EXPLAINING WAYFINDING BEHAVIOUR AND COGNITIVE MAPPING
Book Review of Golledge on Cognitive-Mapping

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Abstract

The debate on what lies behind the amazing wayfinding abilities of animals and humans started several decades ago. No definite answer has been given yet, however many theories have arisen, from which only a handful have been confirmed through experimental results. The book "Wayfinding Behavior" presented here brings together the latest research on wayfinding topics from many areas. It is the first book taking such a multidisciplinary approach.

Keywords

cognitive map; internal representation; navigation; navigation; path integration; place cells; wayfinding.

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1. "Wayfinding Behavior" (Golledge 1999a,b) is a book that is long overdue. Since 1978, when O'Keefe and Nadel wrote "The hippocampus as a cognitive map" (O'Keefe & Nadel 1978), hardly any book has been published explicitly dedicated to cognitive maps. These few books are are usually restricted to certain areas, e.g. Redish's "Beyond the Cognitive Map" (Redish 1999). Golledge succeeded in bringing together wayfinding research from various perspectives by including the latest research results from the contributing authors.

2. It is somewhat challenging to attempt editing a book that includes such a variety of topics. The introductory paragraphs are therefore very useful for tying the different chapters together. Another positive aspect is the subdivision of the book not only into chapters but also into four parts. These parts are equally weighted from the number of pages, but part II seems to be more of a subpart to part I (Human Cognitive Maps and Wayfinding); part IV seems to be a subpart to part III (Wayfinding and

Cognitive Maps in Nonhuman Species). These "subparts" are specialised to the internal representation of wayfinding. A nice feature of the book is the author index, with contact addresses, including e-mail.

3. Despite Golledge's definition of cognitive maps at the beginning, definitions of cognitive mapping and wayfinding are not always consistent throughout the book. Golledge refers to the internal spatial representation of environmental information when using the term "cognitive map", widening the definition by allowing the application of interpretations from the "as if" construct to a hypothetical construct. Whether the term "cognitive map" can be applied to a species, or whether the term "spatial representation" would be more suitable depends on whether it is applied to humans or other animals.

4. Allen for example refers to cognitive maps as "integrated internal representations of relationships among places" (Allen, chapter 2 Golledge 1999). Taking the presence of places as a part of internal spatial representations for granted is already a strong specialisation. Chown goes even further (Chown, chapter 14 Golledge 1999). He includes landmarks as fundamental units of cognitive maps. I disagree with this claim for several reasons: Object recognition is not a necessity for orientation, especially for animals. Even the separation of a constellation of objects into single landmarks without differentiation based on their appearance is not necessarily required. Places can also be defined as entities of visual, auditory or other stimuli without direct recourse to object recognition. Humans certainly make use of landmarks for orientation. There are several studies on the importance of distant and local landmarks (see e.g. Steck et al. 1998), so landmarks definitely help orientation, which does not necessarily mean that they are a fundamental unit of cognitive maps.

5. It is emphasised at different sections in the book that cognitive maps should not be viewed as exact topographical replicas of the environment. In chapter 1, Golledge argues that neither humans nor animals develop complete and precise knowledge of a given environment (Golledge, chapter 1 Golledge 1999). He also reflects that symmetry and reflexivity axioms of Euclidean metrics need not hold universally in a human cognitive representation. Too much information storage can even be disadvantageous (Chown, chapter 13 Golledge 1999). These restrictions are rather obvious: the implications, however, can still be argued about. Etienne et al. remind us in chapter 8 that there are still no clear-cut behavioural results about the existence of true cognitive maps in rodents (Etienne, chapter 8 Golledge 1999).

6. A very recent theory of Judd et al.'s, which has already been reinforced by experimental results, concerns the storage of multiple snapshots in insects (Judd et al. chapter 9 Golledge 1999). It is commonly agreed that insects do not have true cognitive maps. However, it follows from the multiple landmark theory that insects store snapshots, or at least a preprocessed version of them in memory, in an ordered sequence. This can be called route-learning, and represents only a subset of "maps". Judd et al. present a profound theory, which is based not only on biological observations, but also on computer models. By theoretically reconstructing how the image of a cone at different distances moves over the retina, they can predict the position where the wood ant will take a new snapshot. Going even further, they let some simulated creatures evolve on a computer with different control structures. The main advantage of such an approach is that one can include some basic assumptions about a behaviour in the model, but without constructing it by hand. Navigational behaviours can evolve without too many preconceptions.

7. An important point which is emphasised throughout the book is that real cognitive maps, be they in animals or humans, cannot be perfect, nor exact. The reason behind this is that if they were, they would be too large and unmanageable. As Chown puts it: "The world is sufficiently complex that optimality is

not possible" (Chown, chapter 13 Golledge 1999). Optimality is possible in the form of physical laws, which can lead to amazing self-organising optimality in nature (for example, finding a local minimum by exploiting gravity), but optimality in cognitive maps does not mean having a one-to-one representation of the real world. The environment is always the perfect model of itself (or "the best model of a cat is another cat or better yet, the cat itself", as N. Wiener put it) and is superior to any imaginable internal model. Navigation and orientation is most efficient when restricting the cognitive maps to the necessary, and retrieving the missing information online from the environment.

8. Consequently, the term "cognitive maps" may be somewhat misleading. The maps are not a tool for conscious planning, rather they are a coarse template which helps in making short-term predictions about where we are going to be next, and which places are accessible from the current position. Exact details about the environment cannot be found in these maps; the information lies in the structure.

9. From my point of view, the book is slightly biased towards human wayfinding: urban environments are not the ones in which wayfinding skills evolved. Wayfinding in cities is much simpler than finding one’s way through natural environments. Navigation through cities can rather be considered as route following, since the main features consist of places or crossings connected by streets. An additional simplicity comes from the fact that right-angles dominate most urban structures, and navigation is much facilitated by street names and signs, and easily associable features like shops.

10. Wayfinding in forests, in contrast, whether it is human or animal wayfinding, relies much more on general sensory input rather than associations with specific distinguishable landmarks. The configuration of several landmarks is more important than the identity of a single landmark. In this case, error tolerance and generalisation are more important for generating a continuous and stable map, as is a continuous input from the environment.

11. Psychophysical experiments clearly dominate the book, whereas a section with a broad overview of different computational models is lacking. A model of a view-based cognitive map is presented by Mallott (Malott et al. 1998). It can be compared with experimental results from human or rat navigation in mazes. A different approach comes from Lambrinos (Lambrinos et al. 2000). They present a model for insect navigation and implement it on a mobile robot. Behavioural comparisons with real desert ants have also been performed. Several other examples of navigation models, some more and some less biologically plausible, can be found in many AI-related journals.

12. At the end of the book, mobile robots are mentioned as a suitable tool for bringing a new perspective to the understanding of cognitive maps. The use of mobile robots deserves more attention: most of the models brought up in the previous chapters could be tested on mobile robots serving as testing platforms. Robots’ huge advantage over simulated computer models, or even purely theoretical constructs, is their real-world aspect. Animal and human cognitive maps are not restricted to perfect environments either. Some models just do not account for physical laws like gravity or acceleration, or changing light conditions. As robots are embedded into the ‘real world’, an applied model must be able to cope with all such irregularities.

13. In conclusion, "Wayfinding Behavior" is definitely worth reading, despite some of the foregoing criticism. By setting aside the resolution to read it from page one to page 428, but instead browsing it and attentively reading the parts of current interest, many answers are provided, and, at the same time, a further "Pandora’s box" of questions is opened.

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