Explainer: How do homing pigeons navigate?

April 23 2014, by Tim Guilford

Not stopping for directions. Credit: Alan D. Wilson, CC BY-SA

Pigeons have extraordinary navigational abilities. Take a pigeon from its loft and let it go somewhere it has never been before and it will, after circling in the sky for while, head home. This remarkable capacity extends to places tens even hundreds of kilometres from its home and is all the more remarkable to humans because we are apparently incapable of it ourselves.

But we have long made use of the pigeon's homing ability, principally

for carrying messages in the past. And for several decades now the pigeon has played centre stage in scientists' attempts to understand the map and compass mechanisms fundamental to bird navigation.

So what have we learnt?

Out of direct contact with home, and out of the landscape to which birds have become familiar, there must nonetheless be large-scale cues available to the navigating bird with which it can estimate its position relative to home. Many theories have waxed and waned, from reading the sun's arc to the detection of long-distance infra-sounds. But there is little support for these.

Magnetic misgivings

Most attractive and persistent has been the idea that pigeons can use the predictable gradients of intensity and dip-angle in the earth's magnetic field to map their position relative to known values at home. The magnetic map hypothesis is attractive and persistent, but largely without support after decades of experimental research. It is also probably false.

Part of the confusion is that many birds (and probably pigeons) do have a magnetic compass which gives them a sense of direction when they cannot see the sun. A compass helps make long-distance movement efficient and is central to migration, but it cannot help you navigate if you do not know the direction of your goal. This requires a map. Unlikely as it may seem, this map turns out almost certainly to be olfactory – pigeons, and perhaps all birds, navigate using smell.

Good nose for direction

Pigeons deprived of the ability to smell cannot navigate. Fool them with

air form the wrong site and they will fly in the wrong direction. This sounds a simple thing to demonstrate, but in fact testing the olfactory navigation hypothesis conclusively has proved remarkably taxing and there are still experts who doubt it on reasonable grounds.

But the weight of evidence from 40 years of study makes the case pretty strong. It's likely that birds learn the rough composition of atmospheric volatiles characteristic of their home area and how this varies with winds that come from different directions, and are then able to extrapolate to unfamiliar places if they are blown off-course or taken there by a human and released. Even over the open oceans, birds (not pigeons of course) may use odours to navigate.

Closer to home, however, olfactory deprivation has little effect on a pigeon's orientation, and it seems that they switch to a second mechanism dominated by visual landscape cues. Until recently scientists lacked the tools to observe detailed movement with sufficient detail outside the laboratory. But the advent of miniature on-board tracking technologies such as GPS now allows us to follow birds with astonishing precision and unravel the mechanisms of their spatial cognition in the wild.

New findings

We've now learn that pigeons repeatedly released from the same site soon learn a habitual route home which they stick to faithfully even if it is not the quickest. Different individuals learn, and stick to, different routes. Routes often follow linear landscape features, such as roads or field margins, but are learnt most effectively over landscapes of intermediate complexity. This means that urban landscapes may in fact be too complex for optimum route learning.

Pair birds with different ideas about how to get home from the same

place and the result is an elegant exposé of each bird's propensity to lead out or follow others02155-5). Birds that are more faithful to their own route when homing alone are more likely to emerge as leaders when homing socially.

So if the pigeon's brain contains a network of learnt routes, how are these memories acquired and how do they interact? Recently, my colleagues Andrea Flack and Dora Biro showed that having to learn three routes in parallel doesn't cause pigeons any additional confusion. Route-learning is memorised independently, regardless of whether the sites they are released from are encountered sequentially, randomly intermingled or in strict rotation.

Treating the art of pigeon homing as a natural learning laboratory is a new science into which we are just taking the first steps, and it seems that we have yet to find the boundaries of the bird's abilities. Clearly, we still have much to learn from the pigeon.

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