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SENSORIMOTOR NEUROSCIENCE

Session Moderator: Eric Chudler, Bioengineering
234 MGH
1:15 PM to 2:45 PM

* Note: Titles in order of presentation.

Importance of Visually Mediated Abdominal Motion for Flight Stability in *Manduca sexta* and a Biometric Quadrotor Controller

David Julio Colmenares, Senior, Computer Engineering, Bioengineering
Mary Gates Scholar
Mentor: Tom Daniel, Biology
Mentor: Jonathan Dyhr, Biology

Flying organisms achieve flight stability by employing a multitude of control surfaces, most notably the wings. However, airframe deformations, such as abdominal motions in the hawk moth *Manduca sexta*, have recently been shown to play a significant role in stabilizing flight. In my research I have studied the control potential of abdominal deflections using a closed-loop flight arena. Tethered moths controlled the velocity of a projected black bar with their abdominal angle. Image velocity varied according to the difference between the abdominal angle and the set point (relative to the average abdominal angle), scaled by a gain factor. Experimental trials were performed for a ten-fold range of gains at three different set points and consisted of 60s periods during which the moths attempted to stabilize the drifting bar. The moths were capable of stabilizing the image for all experimental conditions, with the highest average performance (50%) occurring at the medium gain and the set point corresponding to the average abdominal angle. Poor performance (<50%) during low gain trials was characterized by steady state error, likely the result of the relatively low image velocities. For high gain trials, the decreased performance (<35%) was characterized by large abdominal oscillations. These results support an active and plastic role for the abdomen in flight control, but also tested the limits of the abdominal control circuit. To continue exploring the role of the abdominal motion I have been working on performing EMG recordings from the abdominal muscles during free flight. For this research the virtual arena serves as a controlled environment to collect preliminary data and to refine the experimental procedure and animal preparation. Finally, I will present my work developing a biometric controller for the Parrot AR.Drone quadrotor. This project utilized a Kinect and custom software to control the quadrotor with body postures.

Background Luminance Alters Tracking Performance of Freely Flying Hawkmoths Revealing Rariable Delays in Optomotor Processing

Robert William Hall, Senior, Biology (General)
Initiative for Maximizing Student Development Scholar, Mary Gates Scholar, Undergraduate Research Conference Travel Awardee
Mentor: Simon Sponberg, Biology
Mentor: Tom Daniel, Biology

Hawkmoths, *Manduca sexta*, feed mainly during early morning and late evening in low light conditions by hovering and tracking moving flowers. The variable lighting conditions in which the hawkmoths feed in nature allow for the perfect setting to examine how visual signal acquisition can affect the performance of motor controlled tasks. By varying the luminance levels, it could result in a change in the amount of time it takes for hawkmoths to react to visual stimuli. In other words, motion-sensing tasks, like tracking a moving flower while feeding, may vary with the background sensory environment. We tested our hypothesis with freely flying moths feeding from a robotically actuated artificial flower at a low luminance level of .3 lux and a high luminance level of 300 lux. Because the flower motion was composed of the superposition of multiple sine waves (0.2-20 Hz), we were able to examine how moths responded at different frequency levels, making it possible to reconstruct a performance pattern. The flower's movement was done in both the vertical and horizontal axes. By calculating the coherence at each frequency, gain, and phase delay, we discovered that moths reliably track at frequencies exceeding 5 Hz. As predicted, we perceived much larger processing delays from the moth's response to the flower's movement at lower luminance levels than higher. This processing delay corresponds to moths being able to perceive and react to visual stimuli 16ms faster at high luminance levels than low luminance levels. At low luminance levels, moths actually overcorrected by overshooting the flower's position at peak tracking frequencies (1-2Hz), possibly due to longer integration delays. Future experiments involve integrating two degrees of freedom by combining multiple axes. Background sensory environment significantly alters the performance of an ecologically-relevant tracking behavior as predicted from sensory neurophysiological mechanisms.

Neuroprosthetic Rehabilitation on Rodents

Tejas Ranade, Senior, Biology (General), Political Science
Mary Gates Scholar
Mentor: Steve Perlmutter, Physiology and Biophysics

Spinal cord injury is currently only treatable to a limited extent and often involves the partial or full loss of motor function. Spinal cord injury is also believed to be a strong factor in muscle loss and motor disorientation in mammals. Recent research has suggested that electrical stimulation of affected areas of the central nervous system can play a role in restoration of the ability to control paralyzed muscles in certain model organisms. Our Neuroprosthetic Rehabilitation project is focused on improving the ability of adult Long-Evans rats to make forelimb movements, via electric micro-stimulation, after localized spinal cord injury. The subject rats will first undergo behavioral training to achieve aptitude at a repeated task such as using one forelimb to reach for pellets at a certain distance. Following this, suitable candidates will be subjected to unilateral, cervical spinal cord contusions and will once again attempt to reach proficiency at pellet retrieval while micro-stimulation is routinely administered during training sessions. Functional improvement in rats stimulated during the pellet retrieval task will be compared with improvement of those stimulated independently of their behavior, and those not receiving stimulation. It is hypothesized that the improvement in the former group will be more significant than that of the latter groups, but will not generalize as well to other behaviors. Significant results will be instrumental to further understanding of how a damaged spinal cord can be repaired – or the effects of injury mitigated – in people suffering from related conditions.

Mirror Self-Recognition to Test for Intelligence in Captive Parrots

Vivien Saori Varga, Senior, Environmental Science & Resource Management (Wildlife Conservation)
Bethany Margaret Drahota, Senior, Environmental Science & Resource Management (Wildlife Conservation)
Mary Gates Scholar
Mentor: John Marzluff, Environmental and Forest Sciences

Mirror self-recognition (MSR), the test of whether or not an animal can identify their own reflection, is one of the highest markers of animal intelligence. To assess this capability, a mark test is conducted. Through this method, the only animals that have reliably displayed self-recognition are humans, magpies, dolphins, and four species of primates. A recent study on magpies showed that this avian species passed a mark test and was capable of MSR. Building on their research, we looked at MSR in parrots *(Psittaciformes)* of varying species to determine if they too were capable of self-recognition. Our test was done on an individual level. Our test subjects come from varied backgrounds with different life histories, and therefore mark test results within each species differ. In our experiment we exposed 24 parrots to reflective mirror surfaces, and analyzed how their behavior towards the mirror changed over time. After the birds grew accustomed to the mirror, we conducted a mark test. We anticipate that individual birds capable of self-recognition will pass this test because of their high brain-to-body ratio and social predispositions, which are signs of a high intelligence level. If our research shows that *Psittaciformes* are capable of MSR, they will become only the second avian order ever to pass this test and this would put them on the same intelligence level as mammals.

A Behavioral Analysis of Visual-Motor Processing in *Drosophila melanogaster*

Samantha Ann (Sami) Williams, Senior, Chemistry
Mary Gates Scholar
Mentor: Michael Dickinson, Biology
Mentor: Max Sizemore, Biology

Visual-Motor processing provides a mechanism for animals to translate visual cues into useful information for locomotion. My research aims to investigate this mechanism by analyzing the responses made by fruit flies to certain visual stimuli. I accomplish this by first tracking and quantifying fruit fly locomotion when two flies are present. By quantifying this behavior I can create a behavioral map of fly responses in relation to other fruit flies. I can then replace one of the flies with a cylindrical, fly-sized magnet that is readily controlled by me. This step is important because by controlling the magnet it is possible to reproduce large amounts of a specific behavior, instead of watching two flies interacting randomly and waiting for relevant interactions. It also will allow me to investigate the affects of object speed and angle of approach and create a behavioral map of the fly's locomotor response. Once this is accomplished it will then be possible to test fruit fly responses to visual stimuli presented on an LED screen surrounding the fly and to measure brain activity in the flies while these stimuli are displayed. Ultimately we hope to identify the neurons that are responsible for visual-motor processing and how they accomplish the transition from visual input to locomotor response.