## *Lecture 10: Friday, July 5*

### Neural codes for natural navigation in the hippocampal formation of bats

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The work in our lab focuses on understanding the neural basis of spatial memory and spatial cognition – using bats as our animal model. To this end, we have developed wireless neurophysiology devices (neural loggers), which allow us to record single neurons from freely flying, behaving bats. In my talk I will present some of our recent studies, which explored the following questions: (i) How does the brain represent positions and directions in 3D ? A set of studies revealed 3D place cells, 3D head-directions cells, and 3D grid cells in the bat hippocampal formation. (ii) How are navigational goals represented in the brain ? We discovered a new kind of vectorial representation of spatial goals – whereby hippocampal neurons encode the direction and distance to a spatial goal. (iii) I will describe our recent discovery of "social place-cells" in the bat hippocampus – neurons that represent the position of other bats (conspecifics). (iv) Finally, I will describe ongoing work towards elucidating hippocampal neural codes in realistic, kilometer-scale environments – where we discovered an unexpected multi-scale coding of space. Our long-term vision is to develop a "Natural Neuroscience" approach for studying the neural basis of behavior – tapping into the animal's natural behaviors in complex, large-scale, naturalistic settings.

**Key References:**

- Finkelstein A, Derdikman D, Rubin A, Foerster JN, Las L & Ulanovsky N, Three-dimensional head-direction coding in the bat brain, ***Nature*** 517, 159-164 (2015).
- Sarel A, Finkelstein A, Las L & Ulanovsky N, Vectorial representation of spatial goals in the hippocampus of bats, ***Science*** 355, 176-180 (2017).
- Omer DB, Maimon SR, Las L & Ulanovsky N, Social place-cells in the bat hippocampus, ***Science*** 359, 218-224 (2018).

## BIOGRAPHICAL SKETCH

**Prof. Nachum Ulanovsky** received a B.Sc in Physics *magna cum laude* from Tel Aviv University (1992), and a Ph.D in Neuroscience and Neural Computation *summa cum laude* from the Hebrew University of Jerusalem (2004) – where he conducted his Ph.D reseach with Israel Nelken. From 2004-2007, he was a postdoctoral fellow in the lab of Cynthia Moss at the University of Maryland, College Park. He joined the Weizmann Institute faculty in 2007.

Prof. Ulanovsky is interested in understanding the neural basis of behavior. His main area of research is how complex naturalistic spaces are represented and remembered in the mammalian brain – and in particular, in the hippocampal formation. To this end, he pioneered bats as a novel animal model for studies of the neural basis of spatial memory and spatial cognition. Prof. Ulanovsky and his colleagues are fitting Egyptian fruit bats with miniature wireless-electrophysiology devices – the smallest deviced of their kind in the world, which his lab developed – and this allows them to measure the activity of individual neurons in freely flying bats. They also fit the bats with miniature tracking devices to track their 3D position in-flight, as well as tiny microphones to record their vocalizations on-board. Prof. Ulanovsky's group conducted the first ever neural recordings in flying animals, which allowed them to describe the coding of 3D maps and 3D compasses in the brain, as well as the neural basis of how bats navigate to goals. They recently recorded from the brains of bats during social interactions, and found neurons in the bat hippocampus that represent the position of another individual – and they suggested that these "social place-cells" may underlie social-spatial cognition in bats and other mammals. The findings of the Ulanovsky group have been published in the world's top journals such as *Nature* and *Science*.

Prof. Ulanovsky received the prestigious SfN Young Investigator Award from the Society for Neuroscience (2015). Among his other honors and awards are the Kimmel Award for Innovative Investigation – a 1 M$ research prize (2018), the André Deloro Prize for Scientific Research (2017), the Bernard Katz Prize in Neuroscience awarded by the Alexander von Humboldt Foundation (2013), the Krill Prize for the advancement of science from the Wolf Foundation (2012), and the Sieratzki Prize for Advances in Neuroscience (2011).

Prof. Ulanovsky is married and has three children. In his free time, he enjoys outdoor activities, especially hiking and scuba diving.