Advanced Course in Behavioral Neurobiology SS 2022 – Research Projects

- This year we are happy to offer 11 possible projects (see pages below).
- Each student will work on one of the proposed topics.

Until May 20th: Students, please provide us with a list of your 3 preferred projects (in order of preference) (Email to armin.bahl@uni-konstanz.de and christoph.kleineidam@uni-konstanz.de). This will allow us to optimally match everyone's interests.

Project #1 Conflicting decision making in *Drosophila* larvae

Advisor: Katrin Vogt

Description: Fruit fly larvae avoid bright light and thus exhibit negative phototaxis. To investigate the flexibility of this phototaxis response we will perform behavioral experiments under conflicting conditions. The experimental context can be changed by adding a second external cue, such as an attractive odor, together with the aversive light stimulus. We will use modern tracking tools to reveal changes in behavioral responses. Finally, we will also be able to investigate the role of underlying neural circuits by employing genetically encoded neuronal manipulations in combination with behavior experiments.

Location: Experiments will be conducted in ZT608. Data analysis will be done in ZT9 and M11.

Project #2 The neural circuits underlying cannibalistic behavior in *Drosophila* larvae

Advisor: Katrin Vogt

Description: Group behavior of fruit fly larvae is not very well understood; however, they are attracted to injured dead conspecifics and will also cannibalize on them. We will investigate if this conspecific /social attractiveness is different from normal food attraction. Therefore, we will perform behavioral experiments and compare larval response to normal food and dead larvae food using modern tracking tools. Testing mutant strains and genetically modified animals, we can investigate if the neural circuit underlying food attraction and dead larva attraction is different.

Location: Experiments will be conducted in M11. Data analysis will be done in ZT9 and M11.

Project #3: **Neurochemical signatures of aggression**

Advisor: Divya Ramesh

Description: Eusociality is a convergent trait. A defining feature of eusocial societies is the separation of the reproductive and the worker castes. There are 2 main hypotheses that explain this, one describing conserved genes, and one describing the rapid evolution of novel genes. The studies supporting one or the other hypothesis only consider defined physiology of the worker or queen castes, but do not include more ancestral and primitive behaviors like foraging or aggression.

For this VTK, we will use multiple eusocial species and test aggression in a well-defined context i.e. nest mate recognition. We will acquire neurochemical signatures of aggression as measured by quantitative mass spectrometry to try and answer if the different lineages of eusocial insects adopted the same modulatory systems for aggression.

The student is expected to work with insects like ants and bees, learn dissection, chemical processing of samples prior to MS, and later analysis of MS data.

Location: M11

Project #4: Repeated testing of aggressive behaviour in caged honeybees

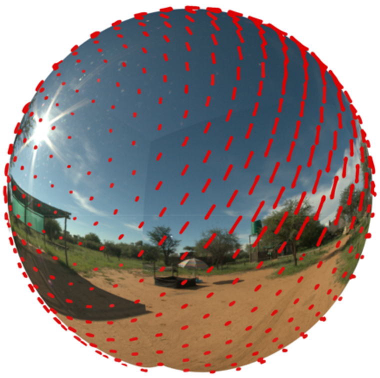
Advisors: Morgane Nouvian and Kavitha Kannan

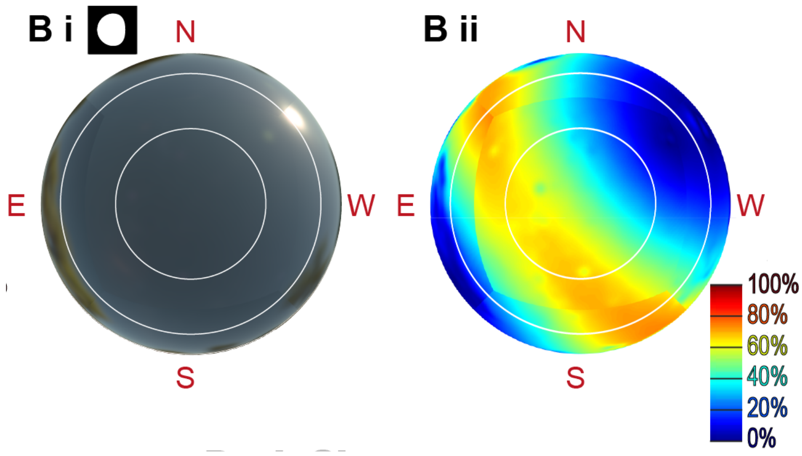
Description: In 1959, Lecomte tested the aggressive behaviour of bees reared in small cages. He ranked individuals according to their aggressiveness, i.e. how often they responded to a perceived threat. He reported that: 1) if the most aggressive bees are removed from the group, the remaining ones become more likely to attack, and 2) aggressive bees stay aggressive even if grouped together. This work is very interesting because it suggests that only a subset of bees are responsible for defending the group, and that their presence inhibits other bees from acting. It was, however, mostly of a descriptive nature, lacking proper quantification and replication. The aim of this VTK project will be to establish an experimental protocol allowing us to replicate Lecomte's seminal experiment in our lab.

Location: M11 and M11 roof

Project #5: Comparing skies through insects' eyes

Advisor: James Foster





Description: To hold their course, or travel between nest and feeding site, insects rely on celestial cues: the sun and patterns of polarized light in the sky. While the former is familiar to us all, the latter is invisible to human eyes, leaving us with few intuitions about its appearance and interpretation. Most previous studies have relied upon simplified models of skylight polarization to predict how it would appear to an insect, but advances in technology for environmental imaging now allow us to record accurate snapshots of natural scenes and examine them from an insect's point of view.

In this project, we will record images of natural skies across different times of day and under a range of different weather conditions, and then post-process these images to estimate the information available to an insect's eye. We will address the questions:

- How does compass information in natural skies differ from traditional models?
- How does sun elevation affect the quality of compass information?
- How might different weather conditions affect homing accuracy?
- How would the available information differ from the points of view of different insect species?

Learning content: The student will learn to operate a machine-vision camera, process images, model ocular anatomy, and analyse image data.

Location: M1109, M11 greenhouse, and terrace.

Project #6: Neural plasticity and social adaptation in the swarm-forming locusts (Calcium imaging)

Advisors: Einat Couzin-Fuchs and Sercan Sayin

Description: With increased population density, locusts undergo a rapid phase transition from shy, cryptically colored, introvert insects into conspicuously colored, highly active, swarm-forming locusts. This extreme adaptation to the gregarious lifestyle includes rapid behavioral and neural changes.

We will employ neural tracing, functional imaging, and microscopy techniques to test the impact of population density on locust odour perception. This will be done by labeling the antennal lobe neurons (the primary olfaction center) with calcium-sensitive dyes, which change their fluorescence emission when calcium is released. In our experiments, we will compare responses of “solitarious” and “gregarious” locusts to grass (food) and colony (social) odours, presented alone or simultaneously.

Note that projects 6 and 7 will focus on how crowding impacts the way locusts perceive social and food odors, utilizing two different approaches.

Learning content: Fluorescence microscopy (widefield and confocal), image analysis, olfaction.

Location: M11

Project #7: Neural plasticity and social adaptation in the swarm-forming locusts (behavior)

Advisors: Einat Couzin-Fuchs and Sercan Sayin

Description: With increased population density, locusts undergo a rapid phase transition from shy, cryptically colored, introvert insects into conspicuously colored, highly active, swarm-forming locusts. This extreme adaptation to the gregarious lifestyle includes rapid behavioral and neural changes.

We will use machine-learning-based appendage tracking to test behaviorally social adaptation to external stimuli. In response to a food-associated odour, locusts open their sensory appendages close to their mouths (the maxillary palps) in anticipation of food. The distance between the palps can be tracked and used as a metric for successfully recognizing the stimulus. Our project will test how the social context impacts olfactory sensitivity by comparing palp-opening responses in solitarious and gregarious locusts to food odor stimuli with increasing concentrations with or without a colony odour background.

Note that projects 6 and 7 will focus on how crowding impacts the way locusts perceive social and food odors, utilizing two different approaches.

Learning content: Simple Arduino-based instrumentation (for controlling odour stimuli), machine-learning-based tracking, data analysis.

Location: ZT6 and Z7

Project #8: Immunostaining - Whole-brain activity mapping in locusts

Advisor: Sercan Sayin

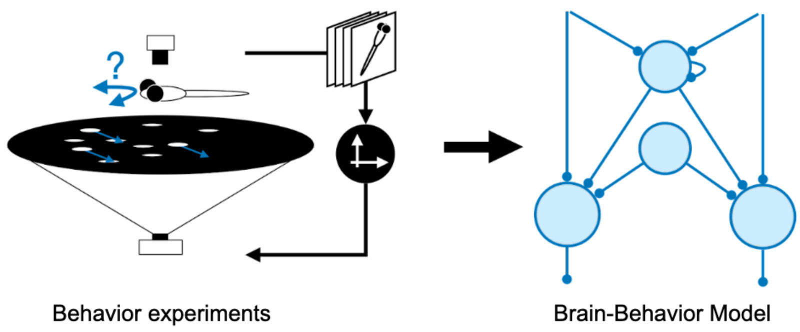
Description: Recent developments in molecular labels and immunohistochemical staining techniques offer new ways to monitor whole-brain activity in behaving animals. Whole-brain activity summarizes recent active regions in a brain, which then enables finding out circuits involved in a relevant behavior. Phosphorylated ERK (pERK) has been successfully used as an activity readout for zebrafish brains. Adapting this to locusts will be a first for the field and open future opportunities in cracking locust neuronal circuits. To confirm that pERK can be used for activity mapping in locusts, we will test staining intensities in the optic lobe and the antennal lobe following controlled visual and olfactory stimuli, respectively.

Learning content: Immunohistochemistry, simple behaviour assays, brain registration, confocal microscopy, image analysis.

Location: M11

Project #9: Multisensory input for evidence accumulation and decision making in larval zebrafish

Advisors: Max Capelle and Katja Slangewal



Description: To make appropriate decisions, animals need to accumulate sensory evidence. Simple integrator models can explain many aspects of such behavior, but how the underlying computations are mechanistically implemented in the brain remains poorly understood. In our lab, we approach this problem by adapting the random-dot motion discrimination paradigm, classically used in primate studies, to larval zebrafish. In this paradigm, a fraction of bright dots moves in one direction, suggesting a drift-off to the larval fish. This triggers an innate optomotor response in which the larvae swim in the direction of motion. Using this response as a measure of decision making, it has been found that larval zebrafish accumulate and remember motion evidence over many seconds and that the behavior is in close agreement with a bounded leaky integrator model.

Up till now, the classical random-dot motion paradigm has been implemented with bright white dots on a dark black background. However, anecdotal observations suggest that the zebrafish might perform better in environments with less intense contrast. Furthermore, it is unknown how other parameters in the decision-making paradigm, like dot size, dot speed, and the number of dots, relate to the decision-making performance of the fish. Do these parameters influence decision-making in the same way as changing the coherence level does? And how could the integration of all these parameters be implemented in the brain? Moreover, the fish' previous environment might influence their innate optomotor response. For example, are fish raised in complete darkness more or less sensitive to the white dots?

In this project, you will perform behavior experiments in our high-throughput set-up to answer these questions. Together we will translate your results into a drift-diffusion-based model that describes decision-making in the larval zebrafish.

Learning content: Zebrafish husbandry, behavioral experiments, data analysis, and modeling.

Location: ZT606 and M11

Project #10: Division of labor during trail-clearing in the leaf-cutting ant *Atta vollenweideri*

Advisors: Christoph Kleineidam (Maximilian Kölle)

Description: Ants, as central place forager, transport food along often well-established trails to the nest. These trails can be observed at nests of local ant species and the trails of the neotropical leaf-cutting ants are exceptionally well-maintained. We study the trail-clearing behavior of leaf-cutting ants in the laboratory where we place obstacles on the foraging trails and we observe which ants are removing the obstacles. So far, we found a very limited number of ants removing the obstacles in repeated carry events. We will address the question why only few ants become engaged in the trail-clearing process and most of the other ants are ignoring the obstacles. Our working hypothesis is: Task performance (here the removal of obstacles) leads to a self-reinforced task fidelity (here the repeated removal of obstacles).

Learning content: Development of a hypothesis driven behavioral experiment. Creation of an ethogram, based on own observations and using tracking tools to quantify animal behavior. This project also allows to explore student-developed hypothesis on trail-clearing related questions.

Location: M1128

Project #11: Heat transport in the red wood ant *Camponotus rufa*

Advisors: Christoph Kleineidam

Description: During spring time, often many workers of wood ants are sun-bathing on top of the nest mound. Heating up their own body allows the workers to forage at low ambient temperature. The sun exposed nest mound acts as a sun-collector, heating up the nest interior for faster brood development. The area where the brood is located is around 30°C and the observation that workers are also shuttling from the sunbathing area to the brood chambers led to the hypothesis that workers are carrying heat into the brood chambers. We can quantify the heating up of workers in our laboratory colonies, using a thermo-vision camera and we observed that the body temperature of the workers is high for a while and then drops quickly. The underlying mechanism how workers can maintain a high body temperature for some time is not understood and subject of this project.

Learning content: Development of measuring procedures to quantify heating and cooling of individual workers under various conditions. Data analysis, relating the measured dynamics of temperature changes to the different experimental conditions. These measurements aim to explore active and passive properties of changing body temperature after sun-bathing.

Location: M513E