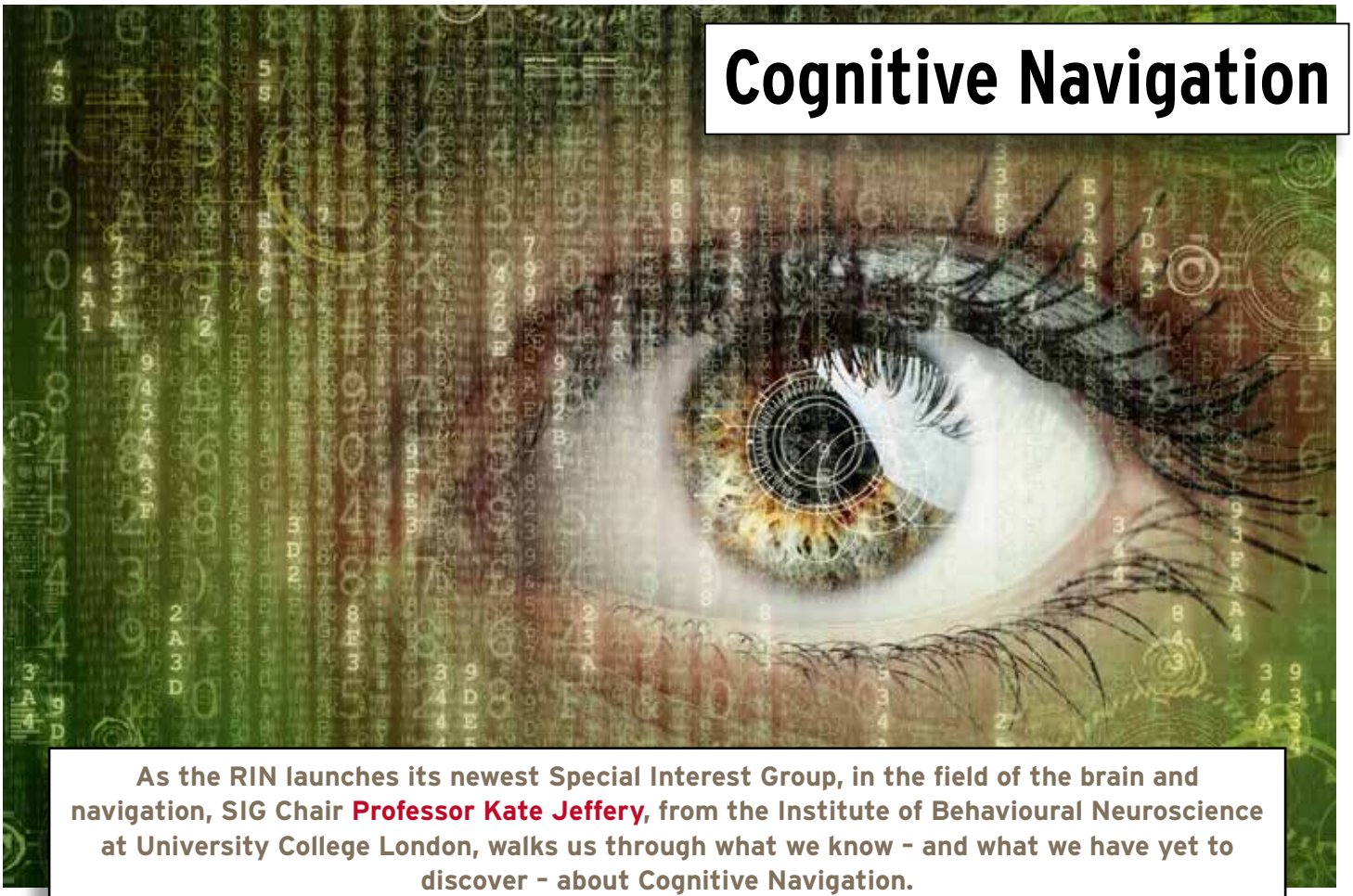
Cognitive Navigation



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As the RIN launches its newest Special Interest Group, in the field of the brain and navigation, SIG Chair Professor Kate Jeffery, from the Institute of Behavioural Neuroscience at University College London, walks us through what we know – and what we have yet to discover – about Cognitive Navigation.

Humans have always liked navigating. Since the earliest times we have, as a species, ventured forth into unknown territory to find new resources or to escape famine, war or disease, and anthropological studies of populations like the Polynesian seafarers [1] or the Aboriginal Australians [2] have revealed an ancient and sophisticated ability to use the sun, the stars and mnemonic devices to allow travellers to return safely home after venturing over vast unknown distances.

Eventually, we learned how to record spatial information in ways that could be used by others, perhaps at a later time. Originally these records were in narrative form, like the Aboriginal songlines [2], but then we learned how to encode spatial information directly, in the form of maps, and navigation technology began.

Aboriginal people used sophisticated natural navigation systems. Credit: iStockphoto.com/USO

Information nodes in the world of the net could change how we think about navigation. Credit: iStockphoto.com/cofotoisme

The Limitations of Technology

Navigation technology for machines travelling long distances is now highly sophisticated and relatively straightforward, making use of global navigation satellite systems (GNSS) to acquire positional information of unprecedented accuracy. It has limitations, however: the dependence of such a critical domain of operation on one single, external technology makes us vulnerable, as the many recent examinations of 'GNSS vulnerability' attest (e.g. (*3*)). Furthermore, despite decades of research into robotics and artificial intelligence, we still have not yet managed to make a navigation device that can fit in a pocket and tell someone how to navigate around a hospital or conference complex, or indeed anywhere where satellite signals do not penetrate. Moreover, it isn't only machines that navigate, it's also humans – 7 billion of us and counting, living in increasingly crowded and complex cities. Think about the millions that pour out of the London Underground every day, for example. The great challenge for the future will be to design navigation technology that interfaces with the human mind, so that we humans can find our way around these cities effortlessly, without really thinking about it and without obstructing each other.

One in 7 billion – humans find their way through their complex urban environments, individually and en masse. Credit: iStockphoto.com/praetorianphoto

The Goal of Knowledge

There is another possible goal that should be considered too. Merely getting people from A to B is one thing, and we can envision ongoing development of smartphone positioning technology until the phone in your pocket does know exactly where it is, even indoors and out of satellite range, and can tell you exactly how to get to where you want to go. But is that entirely satisfying? Are we facing a future populated by billions

of mindless automata being steered by their phones? We should think about an alternative future where our technology doesn't just give us instructions, but gives us *knowledge* – that is, it conveys a sense of where we are not only in X-Y coordinates but also in relation to the world around us. In order to reduce spatial unease (the sense that you don't really know where you are or which way you are facing) we want people to become *more* engaged, not less, with their surroundings, and so we should start thinking about how to provide technology that integrates people with their environment rather than just steering them passively through it.

Self-Augmenting Reality

How can we achieve this? It seems likely that new navigation technology will involve augmented reality, via some (more successful) variant of Google Glass [4] or even implanted devices. We should also be thinking of making the environment more informative. Signage, as a discipline, is becoming ever more sophisticated, but it is still rooted in old-fashioned methods, using words and maps which we know from cognitive science don't readily engage with the brain's navigation circuitry. We should start to think about how to get more creative with our new technologies, so that, in essence, our reality augments *itself*.

Virtual Reality gives the potential for layers of additional context and integration to our awareness of our position.
Credit: iStockphoto.com/franckreporter

Navigation is not just for the real world either. As virtual reality technology advances apace, we are faced with a possible future in which people can navigate through invented worlds, or even multi-dimensional worlds. The internet, the most multi-dimensional world of all, offers amazing possibilities for being organised spatially in a way that can be travelled through by virtual explorers. Can the human mind make 4, 5 or many-dimensional maps? We don't yet know, but the answer will for sure be interesting.

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Going Beyond Co-Ordinates

Navigation that involves minds, rather than just machines, is what we mean by 'cognitive navigation.' Cognition means knowledge, and cognitive navigation – navigation that uses knowledge of the surroundings – has been studied by psychologists for decades. In fact, within psychology it has probably been the most-studied cognitive competence of them all, beginning with the early studies of rats in mazes [5] that still continue today.

> Furthermore, when we design intelligent navigating agents, they will also need spatial knowledge, as well as merely spatial positioning ability.

This is partly because spatial cognition is interesting and fundamental, and because important discoveries over the past several decades have unlocked the door to a rich system within the brain that is involved in figuring out position, and in planning routes to goals [6]. However, it is also because spatial

Maps – not bad, but they require skills and mental processing. Now, where did I go wrong?
Credit: iStockphoto.com/PeopleImages

knowledge forms the foundation of episodic memory [7], which is the memory that we have for the events of our lives that gives those lives richness and meaning. While a machine may be able to report that it is at 51° 30' 5.598" N, 0° 10' 29.946" W, only a human can say 'I'm in the RIN meeting room at the Royal Geographical Society, and as it's a beautiful day, perhaps we should have lunch in Hyde Park since it's just across the road.'

Cognitive navigation integrates the navigator with their surroundings, in both time and space, and also with other navigators, and with plans, goals, emotions and memory. It is rich and complex, and a complete science of navigation will therefore take into account cognition as well. Furthermore, when we design intelligent navigating agents, they will also need spatial knowledge, as well as merely spatial positioning ability.

The RIN – Meeting The Need For Convergence

Because new navigation technology will be modelled on and/or interface with the human mind, it is necessary to know something about how that mind works in order to develop this technology. To achieve this we need cognitive scientists, urban planners, engineers, designers, architects, computer scientists and experts from many other disciplines to meet and exchange ideas.

For this reason we are forming a new Special Interest Group within the Royal Institute of Navigation. Called 'CogNav' (Cognitive Navigation), it aims to provide a forum for all these disciplines to converge.

Our inaugural meeting on 14 June this year will be its launchpad, and we plan to hold regular meetings thereafter, as well as to collect and maintain a database of navigation-related experts that can be consulted for purposes of communication and collaboration.

We hope with this forum to integrate the science of cognition with the science and practice of technology design, so that we can move forward into a future where self-localisation becomes far more than simply placing a cross on a map, and navigation far more than a list of actions.

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