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EDITORIAL

Linking brain and behaviour in animal navigation: navigation from genes to maps

Almut Kelber[1,*], Barbara Webb[2] and Basil el Jundi[3]

Almut Kelber (left) is a JEB Editor and Professor of Sensory Biology at the University of Lund, Sweden. She works on colour vision and visual orientation of animals such as birds and moths. Barbara Webb (middle) is Professor of Biorobotics at the University of Edinburgh. She builds computational and robot models of insect navigation. Basil el Jundi (right) is the head of the Animal Navigation Emmy-Noether Group at the University of Würzburg, Germany. He studies insect orientation using electrophysiological, anatomical and behavioural techniques.

Finding our way to a scientific meeting, to a holiday destination or back home has become less of a challenge with GPS but, historically, this has been a difficult task that has led to major innovation such as compasses, precise clocks and maps. Animals show impressive navigational abilities whether returning to a close-by goal or migrating thousands of kilometres across entire continents and oceans. They move on their own or in large groups and they can use visual landmarks, olfaction, magnetic maps, celestial cues and more, often integrated with internal cues for self-motion. Can we identify common navigational strategies used by animals? How does the brain act as an animal's internal navigation system? And what is the genetic basis of such complex behaviour?

On the one hand, field studies and behavioural experiments on animals as varied as insects, bats and birds have revealed different navigational mechanisms, such as olfactory navigation, landmark memories, path integration and time-compensated sky compass orientation. Electrophysiological recordings, on the other hand, have given us an understanding of how potential cues for navigation are processed in the brain. State-of-the-art-techniques measure neural activity in freely behaving animals, and genetic methods can reveal the role of individual brain areas. Last but not least, navigating robots allow us to test what can be achieved with specific algorithms and models.

This special issue highlights recent advances in our understanding of the physiological mechanisms underlying navigation in a vast array of organisms ranging from tiny insects, snails and fish larvae to rats, humans and robots. The comparative perspective helps us to understand general principles and mechanisms underlying topics such as compass navigation, course control, odometry, spatial and olfactory memory and group navigation. It also clearly demonstrates that different solutions evolved depending on the ecology of the animal; central place foragers such as insects with a sky compass navigate differently from humans moving between known locations of interest. Animals moving through water have access to different reliable cues and mechanisms from those available to animals surrounded by air. In turn, walking on the ground allows animals to use different orientation strategies from those used by flying or swimming animals. While most sensory modalities used for navigation are now quite well understood, the neural basis of the magnetic sense, used by many animals, still awaits discovery.

The brain centres involved in navigation are best understood in mammals and insects and, given the different navigational strategies used by these animals, it is fascinating to see that similar types of information are coded by cells in the mammalian hippocampus and the insect central complex. Perhaps the most fascinating new direction of navigation research is opened up by new genetic tools that may allow us to unravel how naive birds or butterflies find the hibernation or aestivation area that they inherited from their parents.

We hope readers enjoy exploring the different facets of navigation research as much as we do.

[1]JEB Editor at Department of Biology, Lund University, SE-223 62 Lund, Sweden. [2]School of Informatics, University of Edinburgh, 10 Crichton Street, Edinburgh EH8 9AB, UK. [3]University of Würzburg, Biocenter, Zoology II, Emmy-Noether Group, 97074 Würzburg, Germany.

*Author for correspondence (almut.kelber@biol.lu.se)

A.K., 0000-0003-3937-2808; B.W., 0000-0002-8336-6926; B.e.J., 0000-0002-4539-6681