Module A: Probing Behaviour

Data Acquisition, Analysis, and Presentation

The complexity of behaviour and the underlying neuronal processes is enchantingly rich. This richness is reflected in the broad range of analytical methodologies applied to biological data in our endeavor of elucidating this complexity. With respect of our Master program, the topics cover ranges from the theoretical modeling of evolutionary processes to quantitative behavioral analysis in various model systems and the studies of neuronal networks.

The first module within the Master program aims at providing students with an overview to this variety, with a special focus on learning and mastering the broad range of skills and techniques needed to successfully approach this complexity. Using theoretical and practical examples of topics fundamental to the research of the faculty involved in the master program, students are introduced to programming in Matlab®. In doing so, we introduce fundamental concepts of signal analysis (e.g., filtering signals, Fourier transforms, convolution, spike-train analysis, trajectory analysis, ROC analysis and statistical foundations) and approaches to experimental designs and data acquisition (extracellular recordings, psychophysical experiments). In addition to these analytical skills, problems in designing experiments, bibliographic research and the art of scientific-writing and presentation of scientific data are covered and practiced in this module.

Module B: Neural Mechanisms

Brains are believed to belong to the most complex structures in the universe. They consist of densely packed and intricately interconnected networks of neurons, each of which has already highly complex computational properties.

With their neuronal machinery even relatively small animals are able to deal successfully with extraordinary tasks - as least if judged by the performance of man-made artifical systems. In preparation that are accessible relatively easily to experimental approaches (such as semi-intact insects) fundamental issues of neuronal information processing in nerve cells, at synaptic connections and neuronal networks will be addressed by electrophysiological and pharmacological experiments using intra- and extracellular recording techniques. Modern computer-based approaches will be introduced to analyse the experimental data. The experimental analysis will be completed by model simulations based on special software packages to validate experimentally established hypotheses and to assess the functional consequences of the cellular properties. The different projects will be conducted in small groups. Topical papers in the field of cellular information processing and neuronal computation will be discussed in seminars.

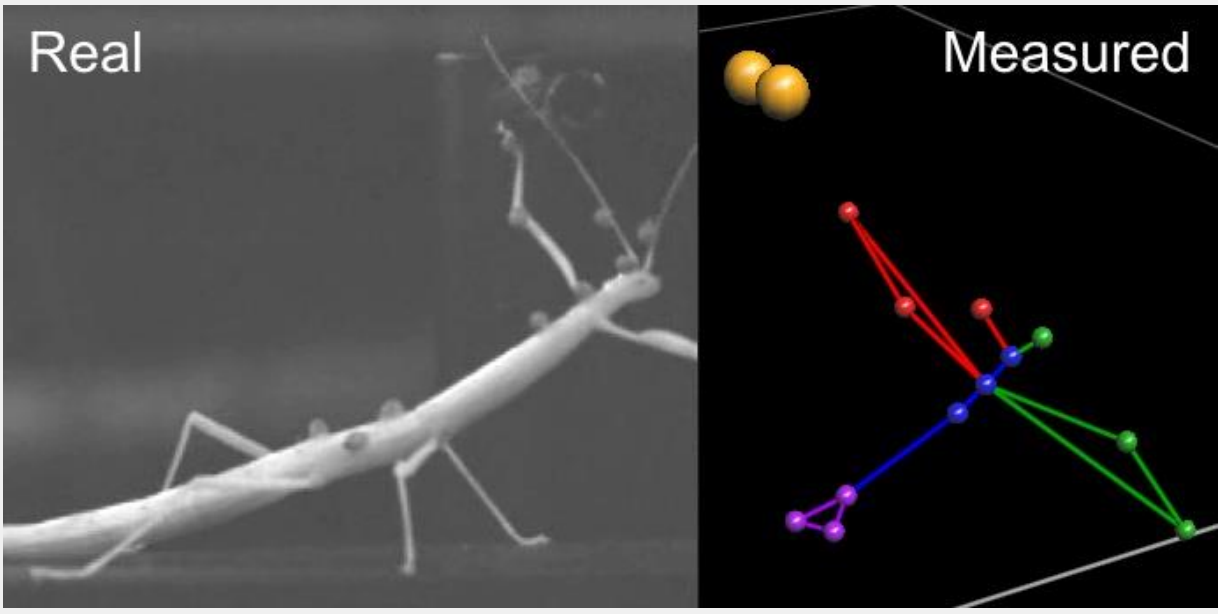
Module C: Control of Behaviour

Animals adapt their behaviour according to the requirements of the current situation. A wide range of sensory organs supply the animal's nervous system with information about the immediate environment (external cues), but also about the current state of the body (internal cues). Depending on both, external and internal cues, the nervous system switches, modulates or sustains the pattern of activity in its output organs - muscles and glands - in order to change the current behaviour or to maintain it. A change in output causes a concurrent change in sensory input, thus closing the loop from the output to the input. The module "Control of Behaviour" addresses different aspects of control loops, ranging from unconscious control of homeostasis and reflexive movements to orientation, course control and the coordination of complex movement sequences. The first part of the module gives an introduction to the basic theory and experimental analysis of feed-back systems (e.g., dynamic properties and stability), using simple examples of animal physiology and neurobiology. The second part is devoted to modelling the neural control of animal movement, with emphasis on the application of Artificial Neural Networks. During the third part, we offer small project experiments, addressing various specific aspects of sensory control of individual joints, limbs (i.e., chains with several joints) or whole bodies (i.e., coordination of multiple limbs).

Suggested Reading:

Biewener, A. A. (2003) Animal Locomotion. Oxford University Press.

Cruse, H (2008) Neural networks as cybernetic systems. 3rd ed., Brains, Minds & Media; ebook: http://www.brains-minds-media.org/archive/1841



Module D: Perception and Action

This module is an introduction into current research topics of Cognitive Neuroscience. First there will be an overview about different experimental methods used in Cognitive Neuroscience research. In small groups the students will then learn to develop their own scientific questions about the neural processing mechanisms underlying cognitive processes. Thereby, one focus will be on human multisensory perception and the interaction of perception and action sequences. Higher cognitive functions, such as learning, attention and navigation/orientation will play a central role. Next to the theoretical introduction, a predominant part of the course will be on receiving hands on experience with Cognitive Neuroscience topics. To this end, scientific questions will be approached experimentally and the results received will be quantitatively analyzed. In addition to the thematic introduction into the field of cognitive neuroscience, one of the main objectives of this module is to learn about the entire scientific process, from the development of the scientific question, the conduction of well-controlled cognitive experiments, all the way to the the presentation of the results in written or oral form.

Module E: Evolution of Behaviour

This course concentrates on how to study the evolution and maintenance of animal behaviour. It has the following components: In the first introductory part the participants attend lectures on the basic mechanisms of evolution and get suggestions for small research projects using insects. In the second part that will take place during an excursion to Greece, the students will work in small groups on the projects they have selected. In the third part the received data have to be analysed and on the last day all participants will give oral presentations of their projects. In addition, all participants have to write reports in the form of scientific publications.

Module F: Function of Behaviour

The aim of this course is to become familiar with concepts and methods used to study animal behaviour, specifically behavioural ecology. Basic principles will be theoretically presented and exemplified by research projects, mostly on small mammals, birds and fish. These experiments serve to obtain experience in asking precise questions on the causation and function of behaviour and to teach experimental design. Experiments on the proximate aspect of behaviour deal mainly with different aspects of communication. Examples are the role of acoustic and visual stimuli in courtship behaviour and partner choice. Ultimate aspects deal, for example, with distribution in space, the study of personality features and phylogenetic and molecular analysis of behaviour. Seminars serve to discuss current ideas based on the study of recent literature.