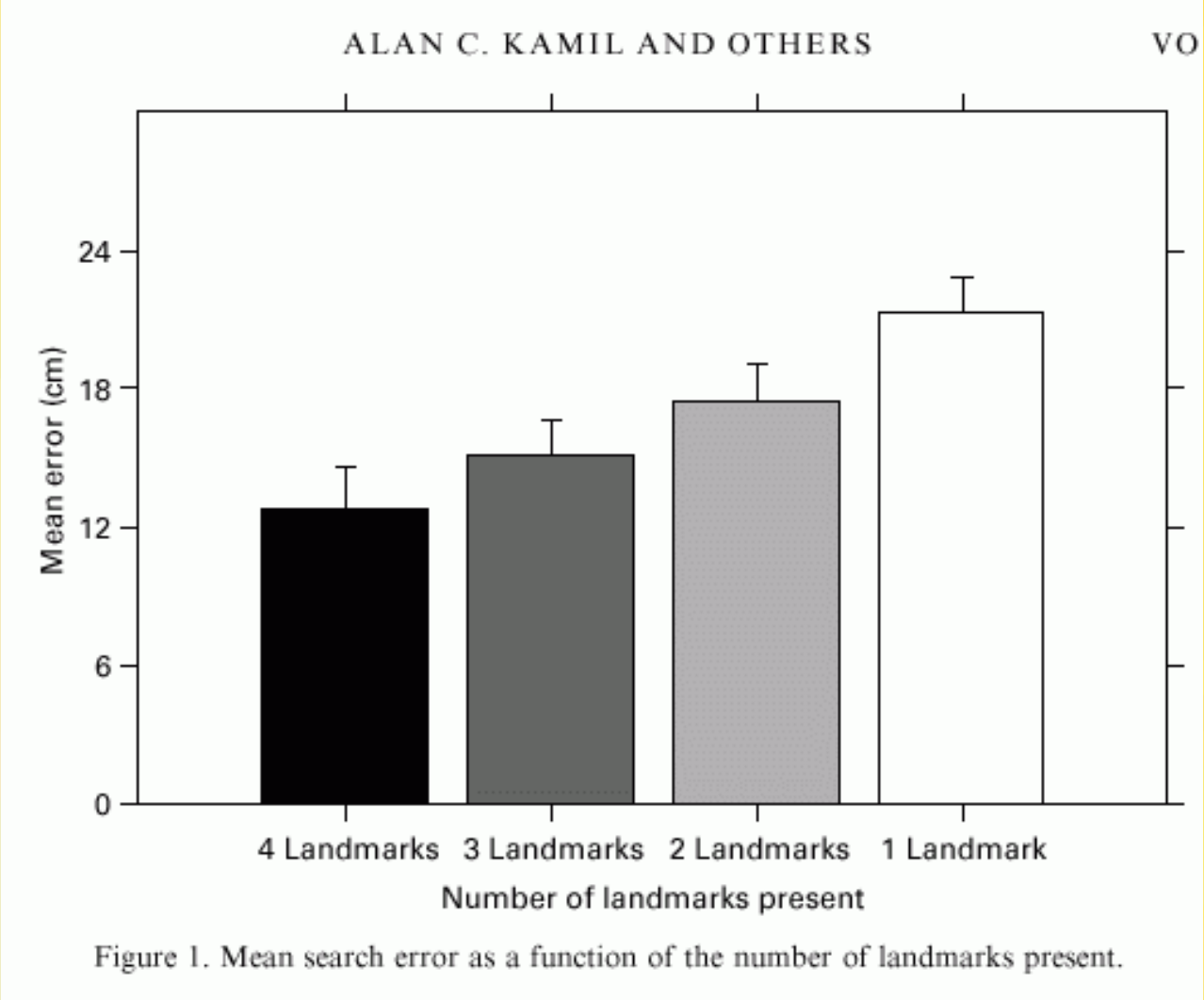


Figure 1. Mean search error as a function of the number of landmarks present.

Where is the memory stored?

Navigation in mammals: hippocampus (later)

Birds: candidate area also in hippocampus

? Testing the hypothesis ?

Lesions in hippocampus

Comparison of storer and non-storer species

individuals

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampal lesions

Storing behaviour not affected

Retriving diminishes

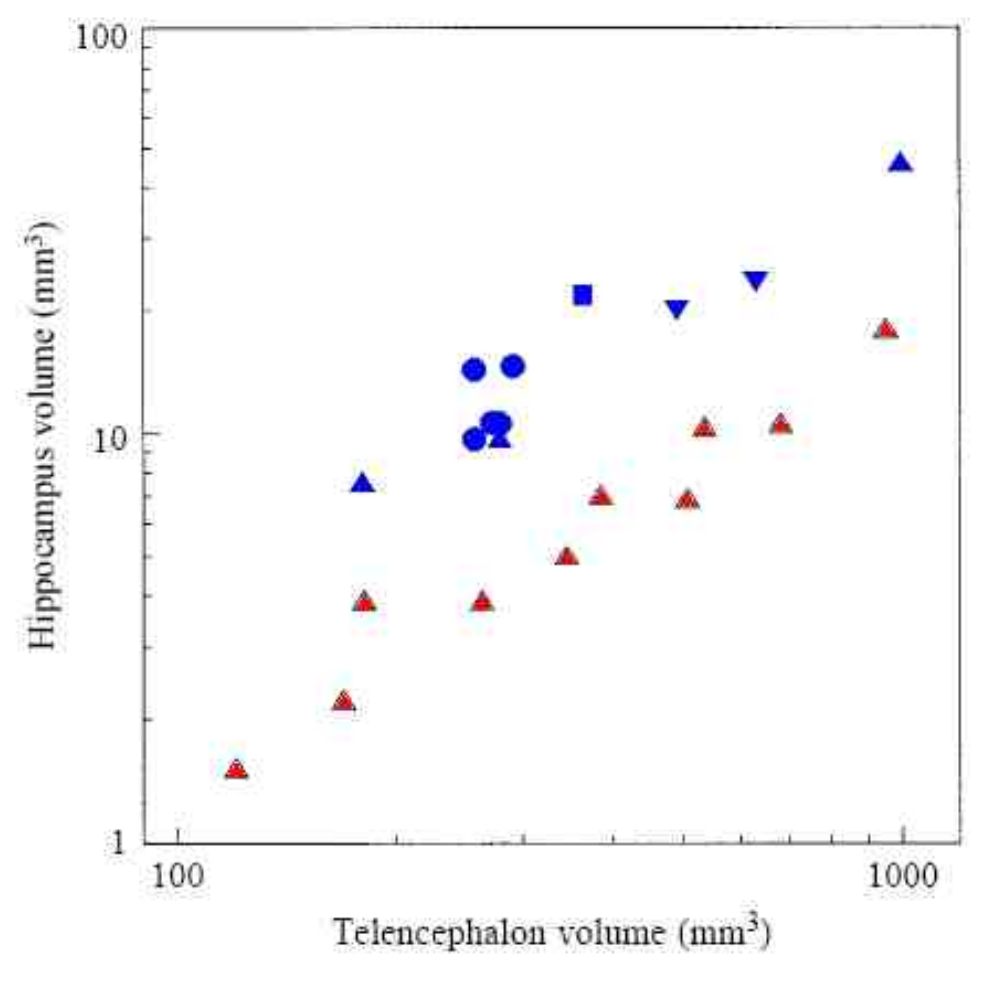
? What does it indicate ?

Motivation, motor skills: independent of hippocampus

Hippocampus is critical in spatial memory

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampus – storers and non-storers



Blue: storers

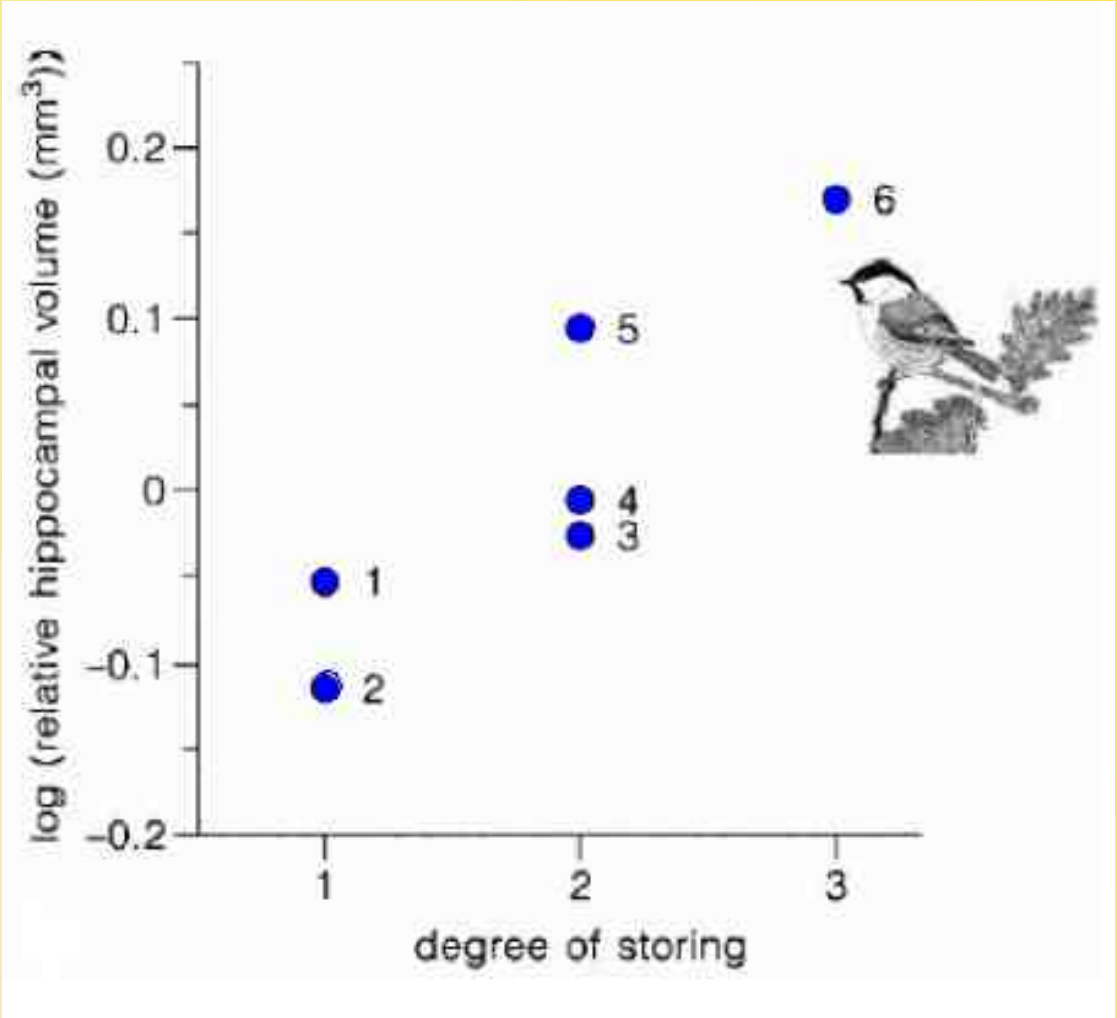
Red: non-storers

Relative volume of Hippocampus of storers is bigger

http://jeb.biologists.org/cgi/reprint/199/1/165.pdf

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampus – comparison within storer species



More caching -

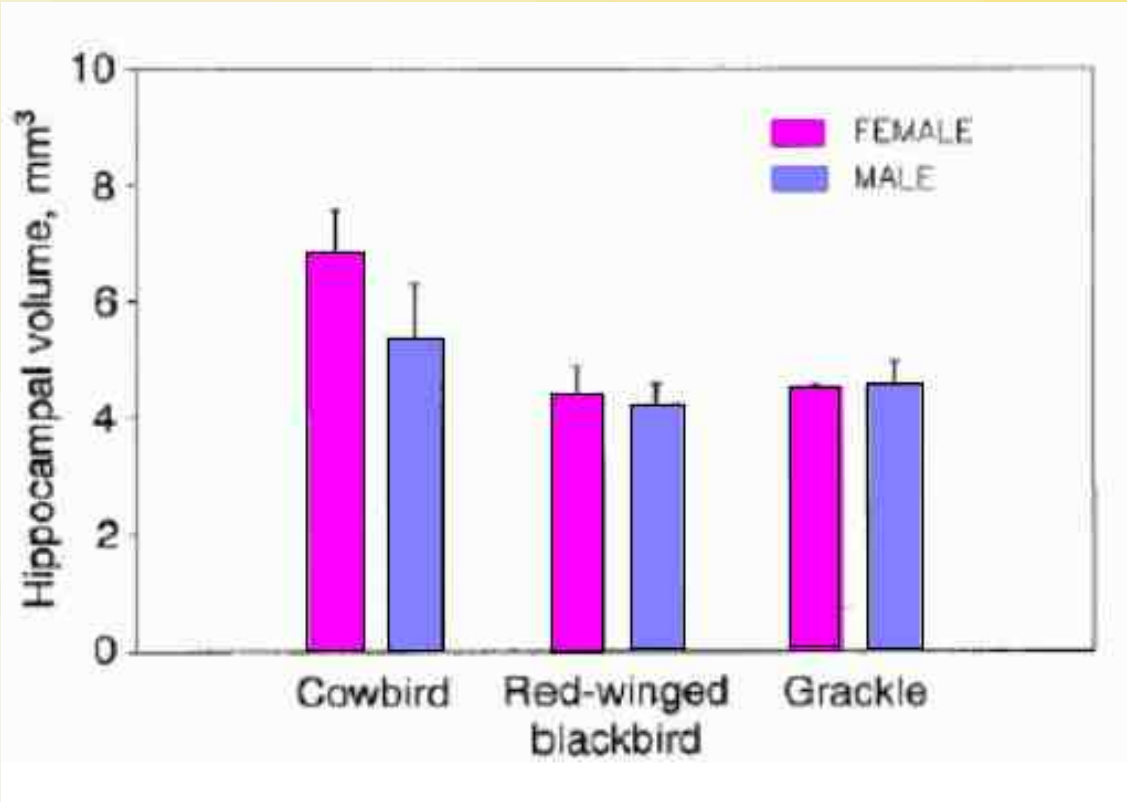
larger hippocampus

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampus – between sexes

No differences (except brood parasites)

Brood parasites: who is smarter, boys or girls?



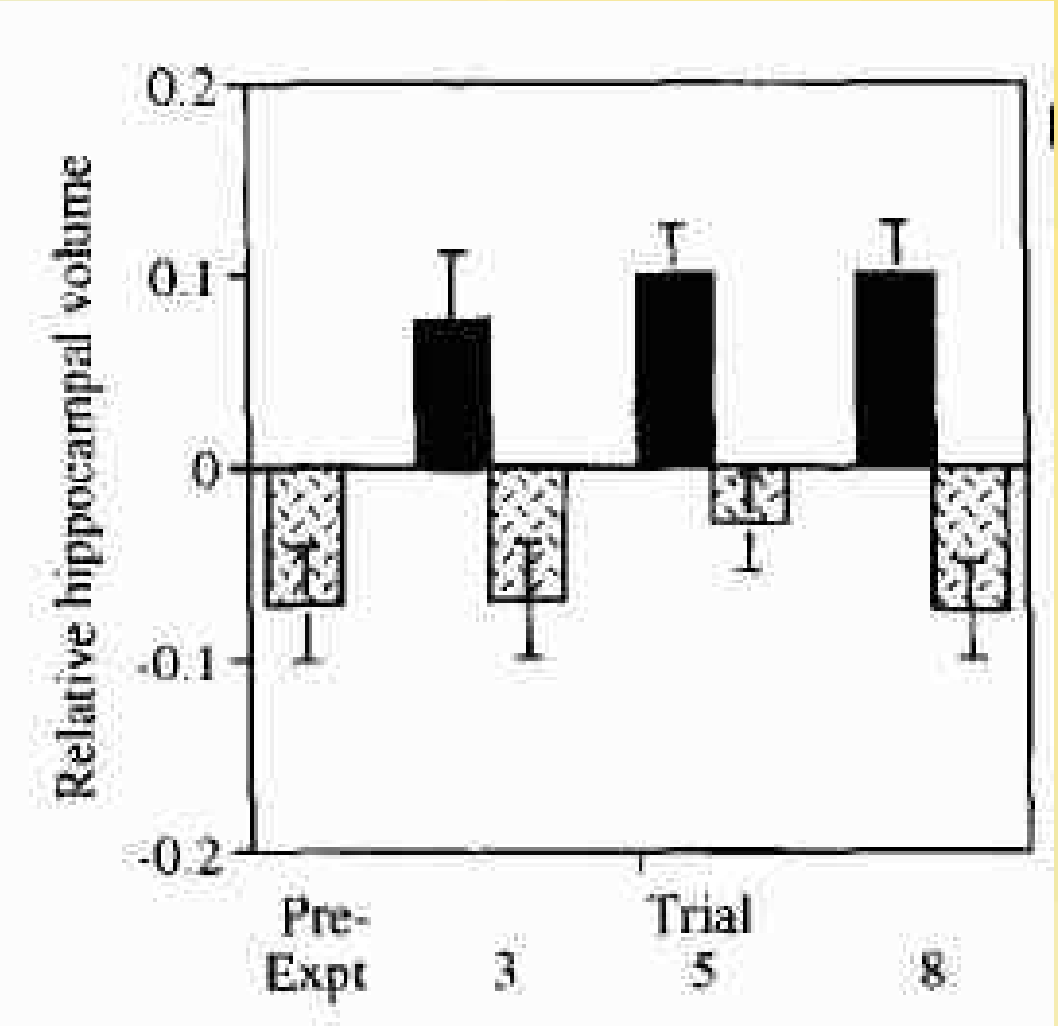
Female > male

? Why?

Memorises all suitable nests

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampus – among individuals



Relative hippocampal volume

black: experienced
grey: naív

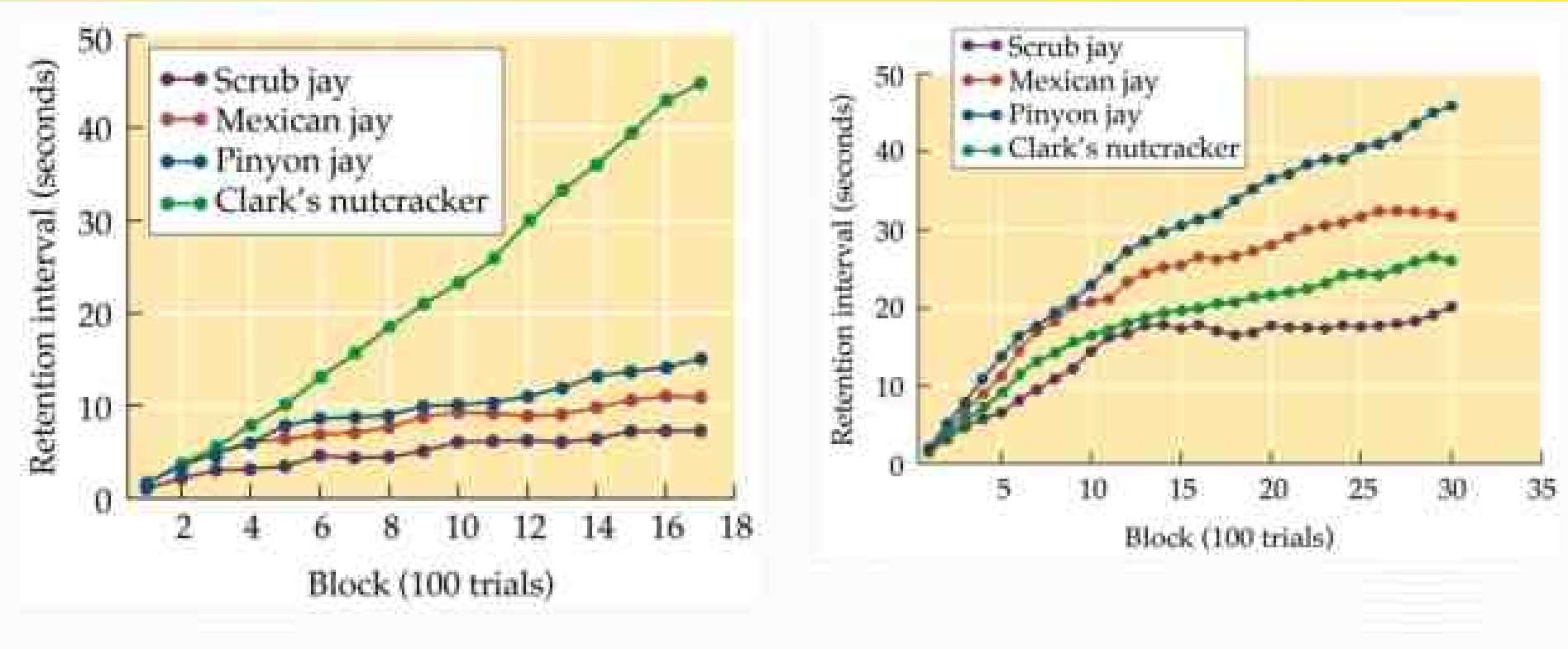
Hippocampal volume increases by practice in young birds.

What is the mechanism?

NEUROGENESIS!

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Retrieval: specific skill



Retreiving a circle in space: Scrub jay is superior

Other tasks (remembering the colur of circle): not better

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Spatial navigation

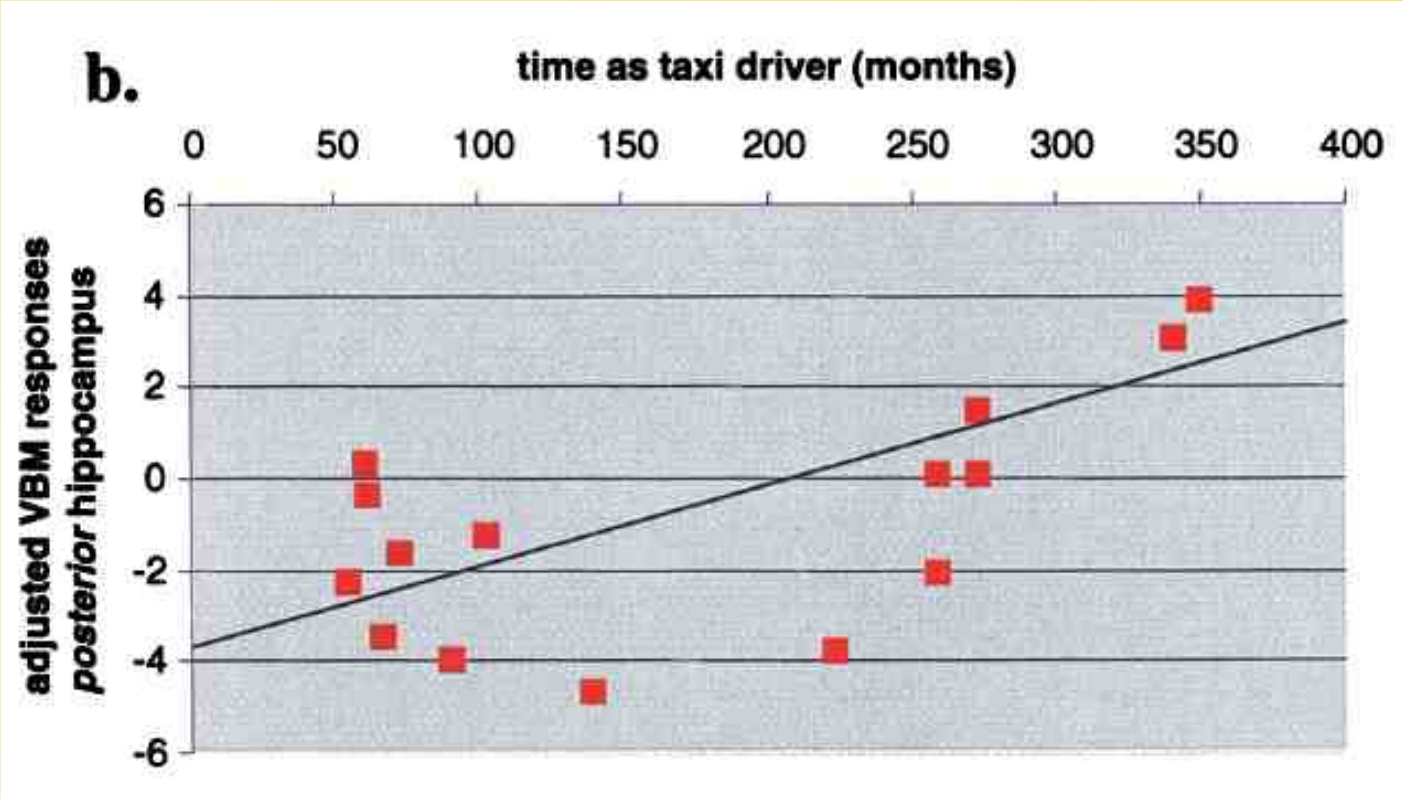
Human hippocampus?

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Taxi drivers in London:

Posterior hippocampal volume increases by practice (Maguire et al., 2000. PNAS)

Cause – causation? Could it be stress?



Taxi drivers have larger hippocampus than bus drivers!

(Maguire et al. 2006. Hippocampus)

Neurogenesis!

Hippampus of one driver was damaged in accident
Computer-simulated driving:

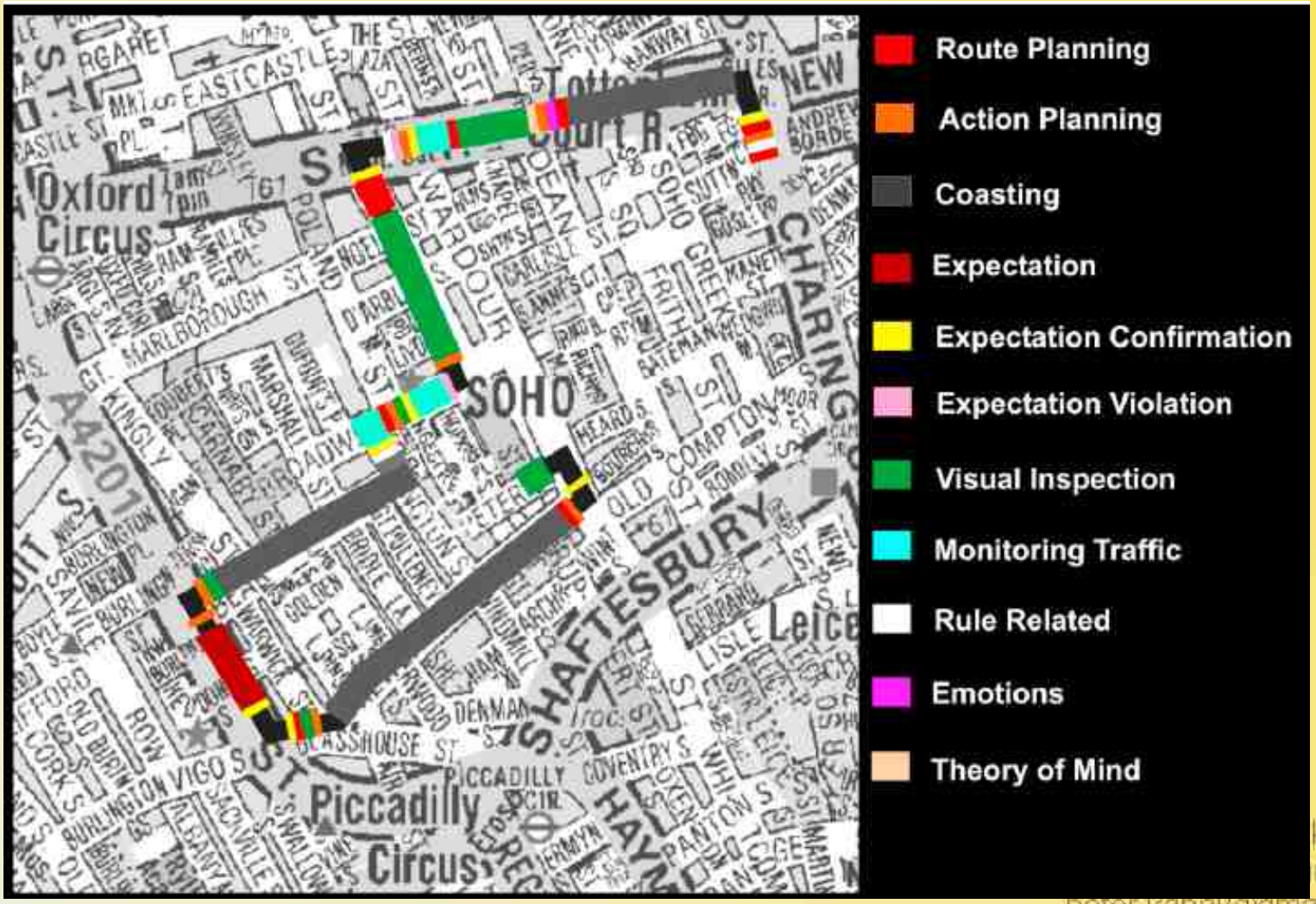
- Driver navigated rather well in places memorised 40 years earlier
- However, only in main streets. Got lost in side streets.

Peter Kabai
www.behav.org
peter.kabai@gmail.com

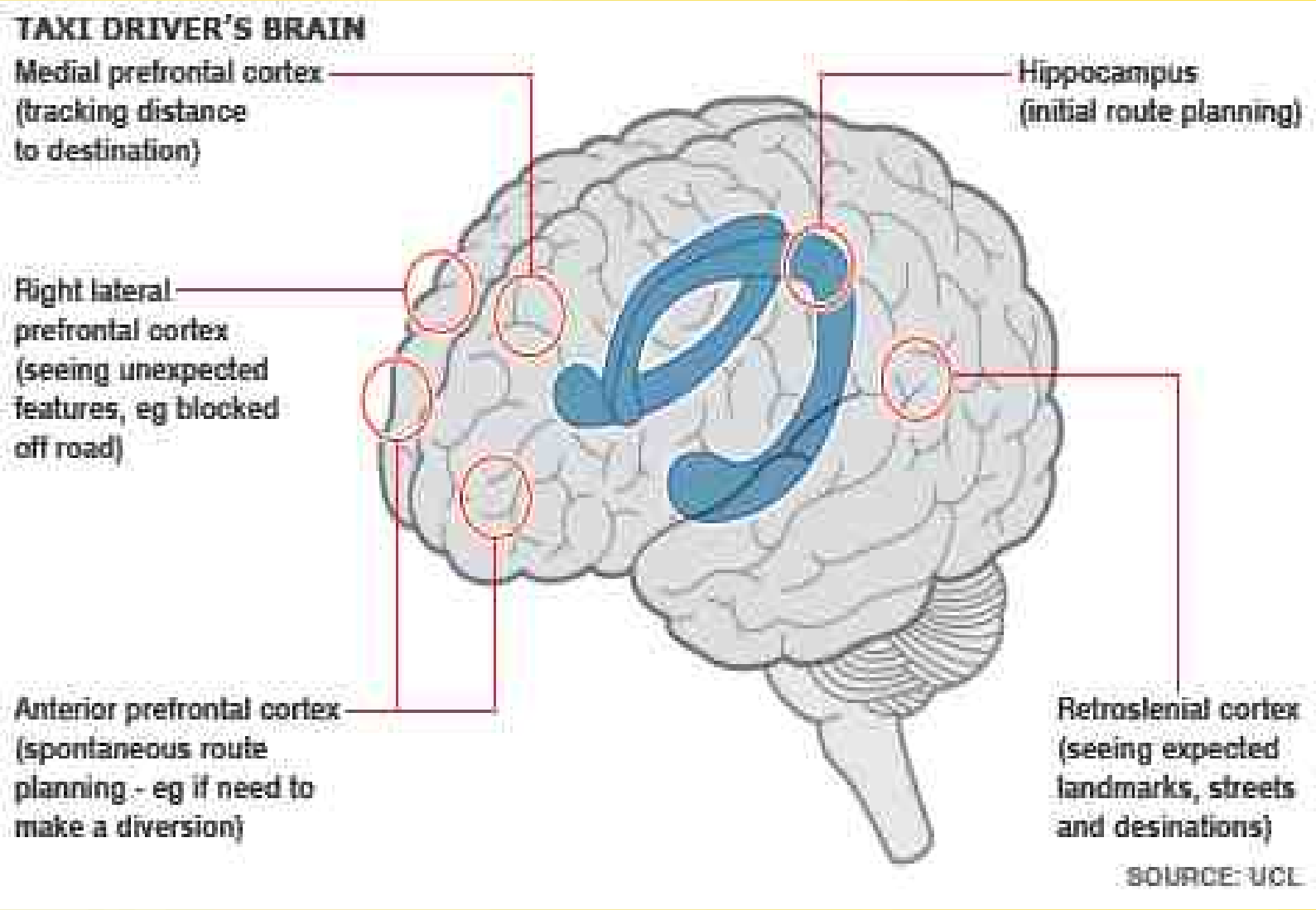
Spiers and Maguire, 2008. *J Environ Psychol*.

Simulated driving (Play-station) in fMRI

Video played back, drivers commented their actions.



Kabai
av.org
peter.kabai@gmail.com



Initial route planning: hippocampus

Tracking distance, seeing unexpected features
spontaneous route planning: prefrontal cortex

Peter Kabai
www.behav.org
peter.kabai@gmail.com

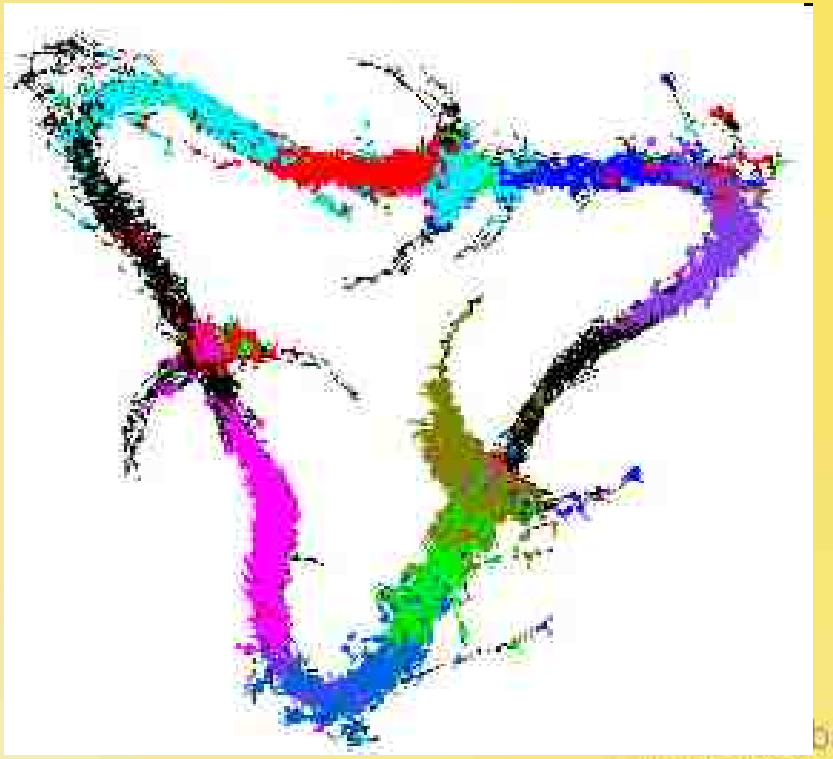
Hippocampus: how are cognitive maps coded?

Figure: rat running on an elevated triangular track, stopping and eating in the middle of each arm. Black dots indicate the position of the head, coloured dots represent firing of individual neurons

Place neurons: location of the rat can be reconstructed

Firing of place cells depend
on context even when the contexts are defined by abstract task demands rather than the spatial geometry of the environment.

Declarative memory: very similar



IN THE NEWS

Sharks navigate using 'mental maps'

By Richard Black
Environment correspondent, BBC News

Some shark species make "mental maps" of their home ranges, allowing them to pin-point destinations up to 50km (30 miles) away, research suggests.

US-based scientists analysed data from tiger sharks tagged with acoustic transmitters, and found that they took directed paths from place to place.

Other species such as blacktip reef sharks did not show this behaviour.

Writing in **the Journal of Animal Ecology**, researchers suggest this shows a capacity to store maps of key sites.

In addition, it is further evidence that the great fish can navigate, possibly using the Earth's magnetic field.

Tiger sharks can navigate on scales of many kilometres - perhaps aided by internal maps

Earlier research in Hawaii had shown tiger sharks swimming across deep channels and finding shallow banks rich in food 50km away.

Related Stories

Shark nations failing

Sensing geomagnetic field?

Peter Kabai
www.behav.org
peter.kabai@gmail.com

Hippocampus: spatial navigation and what else?

Types of memory

Declarative: conscious recall

Semantic: Tinbergen's 4 questions

Epizodic: It was a boring lecture

Procedural memory: implicit learning (motor skills)

Hippocampus: spatial and declerative learning

- If damaged, no new long-term memory
- Procedural memory intact

Spatial memory: remembering places in time

Epizodic memory: remembering events in time

Peter Kabai
www.behav.org
peter.kabai@gmail.com