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NAVIGATION NEWS

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MARITIME NAVIGATION: ART OR SCIENCE? A PILOT'S PERSPECTIVE

Path Integration

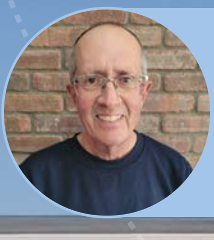
LESSONS FROM THE DESERT ANTS

FROM PAPERS TO POLYTUNNELS

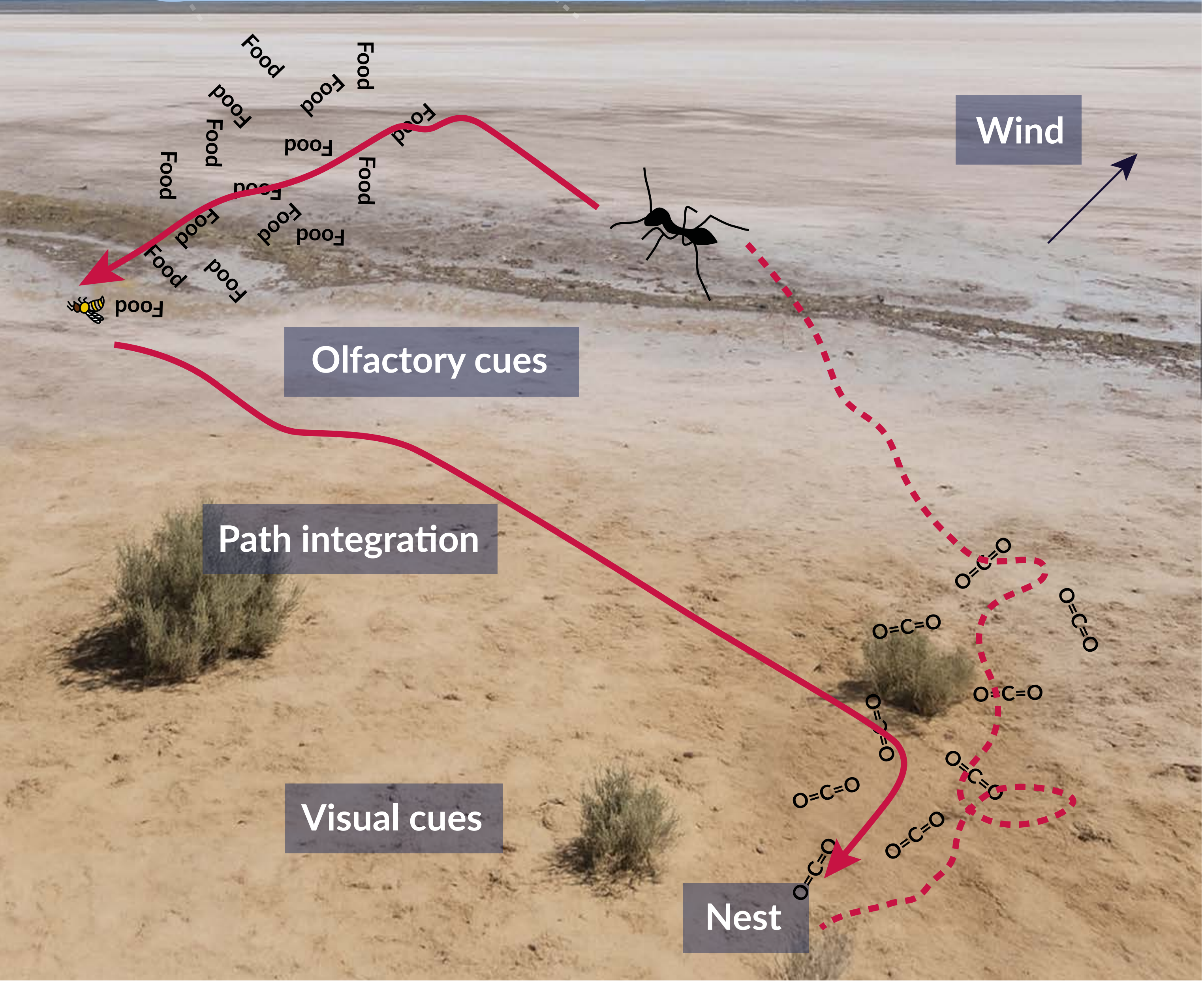
PLUS: 2026 Awards & Fellowship Deadline • Women in Navigation Group

ROYAL INSTITUTE OF NAVIGATION

Path Integration: Lessons from the Desert Ants

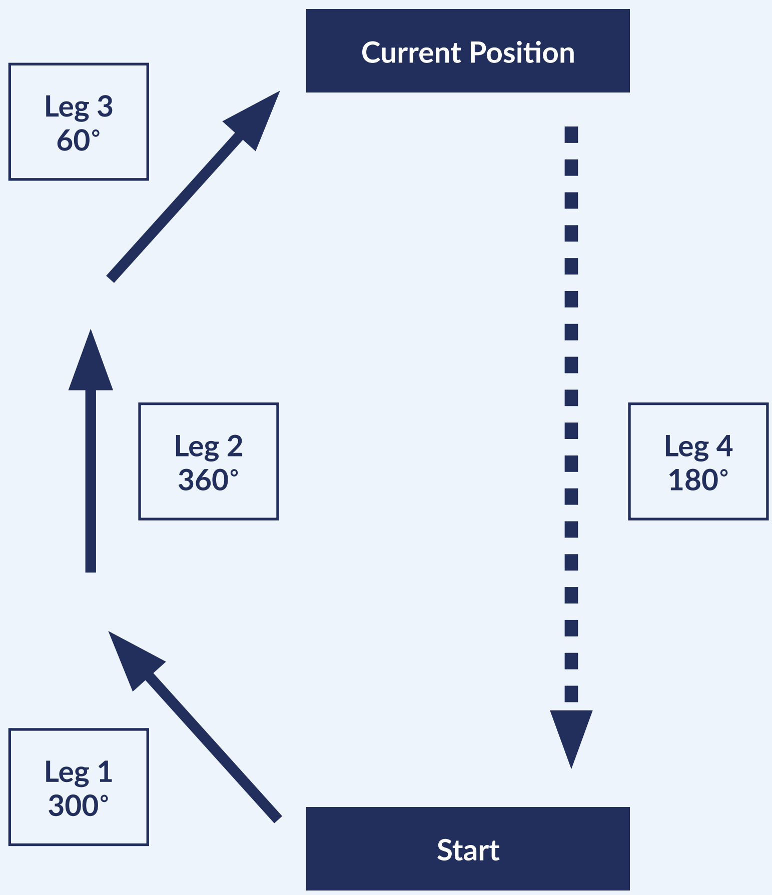


David Wagner, member of the Outdoor Adventure Navigation Group (OANG)



Sailors refer to it as Dead Reckoning. By taking into account the ship's direction, speed, and the duration spent on each course and at each speed, the navigator could determine the route and distance traveled. If a sea chart was available, he could then record this information. Columbus utilized this method.

Path integration involves constantly updating your position and orientation by blending changes in direction and distance as you move. It helps estimate your current location and guides you back to your starting point. Navigating back to your starting point, AKA dead reckoning, is one of the most dependable methods for ensuring you don't get lost, making it especially useful for those who like to explore off the beaten path. Practicing this skill in a familiar local park or when there's dense fog can boost your confidence, just like I found when I was navigating through new areas off-trail (similar to the diagram of one of my practice trips) while in a region with catching features (I was in an area that had trails, fencing, and roads). Start at a recognizable landmark (I chose a kiosk). And remember, don't venture out alone! Make sure to take a GPS device and/or a physical map. Make it simple, e.g., 1 inch = 1 km (like Harvey Maps uses). Jot down your journey in your notepad and take notes as you go.



Cataglyphis velox:
Barbara Webb, University of Edinburgh

"Cataglyphis ants rely on two primary navigation methods: path integration, which allows them to navigate without landmarks, and view-based landmark guidance, enabling them to memorize, recall, and follow various routes through their complex environments."

Images clockwise from top left: Cataglyphis fortis: Pauline Fleischmann, Univ Oldenburg, Melophorus bagoti: Cody Freas, Macquarie Univ, C. fortis: Cornelia Buehlmann

3 Desert Ants, 3 Continents (What we can learn from them)

Cataglyphis fortis (Tunisia), C. velox (southern Spain), and the Melophorus bagoti (central Australia) have mastered the art of precise path integration. These remarkable ants can venture out to forage for food hundreds of meters away from their nest. Equipped with a natural step-counting mechanism and a time-compensated celestial compass, they navigate using the sun's position and the UV polarization patterns in the sky. It's impressive, considering they operate with brains that consist of just 500,000 neurons, in stark contrast to the 85 billion neurons found in humans. Their nests are simply small holes dug into the ground. While seeking dead insects during the sweltering heat of midday – which helps them avoid both predators and competition – soil temperatures can soar to a scorching 70°C (158°F). Cataglyphis ants rely on two primary navigation methods: path integration, which allows them to navigate without landmarks, and view-based landmark guidance, enabling them to memorize, recall, and follow various routes through their complex environments.

Social insect foragers are expert navigators. To accurately localise the nest at the end of a foraging journey, visual cues, wind direction and also olfactory (smell) cues need to be learnt. Using a combination of innate navigational strategies and learnt information from their environment.[1]

Given the availability of a rich array of cues, from idiothetic (self-motion) information to input from sky compasses and visual information through to olfactory and other cues (e.g. gustatory (taste), magnetic, anemotactic (wind) or thermal) it is no surprise to see multimodality in most aspects of navigation.[2]

We show that despite their impressive homing accuracy, ants returning from long foraging journeys face a mortality rate of up to 20%. Our data suggest that the desert ant builds its own landmark, elevating their nest entrance on purpose in a featureless environment to increase its chances of successful homing and survival.[3]

M. bagoti, which inhabits a visually cluttered environment; whereas the relatively featureless terrain traversed by C. fortis may have led them to optimize for path integration.[4]

> "Equipped with a natural step-counting mechanism and a time-compensated celestial compass, they navigate using the sun's position and the UV polarization patterns in the sky."

Transferable "Toolkit Strategies" from the desert ant to humans

INFORMATION

- [ ] Pacing (odometer)/Vector length
- [ ] Visual cues (landmarks, e.g. nest mound) Including...
  - [ ] Celestial Cues (sun's position and UV polarization patterns)
  - [ ] Terrestrial Cues (vegetation)
- [ ] Magnetic (compass)
- [ ] Wind (anemotactic)
- [ ] Smells (olfactory)

STRATEGIES

- [ ] Long term memory of environmental information
- [ ] Innate responses to environmental information
- [ ] Exploration (Learning Walks) and Search (when Path Integrations has some errors)
  The ants repeatedly stop their forward movement to perform rotational body turns. Two distinct types of turns – voltes and pirouettes. It's a looking-back behaviour to see where they came from
- [ ] Backtracking (recent experience of nest views and remembering direction just travelled)
- [ ] Local Vectors (e.g. Nest to large rock)

Robotics

This work focuses on animal behavior, bio-inspiration, biomimicry, and bio-inspired robotics to create precise long-term navigation systems which operate without recourse to man-made infrastructures (e.g. GPS or 5G networks). This allows us to explain perception-action coupling to understand animals' spatial orientation mechanisms and to apply them to robotics. The researchers drew inspiration from the Cataglyphis fortis!

Source: Institute of Movement Sciences – Étienne-Jules Marey (CNRS/Aix Marseille Université, UMR7287)

AntBot

https://www.youtube.com/watch?v=MDWShtqXxyY&t=106s

https://serres-lab.com/research/completed-projects/the-hexapod-robot-antbot/

AntCar

https://www.youtube.com/watch?v=iRewX9KLJDQ&t=81s

https://serres-lab.com/research/completed-projects/antcar/

AntBot & AntCar: Julien Serres, Aix Marseille Univ

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(2) Buehlmann, C., Mangan, M., & Graham, P. (2020). Multimodal interactions in insect navigation. Animal Cognition, 1-13.
(3) Desert ants increase the visibility of their nest entrances in the absence of landmarks https://www.ice.mpg.de/448076/PR_Freire (by Dr. Markus Knaden)
(4) Michael Mangan, Barbara Webb, Spontaneous formation of multiple routes in individual desert ants (Cataglyphis velox), *Behavioral Ecology*, Volume 23, Issue 5, September-October 2012, Pages 944–954 , https://doi.org/10.1093/beheco/ars051
(5) Dupeyroux, J., Serres, J. R., & Viollet, S. (2019). AntBot: A six-legged walking robot able to home like desert ants in outdoor environments. *Science Robotics*, 4(27), eaau0307. HAL: https://hal.science/hal-02075700
(6) Gattaux, G., Wystrach, A., Serres, J. R., & Ruffier, F. (2024). Continuous Visual Navigation with Ant-Inspired Memories. HAL: https://hal.science/hal-04820343

IMAGE CREDITS

Page 20 – Cornelia Buehlmann, University of Sussex
Page 21 – Chris Sweetman, Associate Fellow of RIN, Intro Directional Graphic, UK

FURTHER READING

"Incredible Journeys", David Barrie (Animal Navigation Group, RIN)
"Desert ant navigation: How miniature brains solve complex tasks." Dr. Rudiger Wehner
"Cataglyphis ants have a polarity-sensitive magnetic compass," Grob, Robin et al. Current Biology, Volume 34, Issue 24, 5833-5838. e2
The Green Beret's Compass Course, Don Paul, 2006.
Land-Navigation.com (Reid Tillery) Online course

CONTRIBUTORS

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5. Dr. Cody Freas, School of Natural Sciences, Macquarie University, Sydney AUSTRALIA
6. Robert J. Koester, PhD, author of Lost Person Behavior, USA

Tunisian Salt Pan:
Pauline Fleischmann