368 Beyond the retina: Central visual circuits - Minisymposium
Tuesday, May 09, 2017 3:45 PM–5:30 PM
Room 308 Minisymposium
Program #/Board # Range: 3410–3414
Organizing Section: Visual Neuroscience

Program Number: 3410
Presentation Time: 3:45 PM–4:05 PM
Beyond the retina:Central visual circuits
Peter W. Campbell. Anatomical Sciences & Neurobiology, University of Louisville, Louisville, KY.
Presentation Description: The reciprocal connections between the dorsal lateral geniculate nucleus (dLGN) and the thalamic reticular nucleus (TRN) play an important role in regulating thalamocortical activity during different behavioral states such as attention, wakefulness, and sleep. Axon collaterals of thalamocortical neurons provide feedforward excitatory input onto GABAergic TRN neurons, which in turn convey feedback inhibition to dLGN relay neurons. Here we examined when and how these circuits arise during early postnatal life. We employed mouse transgenics to visualize when inputs appear and optogenetics to assess when functional patterns of connectivity emerge. We also used a form of genetic deaffrentation (Math 5 null; Wang et al. 2002) to investigate whether removing retinal inputs to dLGN altered the developmental time course of this circuit. Our results show that TRN terminals arrive in dLGN at P2 and cover the nucleus by P6. In the absence of retinal inputs TRN projections arrived earlier compared to controls. However, deaffrentation did not affect the functional inputs from TRN onto relay neurons as the amplitude of evoked IPSCs was not changed. In both control and Math 5 null mice, evoked responses emerged during the first postnatal week, were larger at the time of eye opening (P12-14) and steadily increased to adult-like levels by the end of the third postnatal week (P21). Combined with previous work from our lab on other sources of non-retinal inputs, the data indicate that retinal inputs coordinate the innervation of non-retinal projections. These data also show that, anatomically, both feedback projections (excitation from V1 or inhibition from TRN) resemble adults by eye opening. Eye opening is also an important developmental time point for the feed-forward excitatory projections from dLGN to TRN. At this time evoked EPSCs recorded from TRN neurons began to exhibit much larger responses than at younger ages. These responses rapidly matured to reach adult-like levels by P21. Therefore, both parts of the inhibitory feedback loop connecting dLGN and TRN follow a similar functional developmental time course. Together, these data indicate that the inhibitory feedback loop is established after retinal terminals arrive in dLGN but prior to eye-opening. Functionally, this circuit continues to develop between P14 and P21 – at which point adult-like responses emerge.
Commercial Relationships: Peter W. Campbell, None
Support: NEI Grants EY026792 & EY012716

Program Number: 3411
Presentation Time: 4:05 PM–4:25 PM
Top-down input to V1 is gated by subcortical modulation
Sandra Kuhlman[1, 2]. [1]Biological Sciences, Carnegie Mellon University, Pittsburgh, PA; [2]Center for Neural Basis of Cognition, Pittsburgh, PA.
Presentation Description: Reciprocal connectivity among brain regions is a prominent feature of all sensory cortices. In primary visual cortex (V1), top-down signals from association areas aid in context-dependent perception of visual scenes by altering the response properties of individual neurons. Sensory-evoked responses in V1 are also highly dependent on subcortical neuromodulation pathways that regulate brain state. Here, with cell-type-specific resolution, we addressed how corticocortical and subcortical pathways interact to regulate responsiveness of V1. Spatially retricted optogenentic silicing of higher-order visual cortex during visual stimulation in mice in conjuction with nucleus basalis stimultion was performed while recording V1 neuron responses. We found that the impact of top-down feedback on V1 is altered by nucleus basalis activation. Our results demonstrate that control of V1 can be internally rebalanced such that cortical layer 2/3 excitatory neuron response properties are more strongly determined by sensory-driven bottom-up inputs at the expense of LM-mediated feedback and provide insight into the rules and conditions governing activity propagation in reciprocally connected networks.
Commercial Relationships: Sandra Kuhlman, None
Support: Knights Templar Eye Foundation, Howard Hughes Medical Institute Undergraduate Program, Fight-For-Sight Foundation, and NIH R01EY024678

Program Number: 3412
Presentation Time: 4:25 PM–4:45 PM
State-dependent regulation of visual cortex function
Jess Cardin. Yale School of Medicine, New Haven, CT.
Presentation Description: Spontaneous and sensory-evoked cortical activity is highly state-dependent, yet relatively little is known about transitions between the distinct waking states that are associated with cognition and perception. In addition, transitions between distinct states highlight the full dynamic range of local circuit activity and allow us to examine how cortical activity is optimized for different operations according to behavioral and environmental context. Patterns of activity in mouse primary visual cortex (V1) differ dramatically between quiescence and locomotion, but this difference could be explained by either motor feedback or a change in arousal levels. Using naturally occurring and induced behavioral state transitions, we have dissociated arousal and locomotion effects in V1. Our findings suggest complementary roles of arousal and locomotion in promoting functional flexibility in cortical circuits. In animals performing a visual task, we find a consistent level of arousal associated with a stably maintained cortical state, and a correlation between arousal state and perceptual performance. This tight regulation of the relationshiop between arousal and cortical information processing is a key aspect of cortical function, and is disrupted in disease. In recent work, we find that developmental disruption of specific inhibitory interneurons in models of neurodevelopmental disease dysregulate the state-dependent modulation of V1 cortical activity and V1-dependent visual perception.
Commercial Relationships: Jess Cardin, None
Support: NIH/NEI R01 EY022951

Program Number: 3413
Presentation Time: 4:45 PM–5:05 PM
Connecting the retina to the brain: specificity of subcortical targeting
Tania A. Seabrook. Department of Neurobiology, Stanford University School of Medicine, Stanford, CA.
Presentation Description: I will present new data on how visual system neurons select their targets during development. Despite the functional importance of linking specific retinal circuits to their correct brain targets, the developmental mechanisms that ensure this process occurs accurately remain poorly understood.
This important question will be discussed in the context of parallel visual circuits in the midbrain pretectum. Pretectal targets receive input from distinct types of retinal ganglion cells (RGCs).

Early-born luminance-sensing RGCs initially send their axons to several incorrect targets during development (Osterhout et al., *Cell Reports*, 2014). After this initial mistargeting, they remove inappropriate axon projections and maintain the correct ones to the olivary pretectal nucleus (OPN) and posterior pretectal nucleus (mdPPN). By contrast, the axons of later born RGCs such as those driving image stabilization and optokinetic reflexes, are more accurate in their targeting, bypassing the OPN and mdPPN and targeting other nearby retinorecipient nuclei instead, such as the nucleus of the optic tract (NOT).
Based on the differences in timing and dynamics of luminance versus optokinetic-related RGCs, we tested whether competitive interactions between functionally distinct RGC subsets are important for target selection in the pretectum. We used Cre-dependent deletion of Tbr2, a transcription factor whose expression is important for RGC survival, to specifically eliminate the early-projecting cohort of luminance-sensing RGCs. We then asked whether other intact types of RGCs redirect their axonal inputs to the vacated targets. Remarkably, even when the OPN and mdPPN were rendered devoid of their normal retinal input, the axons of other RGC types continue to avoid the vacant targets. This suggests that axon-target matching is controlled by molecular matching mechanisms that do not tolerate cross-wiring and most likely involves both positive signals that direct specific axons to their targets and repellant signals that actively restrict the wrong types of afferents from innervating those same targets. The relevance of these findings to visual development, function and regeneration will be discussed.

Commercial Relationships: Tania A. Seabrook, None
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Program Number: 3414
Presentation Time: 5:05 PM–5:25 PM
Eye dominance and Acuity are Independent in a Murine Model of Amblyopia
Aaron W. Mcgee. University Southern California, Los Angeles, CA.
Presentation Description: Brief presentation description: Early prolonged visual deprivation alters eye dominance and induces deficits in acuity in models of amblyopia. Mice lacking a functional gene for the nogo-66 receptor (*ngr1*) retain visual plasticity otherwise confined to a developmental critical period and recover both normal eye dominance and acuity with extended restoration of normal vision. I will present a genetic dissection strategy we employed to identify the neural circuits contributing to this recovery of vision. Surprisingly, we discover that that the circuits mediating eye dominance and acuity are not only dissociable but independent.
Commercial Relationships: Aaron W. Mcgee, None