Carola Eschenbach, Cynthia Moss,
Hans-Ulrich Schnitzler

Spatial Cognition in Vertebrates: Concepts and Critical Experiments[1]

The processing and representation of spatial knowledge and the resulting action in space involves a broad range of cognitive functions. These include integrative processes that culminate in spatial representations. Such processes are based on internal representations and may involve attention, expectation and active exploration. Studying these processes raises a number of compelling questions. For example, how is spatial knowledge acquired? How is spatial information represented in the brain? What roles do attention and learning play in the processing and use of spatial information? Which concepts from topology and geometry can contribute to our understanding of spatial representation? Which properties of various spatial representations can we formally describe? How are spatial information and action combined?

The members of the Spatial Cognition group at the Wissenschaftskolleg zu Berlin organized a workshop to discuss current concepts in the field of spatial cognition. The aim of this discussion was to identify critical questions and testable hypotheses. In preparation for the workshop, participants read key articles recommended by the organizers. Each participant made a brief presentation of his/her specific research area, and the group as a whole discussed selected issues.

The program of the workshop included the following speakers and talks:

Hans-Peter Mallot, C. Hölscher, Universität Tübingen: "The View-Graph Approach to Spatial Cognition"

Anette Denzinger, Hans-Ulrich Schnitzler, Universität Tübingen: "Guidance Behavior and Orienting Reaction in Commuting CF-Bats"

Gerhard Neuweiler, Ludwig-Maximilians-Universität München: "Spatial Memory and Obstacle Avoidance. Old Experiments Revisited"

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[1] Workshop held at the Wissenschaftskolleg zu Berlin from February 22 to 24, 2001 under the auspices of the Otto and Martha Fischbeck Foundation.

Neil Burgess, University College, London: "Hippocampus, Space and Memory"
Carola Eschenbach, C. Habel, Universität Hamburg: "Geometric Concepts and Spatial Language"
Thiemo Krink, University of Aarhus: "Spatial Cognition in Mate Guarding of the African Elephant Loxodonta Africana"
Barry Frost, Queens University, Kingston: "Neural Mechanisms of Navigation in Birds"
Cynthia Moss, University of Maryland, *A. Surlykke*, Odense University: "Auditory Scene Analysis for Spatially-Guided Behavior"
York Winter, Ludwig-Maximilians-Universität München: "Ecological Specialization and Spatial Memory in Nectar-Feeding Bats"
Helmuth Adelsberger, Ludwig-Maximilians-Universität München: "Studying Changes in Mouse Hippocampal Protein Expression Patterns after a Spatial Memory Task"

Several central concepts of spatial cognition were chosen as topics of the main discussion sessions. The following list summarizes the topics, working definitions and main questions discussed.

A *Landmark* is something that serves to assist an individual or a group in reaching a goal.

How does spatial memory interface with landmark information?
How do humans and other animals make use of landmarks?
How are landmarks chosen? Can the same landmark serve different functions?
Does landmark information depend on the sensory modality through which it is selected and monitored?
What contextual information influences the recognition of established landmarks?
What role do landmarks play in the performance of spatial tasks?

Spatial planning anticipates the arrangement of objects under changing conditions.

How do different levels of planning interface with different types of decisions (selection of a spatial goal, a route, an action, a sequence of routes or of actions)?
How do different levels of planning interface with different types of spatial memory?
Do plans necessarily exhibit a hierarchical structure?
How does spatial planning and dynamic sensory information interact in the course of seeking a goal?

Mental World Models are representations of space in an allocentric reference frame.

How is sensory information transferred to different kinds of spatial memory?

What role does motion play in the development of a world model?

What distinguishes mental maps and network-type representations of space?

Are network representations of space grounded in behavioral distinctions between activity spaces (nodes) and commuting spaces (links)?

Multi-model integration of information about space is based on the coordination of the reference systems of different sensors or different information channels deriving from a single sensor. Different modalities can contribute redundant or complementary information.

Once established, is spatial memory amodal, or does it reference the sensory modality through which relevant spatial information was first obtained?

How much does the spatial resolution of a sensory modality influence the integration and update of memory with new information?

How can the resolution of spatial memory obtained through different modalities be compared?

The aim of this workshop was to summarize and discuss current concepts concerning the processing and representation of spatial information in vertebrates, including humans. Vibrant discussions by specialists in several different fields contributed to a deeper understanding of some aspects of spatial cognition, but also revealed many questions that remain open. The participants agreed that the workshop produced new perspectives in the rapidly developing field of spatial cognition. They suggested future meetings that would introduce diverse perspectives on new approaches to studying research issues on spatial cognition.