1:30 - 2:00 (F1) Collision avoidance behaviors of minimally restrained locusts to looming stimuli
Fabrizio Gabbiani (Baylor College of Medicine)

Visually guided collision avoidance is of paramount importance for flying animals with a strong visual sensory modality, for instance to allow escapes from potential predators. Yet, little is known about the types of collision avoidance behaviors that may be generated by flyers in response to an impending visual threat. We studied the behaviour of minimally restrained locusts flying in a wind tunnel as they were subjected to looming stimuli presented on the side of the animal, simulating the approach of an object on a collision course. Using high-speed video recordings, we observed a wide variety of collision avoidance behaviours including climbs and dives away - but also towards - the stimulus. In a more restrained setting, we were able to relate kinematic parameters of the flapping wings with yaw changes in the trajectory of the animal. Asymmetric wing flapping was most strongly correlated with changes in yaw, but we also observed a substantial effect of wing deformations. Additionally, the effect of wing deformations on yaw was relatively independent of that of wing asymmetries. Thus, flying locusts exhibit a rich range of collision avoidance behaviours that depend on several distinct aerodynamical characteristics of wing flapping flight.

2:00 - 2:30 (F2) Mechanisms of spike generation in a mammalian touch receptor
Ellen Lumpkin (Columbia University), and Gregory Gerling

This CRCNS-funded project aims to elucidate cellular and systems-level mechanisms through which branching tactile afferents integrate inputs to generate neural signals that carry specific information about touch to the brain. Most vertebrate neurons initiate action potentials, or spikes, via sodium channels clustered at axon initial segments located near the cell body; however, the unique structure of vertebrate touch receptors dictates that they use a different tactic. These neurons have meter-long peripheral afferents that lack cell bodies in their conduction pathway. They must integrate information and generate spikes in the absence of a canonical axon initial segment, but the structural, molecular and computational bases of spike generation in these arbors is unknown.

Different tactile qualities, such as curvature, texture and vibration, are encoded by touch receptors with distinct end-organ morphologies and physiological properties; however, the principles that govern firing in mammalian somatosensory afferents have not been defined. Our studies focus on the mouse slowly adapting type I (SAI) afferent as a model accessible for computational and experimental studies. SAI afferents innervate Merkel cells in skin regions specialized for high tactile acuity (*e.g.,* fingertips, whisker follicles and touch domes). This evolutionarily conserved vertebrate touch receptor encodes information about shapes and curvature to inform our awareness of the objects that surround us. This is a key component of the sense of discriminative touch, which humans rely on to recognize and grasp objects in virtually every aspect of our daily life.

We have developed a combination of experimental and computational methods to model and test spike integration strategies that dictate firing patterns in tactile afferents. Computational models combine finite element analysis, fitted functions, probabilistic noise distributions and differential equations. To identify structural features that might govern an end organ's physiological output, we perform quantitative morphometric and molecular analysis of SAI afferent arbors in mouse touch domes. Skin mechanical measurements are used to constrain finite element models. Model outputs are evaluated by comparing with neurophysiological recordings from SAI afferents in the intact skin. Collectively, our studies aim to 1) determine the number and three-dimensional arrangement of Merkel cells and spike initiation zones in touch-dome SAI afferents; 2) develop a computational model to explain the biphasic sensitivity and variability of SAI afferents; and 3) determine the impact of Merkel-cell number & spike initiation strategies on the SAI afferent's firing patterns.

2:30 - 3:00 (F3) Biophysical properties of parallel neural circuits serving night vision

Joshua Singer (University of Maryland), Jonathan Demb, William Kath, and Hermann Riecke

Near visual threshold, signaling in the mammalian retina is mediated by a microcircuit known as the rod bipolar (RB) cell pathway. The RB pathway comprises two critical interneurons: RBs and AII amacrine cells. The general aim of this project is to understand both the cellular properties of RBs and AIIs and the circuit properties of the pathway in which they function. Here, we present combined experimental and computational analyses of the presynaptic properties of the RB-AII synapse and of the intrinsic properties of the postsynaptic AII.

We studied gain control (i.e., adaptation) of the RB-AII synapse by stimulating presynaptic RBs with quasi-white noise voltage commands and recording synaptic currents evoked in the AII. We mimicked changes in background luminance or contrast, respectively, by depolarizing the presynaptic membrane potential (V_M) or by increasing its variance. A linear systems analysis showed that both manipulations reduced synaptic gain. A phenomenological model of synaptic transmission demonstrated that background and contrast adaptation depend on a common synaptic mechanism: depletion of the readily-releasable vesicle pool (RRP) in the presynaptic terminal. Additional analyses suggested that the dynamics of transmission at the RB synapse limit it to encoding low-frequency, high-contrast information at background intensities above those at which rods capture just a few photons / sec.

We studied intrinsic properties, in particular the mechanism of atypical, Na-channel dependent spiking, of postsynaptic AIIs with a combination of electrophysiological recording and compartmental modeling. We found that somatic spikes likely represent large, brief action potential-like events initiated in a single, electrotonically distal dendritic compartment. In this same compartment, spiking undergoes slow modulation, likely by an M-type K conductance. The structural correlate of this compartment is a thin neurite that extends from the primary dendritic tree: local application of TTX to this neurite, or excision of it, eliminates spiking. Thus, the physiology of the axonless AII is much more complex than would be anticipated from morphological descriptions and somatic recordings; in particular, the AII possesses a single dendritic structure that controls its firing pattern.

3:30 - 4:00 (F4) Behaviorally relevant network states revealed through analysis of trial-to-trial variability in cortical activity

Paul Miller (Brandeis University)

Animals must often make opposing responses to similar complex stimuli. Multiple sensory inputs from such stimuli combine to produce stimulus-specific patterns of neural activity. It is the differences between these activity patterns, even when small, which provide the basis for any differences in behavioral response. Here, we investigate three tasks with differing degrees of overlap in the inputs, each with just two response possibilities. We simulate behavioral output via winner-takes-all activity in one of two pools of neurons forming a biologically based decision-making layer. The decision-making layer receives inputs either in a direct stimulus-dependent manner, or via an intervening recurrent network of neurons that form the associative layer, whose activity helps distinguish the stimuli of each task. We show that synaptic facilitation of synapses to the decision-making layer improves performance in these tasks, robustly increasing accuracy and speed of responses across multiple configurations of network inputs. Conversely, we find that synaptic depression worsens performance. In a linearly non-separable task with Exclusive-Or logic, the benefit of synaptic facilitation lies in its superlinear transmission – effective synaptic strength increases with presynaptic firing rate – which enhances the already present superlinearity of presynaptic firing rate as a function of stimulus-dependent input. In linearly separable single stimulus discrimination tasks, we find facilitating synapses are always beneficial because synaptic facilitation always enhances any differences between inputs. Thus, we predict that for optimal decision-making performance and speed, synapses from sensory or associative areas to decision-making or premotor areas should be facilitating.

4:00 - 4:30 (F5) Complex visual processing in Drosophila larvae?

Barry Condron (University of Virginia)

Drosophila larvae have relatively simple visual systems and are thought to detect only crude visual detail such as light level. However, many predatory insect larvae using a small number of visual inputs seem to distinguish complex image targets. This implies that the central processing of images, probably using spatial scanning and/or temporal summation, might compensate for the simple input. Here we show that *Drosophila* larvae can distinguish distinct species-specific motions on other larvae and that this recognition requires the visual system and early exposure to other larvae. We found that tethering a larva induces a distinctive writhing motion and that other larvae are attracted to this cue. Genetic analysis indicates that this attraction requires the visual system and that larvae can discriminate amongst fly species. In addition, attraction to tethered larvae still occurs across a clear plastic barrier, does not occur significantly in the dark, and attraction also occurs to a movie playing on a computer screen. Finally, social rearing is required to fully develop this visual ability. Our results demonstrate that a simple but experimentally tractable visual system can distinguish complex images and that processing in the relatively large central brain may compensate for the simple input.

4:30 - 5:00 (F6) Understanding cortical surround modulation with natural stimuli using a principled statistical model

Odelia Schwartz (Albert Einstein College of Medicine), and Adam Kohn

Drosophila larvae have relatively simple visual systems and are thought to detect only crude visual detail such as light level. However, many predatory insect larvae using a small number of visual inputs seem to distinguish complex image targets. This implies that the central processing of images, probably using spatial scanning and/or temporal summation, might compensate for the simple input. Here we show that *Drosophila* larvae can distinguish distinct species-specific motions on other larvae and that this recognition requires the visual system and early exposure to other larvae. We found that tethering a larva induces a distinctive writhing motion and that other larvae are attracted to this cue. Genetic analysis indicates that this attraction requires the visual system and that larvae can discriminate amongst fly species. In addition, attraction to tethered larvae still occurs across a clear plastic barrier, does not occur significantly in the dark, and attraction also occurs to a movie playing on a computer screen. Finally, social rearing is required to fully develop this visual ability. Our results demonstrate that a simple but experimentally tractable visual system can distinguish complex images and that processing in the relatively large central brain may compensate for the simple input.