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Barrels XXVII meeting report: Barrels in the monument city

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ORIGINAL ARTICLE

Barrels XXVII meeting report: Barrels in the monument city

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Abstract

The 27th annual Barrels meeting highlighted the latest advances in this rapidly growing field. The Barrels meeting annually focuses on the role of the posterior medial thalamus in somatosensation, dendritic processing, and the cortical dynamics involved during touch perception. Speakers utilized diverse molecular, physiological, computational techniques to understand the development, sensory processing, and motor commands that are involved with the rodent mystacial vibrissae. The meeting was held Thursday, 13 November through Friday, 14 November 2014 on the Homewood campus of Johns Hopkins University, Baltimore, MD.

Keywords

Barrels, dendrites, whiskers

History

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The 27th annual Barrels conference convened in Baltimore, Maryland at the Johns Hopkins University campus on 13–14 November 2014 in the Glass Pavilion not far from the birthplace of the Barrel a few miles away at the Johns Hopkins University School of Medicine. The meeting principally focused on the role of the secondary thalamus in somatosensation, dendritic processing in the somatosensory and visual cortices, and the cortical dynamics involved during touch perception (see the Appendix for a complete listing of the meeting talks and events).

The first session was moderated by **Kevin Alloway** (Pennsylvania State University) and began with an overview of the rodent secondary thalamus (posterior medial thalamus—POm). The somatotopic organization of POm along with current knowledge of the underlying microcircuitry between cortical and subcortical structures was discussed. The role of POm specifically during whisking behaviors remains an open question, and led to the first talk by **Elaine Zhang** (Columbia University). Zhang's research focused on three feedback pathways to the somatosensory cortex (primary motor cortex (M1), secondary somatosensory cortex (S2), and POm) and their role in activating layer 2/3 neurons. After *in vivo* expression and light activation of channel-rhodopsin within these three main pathways, it was found that POm synapses strongly depolarized layer 2/3 neurons while responses of the same neurons to M1 and primary somatosensory cortex (S1) activation were weak. POm stimulation during active sensing evoked stronger responses in layers 2/3, suggesting a possible role for POm in supragranular modulation during active sensing.

Jeff Moore (University of California, San Diego) focused on the role of the paralemniscal and lemniscal pathways during vibrissae self-motion and touch. It is known that neurons along the lemniscal pathway are robustly affected by touch while neurons in the paralemniscal pathway are weakly affected. Exactly which pathways encode self-motion and/or touch remain unknown. This question was addressed and it was found that neurons along the lemniscal pathway were found to encode rhythmic whisking while paralemniscal neurons showed no evidence of encoding active whisker motion. Evidence suggests that both touch and self-motion are encoded within the lemniscal pathway and a computational model was put forth to describe how these neurons are capable of encoding both signals.

Alison Barth (Carnegie Mellon University) discussed the potential role of supragranular neurons in the composition of whisker surround receptive fields in the barrel cortex. A transgenic mouse line with an activity-dependent reporter gene, fosGFP, was used, which robustly expressed within layer 2 neurons of the barrel cortex of juvenile mice. In response to whisker deflections, both fosGFP+ and fosGFP− neurons responded similarly to whisker deflections. When the surround whiskers were deflected, fosGFP+ neurons responded with shorter latency and larger amplitudes. Optogenetic activation showed that axons of POm neurons contact fosGFP+ neurons and that cortical fosGFP+ expression reveals broad surround receptive field excitatory neurons targeted by POm in layer 2.

The final talk of the session was by **Alex Groh** (Technische Universitaet Muenchen, Germany) who focused on the role of corticothalamic pathways in the mouse whisker

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system. Two corticothalamic feedback pathways were discussed: (1) layer 6 neuron feedback to the ventral posterior medial nucleus (VPM) and (2) layer 5 neuron feedback to POm. It is known that layer 6 neurons feed back to VPM to influence the thalamic firing mode and sensory adaptation. The POm pathway, although sparse, appears to transmit spike patterns that underlie cortical slow oscillations. During both anesthesia and wakefulness, it was found that cortical efferents affect the activity of POm neurons in a manner independent of sensory input. These results demonstrate the differences between the two corticothalamic feedback systems and suggest two distinct functional roles for cortical feedback within the VPM pathway and POm pathway.

After a brief intermission, **Randy Bruno** (Columbia University) moderated the short platform talks. The first talk by **Adam Packer** (University College London, UK) showcased an all optical manipulation and recording technique for neuronal circuits *in vivo*. Utilizing new dual two-photon microscopy technology, it was shown to be possible to select multiple neurons for precise optogenetic stimulation and simultaneous fast Ca^{2+} imaging with single action potential resolution in the awake behaving animal.

Philip Chu (The Graduate Center, City University of New York) discussed the impact of perineuronal net (PNN) digestion on the intrinsic electrophysiological properties of barrel cortex neurons. PNNs are extracellular matrix structures that are hypothesized to play a role in cortical plasticity. Since the mechanisms of plasticity mediated by PNNs are unknown, Chu's study sought to uncover how the nets can regulate intrinsic neuronal physiology by enzymatic digestion of PNNs followed by whole cell patch-clamp recordings of barrel cortex neurons *in vitro.* A novel method for *in vitro* digestion of PNNs within an incubation chamber was employed which resulted in decreases in action potential amplitude and input resistance specifically within fast spiking interneurons. These results are consistent with previously published literature demonstrating that PNNs predominantly ensheath this particular class of inhibitory interneuron. Exactly how the PNNs modulate synaptic communication was also examined; it was found that low threshold spiking inhibitory interneurons showed significant decreases in excitatory postsynaptic potential (PSP) frequency following PNN digestion. Results of this study demonstrate that PNNs are capable of modulating the intrinsic properties of neurons in the barrel cortex.

Stuart Greenhill (Cardiff University, UK) focused on the developmental plasticity in regular spiking (RS) and intrinsic bursting (IB) cells in layer V of the mouse barrel cortex *in vivo*. It was demonstrated that unilateral sensory deprivation results in decreased firing rates in RS layer V cells in response to whisker stimulation of both the principal and adjacent whiskers. Subthreshold responses displayed increases in amplitude with longer latencies when compared to control. Spontaneous firing was also reduced in RS cells in sensory-deprived animals. Conversely, IB cells displayed an increase in action potential firing rate after 10 days of sensory deprivation. Subthreshold IB responses displayed larger amplitude and longer latency after deprivation. The results are consistent with previously published data on rat layer V RS and IB cells in that both mouse RS and IB cells have different forms of plasticity in response to sensory deprivation.

After a sumptuous lunch the Barrels meeting reconvened for a session on dendritic processing in the somatosensory and visual cortices moderated by **Robert Sachdev** (Charité Universitäts Medizin, Berlin, Germany). He reminded the audience that all dendrites are not created equal, with the principal distinction being between the apical and basilar dendrites. The first invited speaker of the afternoon was **Arthur Konnerth** (Institute of Neuroscience, Technical University Munich, Germany). He began his talk by posing a key question; how are stimuli represented in the dendrite or alternatively, how are inputs mapped onto the dendrites? Using imaging techniques, he demonstrated that within the primary visual cortex, all orientations are represented in the dendrites in a sparse pattern. Similarly in the barrel cortex, principal vs. adjacent whisker deflections evoked Ca^{2+} transients in dendritic spine heads in a non-clustered fashion. The Ca^{2+} transients are evoked via *N*-methyl-D-aspartate (NMDA) currents as its antagonist APV5 blocked them. When evaluating latencies to response, the principal whisker had much shorter response times than the adjacent whisker. Furthermore, the short latency responses tended to be closer to the soma and the responses were of greater magnitude in the spines vs. the dendritic shaft and they summed linearly. The data suggested that individual cells respond in a cell-specific manner as a function of the number and distribution of activated inputs.

Matthew Larkum (Humboldt University, Berlin, Germany) reminded the audience that NMDA spikes are local, but can lead to large dendritic depolarizations. Once again using imaging techniques he was able to show that NMDA inputs evoked Ca^{2+} spikes in the middle section of the apical dendrite and that spikes can also occur in the apical tuft. In general, it was observed that there were more Ca^{2+} events in the apical vs. the basilar dendrites *in vivo*. It was then shown that NMDA spikes can be evoked by sensory stimulation and that there was an increased likelihood of a response when the sensory stimulation was paired with stimulation of cortical layer 1. The findings emphasize that not only are the sources of input important, but their postsynaptic location is just as important.

Jeff Magee (Janelia Farm Research Campus) began his talk defining top-down (layer 1 influencing a layer 5 cell) vs. bottom-up (sensory stimulation influencing the same layer 5 cell) processing. He went on to show that the dendritic plateau potential due to Ca^{2+} influx served as a gain mechanism for the neuron and that fast inactivating A-type K+ channels in conjunction with hyperpolarization-activated cation currents (HCN channels) regulate dendritic excitability. Using a synthesis of Ca^{2+} imaging and optogenetics *in vivo* he was able to show that thalamocortical inputs targeted the soma of layer 5b cells and layer 1 inputs targeted the apical tuft of the same cells. The layer 1 evoked Ca^{2+} plateau helped to determine a temporal window of opportunity wherein thalamocortical or other cortico-cortical inputs could be integrated. Using a behavioral task where the mouse had to identify the location of a pole in its whisking field they monitored the impact of M1 inputs on responses of layer 5b neurons in mouse barrel cortex. If M1 was inactivated with

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muscimol, no Ca^{2+} potentials were observed in the apical dendrites and there was no refinement of the motor whisking strategy.

Finally, **Spencer Smith** (University of North Carolina School of Medicine) focused on the question of whether dendritic Ca^{2+} events are local in origin. During imaging of the visual cortex of awake behaving mice, he was able to show that mice could learn a visual discrimination task. Patching *in vivo* on to neurons while the mouse was performing this task showed that bursts of action potentials were orientation tuned and that overall there were more action potentials in the soma compared to the apical dendrite. In sum, these talks reminded the audience of the critical role that dendrites have in integrating inputs and shaping the responses of cortical neurons.

Following a short break there was a Data Blitz session that briefly highlighted the most recent advances in the barrel field followed by an engrossing dinner and poster session, bringing to a close the first day of the 27th annual Barrels meeting.

Friday morning began with a series of short talks moderated by **Mary Ann Wilson** (Johns Hopkins University). **Rony Azouz** (Ben-Gurion University of the Negev, Israel) started the Friday morning session with the examination of the functional organization of the rat whisker pad. Most sensory information available to the rodent enters through the somatosensory whisker system. This system can be separated into the micro and macro vibrissal system, or the ''what'' vs. ''where'' pathways, respectively. Examining whisker angle and mystacial pad movement, it was discovered that caudal whiskers are used for object localization whereas rostral whiskers are most useful for fine texture discrimination.

Next, **Robert Egger** (Max Planck Institute for Biological Cybernetics, Tübingen, Germany) revealed the barrel cortex connectome, a three-dimensional map of the synaptic connections within the barrel cortex. Using statistical analysis based on sparse neuronal connections, he was able to reconstruct the dendrites and axons across cortical layers. Creating a dense network of over half a million neurons, this model is able to predict the connectivity beyond just neuron pairs. **Randy Bruno** (Columbia University) followed by asking what patterns of sensory stimuli drive the barrel cortex. While there is a dense projection between layers 2/3 and layer 4 in the barrel cortex, layers 2/3 remain fairly inactive. Using fentanyl-sedated rats, several whiskers were deflected and cortical activity was recorded. Using reverse correlations, every time a spike was evoked, the activity that preceded it was examined. However, layers 2/3 remained unresponsive through all conditions. The first morning session concluded with **Ariel Agmon** (West Virginia University) and his talk on thalamocortical inhibition by infragranular somatostatin-containing interneurons. Agmon stimulated the thalamus and recorded from two classes of interneurons in layer V: parvalbumin positive (PV^+) and somatostatin positive (SOM^+) cells. It was found that inhibiting SOM^+ cells stops activity in RS cells. However, suppressing PV^+ cells did not alter neuronal excitability. Agmon concluded that PV^+ cells are not the main purveyors of the inhibitory–excitatory balance as was previously believed.

Following a short break, a second session of short talks was moderated by **Rony Azouz** (Ben-Gurion University of the Negev, Israel). **Chris Bresee** (Northwestern University) started off by presenting the constraints on vibrissal movement in the three-dimensional setting, or how biomechanics can influence the variability in rodent whisker protraction. Quantifying the follicle length and the interfollicle gap, it was found that the angles of the whiskers with respect to the skin was constant, clustering at 60 degrees. Taking into account the follicle diameter, it was shown that all follicles move consistently. It appears all whiskers protract at similar angles, but that doesn't often occur behaviorally. It is unknown how the rodent controls for the observed difference. Next, **Mitra Hartmann** (Northwestern University) described her anatomical model of a whisker array. While rodents are housed in plastic cages, it is not clear whether that is the best way to observe natural behavior. Creating a whisker protraction model in respect to changes in elevation and varying angles of rotation, it was found that rodents use their visual system in conjunction with their whiskers to sense space and predict spatial structure.

Edward Zagha (Yale University School of Medicine) then presented the motor cortex ensemble activities underlying goal-directed behavior in a sensory detection task. Mice were head fixed and trained to detect and whisk at a paddle that appeared on either side of their mystacial pad. Making an appropriate response would result in a reward. Recording from layer 5 primary motor cortex, it was found that 50% of the neuronal population would show activity at the onset of the stimulus whereas 35% would turn off. Whisking behavior alone only shows enhancement, but this pattern of activity is task dependent which whisking behavior cannot fully account for. The following presenter, **Bing-Xing Huo** (Pennsylvania State University), investigated cortical neurovascular coupling and decoupling during voluntary locomotion in awake behaving mice. It is believed that increased neural activity is associated with increased dilation of nearby blood vessels. However, it is possible to have a negative or zero correlation between neural activity and vascular dynamics. Creating a cranial window and using optical imaging, neural activity and cerebral blood volume (CBV) were measured in mice during voluntary locomotion. Where neural activity increased in cortical areas associated with the forelimb, hindlimb as well as the frontal region, CBV only increased in the forelimb and hindlimb areas.

The last talk of this session was chronic cranial window with access port allowing repeated cellular manipulations and electrophysiology presented by **Bern Kuhn** (Okinawa Institute of Science and Technology Graduate University, Japan). While the cranial window has been a useful tool in examining brain activity over several days or weeks, it is difficult to reenter the brain for cellular manipulations. Using a relatively simple alteration, it was possible to create a cranial window with a resealable access port allowing for different recording methods, including patch recordings, without sacrificing imaging. This adjustment had been described as cheap, easy, and adaptable allowing for greater experimental possibility using the cranial window.

Following lunch, the final round of short platform talks at Barrels XXVII was introduced and moderated by

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Chia-Chien Chen (University of California, Santa Cruz). **Bryan Hooks** (Janelia Farm Research Campus) led off the session by presenting data from newly developed Cre-recombinase driver lines for labeling long-range projection neurons in the barrel cortex in the hope of elucidating the details of multimodal integration between S1 and M1. The two lines, derived from GENSAT BAC-Cre driver lines, preferentially label layer 5 projection neurons. The first line PL56 (Tlx3) projects ipsi- and contralaterally to cortex and striatum. The second line KJ18 (Sim1) is expressed in pyramidal tract type neurons that project to ipsilateral thalamus, zona incerta, superior colliculus, contralateral brain stem nuclei, and have collateral branches in the ipsilateral striatum and contribute to the corticospinal tract. He validated these mouse lines using fluorescent tracer injections and used digital flattening of the cortex to visualize the projection maps, thereby confirming these lines as potential tools for studying circuitry of long-range projection neurons in the cortex. The second afternoon speaker, **Alexander Van der Bourg** (Brain Research Institute, Zurich, Switzerland), pointed out that little is known about the development of spontaneous and evoked activity in the barrel cortex. Using two-photon imaging of bolus loaded calcium indicators (Oregon Green BAPTA-1) and a novel whisker stimulator that can exert both longitudinal force (''tapping'') and transversal force, he described the development of layer 2/3 barrel cortex neurons between postnatal day (P)10 and P28. Highly synchronized responses to principal whisker stimulation occurred until P12 which became lower amplitude and decorrelated by P13. He noted that stimulus selective neurons (longitudinal vs. transversal force) also emerged at P13 at the same time that overall neuronal population activity was decreasing. By P16, he noted that population activity was highly selective and sparse, resembling young adult activity. The results suggest that understanding the maturation of sensory cortices may inform emerging behaviors during the transition from juvenile to adult stages.

Following a stimulating discussion and coffee break **Daniel O'Connor** (Johns Hopkins University) introduced and moderated the final round of invited long talks of Barrels XXVII. First to speak was **Takayuki Yamashita** (École Polytechnique Fédérale de Lausanne, Switzerland) who used *in vivo* patch-clamp recordings of layer 2/3 neurons in awake behaving mice to dissect intracortical circuits during active whisker touch. Using retrograde Alexa labeling in M1 and S2 in conjunction with recordings in S1, he reported that M1 projecting neurons have lower input resistances and receive depressing inputs during repetitive whisker contact, phase lock to whisking, and exhibit firing rates that scale with contact. In contrast, S2 projecting neurons show facilitation during repetitive whisker contact, do not phase lock to whisking, and show greater latency to fire following passive whisker stimulation. Further, M1 projecting neurons show larger amplitude PSPs, but S2 projecting neurons exhibit larger PSPs during cortical upstates during whisking. He proposes that transient S1 to M1 projections may be optimized for object detection whereas sustained and facilitating S1 to S2 projections may underlie object feature recognition. **Jerry Chen** (Universität Zürich, Switzerland) followed with the penultimate talk of the barrels meeting. Using *in vivo* two-photon calcium imaging with genetically encoded calcium indicators (TD tomato CRE) and fluorescent retrograde tracer injections (yellow chameleon nano 140), he monitored the long-range connectivity between S1 to M1 and S1 to S2 during texture discrimination tasks to determine where plasticity was occurring during learning. Mice whiskers' ''slip–stick'' events and curvature changes were monitored during their training and the activity of M1 vs. S2 projecting neurons in layers 2/3 of the barrel cortex was correlated to learning efficacy. He reported that M1 projecting neurons reliably encode basic whisker kinematic features throughout training, but that S2 projecting neurons show increased turnover through reductions of non-touch-related neurons once animals reached a high level of discrimination performance. Overall, he proposes that learning-related changes in S1 may affect downstream areas in a pathway-specific manner that is relevant for behavior. **Garrett Stanley** (Georgia Institute of Technology) capped off the final talk at the Johns Hopkins University's Glass Pavilion. Following an instructive summary of the historical aspects of behavioral and perceptual threshold studies in the barrel community, he presented data using *in vivo* imaging using voltage-sensitive dyes (VSD) to examine how response adaptation is gated by the thalamus through neuronal bursting patterns and how that may affect perceptual detection. First he showed that through VSD imaging in barrel cortex *in vivo*, discrimination responses between whiskers is present in layers 2/3. Then using multiunit thalamic local field potential recordings *in vivo*, he showed that adaptation is also present at the level of the thalamus which, based on computational models, is sufficient to generate adaptation in the cortex. He also showed that decreasing signal to noise ratios decreases thalamic bursting probability and that the balance between bursting and single spiking is important for optimal signal detection. He further suggested that bottom-up adaptation and bursting may be mechanisms to regulate signal detection in sensory systems.

The meeting was concluded with an announcement that **Shane Crandall** (Brown University) would be the inaugural winner of the Hendrik Van der Loos prize for the best presentation by either a graduate student or postdoctoral fellow. It was also announced that starting with the 28th annual Barrels meeting there will be a Thomas A. Woolsey prize for individuals who have made significant contributions to the Barrels field and will be presented for the first time to Thomas Woolsey in Chicago at the next Barrels meeting to be held on 15–16 October 2015 at the Northwestern University School of Law.

Declaration of interest

The authors report no conflicts of interest.

Appendix

Barrels XXVII—complete schedule

13–14 November 2014, Johns Hopkins University

Thursday, 13 November

8:45–9:00 Continental Breakfast, Name Tag Pickup

9:00–9:05 Welcome: **Joshua C. Brumberg**, Queens College, CUNY

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Daniel O'Connor, Johns Hopkins University

9:05–12:00 Secondary Thalamus in Somatosensation

9:05–9:15 Introduction/Overview: **Kevin Alloway**, Pennsylvania State University

9:15–9:45 **Elaine Zhang**, Columbia University

In vivo *dissection of L1 inputs in the barrel cortex*

9:45–10:15 **Jeff Moore**, University of California, San Diego

Trigeminal and thalamic representation of vibrissa self-motion versus touch

10:15–10:45 **Alison Barth**, Carnegie Mellon University

The origin of surround receptive fields in superficial layers of the barrel cortex

10:45–11:15 **Alex Groh**, Technische Universitaet Muenchen, Germany

Corticothalamic feedback in higher-order thalamus during different behavioral states

11:15–11:30 Coffee Break

11:30–12:00 Discussion

12:00–1:00 Short Platform Talks 1

Moderator: **Randy Bruno**, Columbia University

12:00–12:15 **Alexander Van der Bourg and Fritjof Helmchen**

Brain Research Institute, Zurich, Switzerland

Postnatal development of sensory-evoked neuronal population activity in mouse barrel cortex (Due to scheduling issues this talk was swapped with Packer et al.)

12:15–12:30 **Philip Chu[1], Reena Abraham[2], Usma Khan[2], Kumarie Budhu[3], and Joshua C. Brumberg[1,2,3,4]**

[1]Psychology PhD Program, The Graduate Center, City University of New York (CUNY), [2]Neuroscience Major, Queens College, CUNY, [3]Psychology Department, Queens College, CUNY, and [4]Neuroscience–Biology PhD Subprogram, The Graduate Center, CUNY

Perineuronal nets as regulators of the intrinsic physiology of barrel cortex neurons

12:30–12:45 **Stuart D. Greenhill and Kevin D. Fox**

School of Biosciences, Cardiff University, UK

Development of sub- and suprathreshold plasticity in RS and IB cells in layer V of the mouse barrel cortex in vivo

12:45–1:00 Discussion

1:00–2:30 Lunch Break

2:30–5:10 Dendritic Processing in Somatosensory and Visual Cortices

2:30–2:40 Moderator: **Robert Sachdev**, Charité Universitäts Medizin, Berlin, Germany

2:40–3:10 **Arthur Konnerth**, Institute of Neuroscience, Technical University Munich, Germany

Dendritic integration in cortical neurons in vivo

3:10–3:40 **Matthew Larkum**, Humboldt University, Berlin, Germany

Influence of NMDA receptors on dendritic integration

3:40–4:10 **Jeff Magee**, Janelia Farm Research Campus

Active dendritic integration in L5 pyramidal neurons contributes to sensorimotor learning

4:10–4:40 **Spencer Smith**, University of North Carolina School of Medicine

Active dendritic synaptic integration and dendrite-targeted inhibition in visual cortical circuitry during sensory processing

4:40–4:50 Coffee Break

4:50–5:10 Discussion

5:10–5:30 Data Blitz

Moderator: **Joshua C. Brumberg**, Queens College, CUNY

5:30–8:00 Poster Session

6:30 Dinner (Posters and Pizza)

Friday, 14 November

8:45–9:00 Continental Breakfast

9:00–11:00 Short Platform Talks 2

Moderator: **Mary Ann Wilson**, Johns Hopkins University

9:00–9:15 **Rony Azouz**

Department of Physiology and Cell Biology, Zlotowski Center for Neuroscience, Faculty of Health Sciences, Ben-Gurion University of the Negev, Israel

Functional organization of the whisker pad

9:15–9:45 **R. Egger[1,2], V. J. Derksen[3], D. Udvsry[1,2], H.-C. Hege[3], and M. Oberlaender[1,4,5]**

[1]Computational Neuroanatomy, Max Planck Institute for Biological Cybernetics, Tübingen, Germany, [2]Graduate School of Neural Information Processing, University of Tuebingen, Germany, [3]Visualization and Data Analysis, Zuse Institute Berlin, Germany, [4]Digital Neuroanatomy, Max Planck Florida Institute, Jupiter, FL, and [5]Bernstein Center for Computational Neuroscience, Tuebingen, Germany

The barrel cortex connectome—dense connectivity from sparse reconstructions of neural circuits

9:45–10:00 **Alejandro Ramirez, Eftychios A. Pnevmatikakis, Josh Merel, Liam Paninski, Kenneth D. Miller, and Randy M. Bruno**

Departments of Neuroscience and Statistics, Kavli Institute for Brain Science, Center for Theoretical Neuroscience, and the Grossman Center for the Statistics of Mind, Columbia University

Which patterns of sensory stimuli drive barrel cortex neurons?

10:00–10:15 **Hang Hu and Ariel Agmon**

Department of Neurobiology and Anatomy and the Sensory Neuroscience Research Center, West Virginia University

Thalamocortical feedforward inhibition by infragranular somatostatin-containing interneurons

10:15–10:30 Discussion

10:30–11:00 Coffee Break

11:00–12:30 Short Platform Talks 3

Moderator: **Rony Azouz**, Ben-Gurion University, Israel

11:00–11:15 **Chris S. Bresee[1], Lucie A. Huet[2], Jasmine L. Alade'Fa[3], Hayley M. Belli[3], and Mitra J. Z. Hartmann[2,3]**

[1]Interdepartmental Neuroscience Program, [2]Department of Mechanical Engineering, and [3]Department of Biomedical Engineering, Northwestern University

Constraints on vibrissal movement imposed by the three-dimensional anatomy of the follicles

11:15–11:30 **Jennifer A. Hobbs[1], Lucie A. Huet[2], and Mitra J. Z. Hartmann[2,3]**

[1]Department of Physics and Astronomy, [2]Department of Mechanical Engineering, and [3]Department of Biomedical Engineering, Northwestern University

The whisking search space and steps towards quantifying the vibrisso-tactile natural scene

11:30–11:45 **Edward Zagha, Xinxin Ge, and David A. McCormick**

Yale University School of Medicine

Motor cortex ensemble activities underlying goal-directed behavior in a sensory detection task

11:45–12:00 **Bing-Xing Huo, Jared B. Smith, and Patrick J. Drew**

Center for Neural Engineering, Department of Engineering Science and Mechanics, Pennsylvania State University

Cortical neurovascular coupling and decoupling during voluntary locomotion in awake, behaving mice

12:00–12:15 Discussion

12:15–1:45 Lunch Break

1:45–2:45 Short Platform Talks 4

Moderator: **Chia-Chien Chen**, University of California, Santa Cruz

1:45–2:00 **Bryan M. Hooks[1,2,3], Zengcai Guo[1], Nuo Li[1], Tsai-Wen Chen[1], Karel Svoboda[1], and Charles R. Gerfen[1,2]**

[1]Janelia Farm Research Campus, Ashburn, VA, [2]National Institutes of Health, NIMH, Bethesda, MD, and [3]Department of Neurobiology, University of Pittsburgh School of Medicine, Pittsburgh, PA

Cre-recombinase driver lines for pyramidal neurons of primary sensory and motor areas involved in vibrissal somatosensation

2:00–2:15 **Adam M. Packer, Henry W. P. Dalgleish, Lloyd Russell, and Michael Hausser**

Wolfson Institute for Biomedical Research, University College London, UK

All-optical manipulation and recording of neural circuit activity in vivo (Due to scheduling issues this talk was swapped with Van der Bourg and Helmchen)

2:15–2:30 **Christopher J. Roome and Bernd Kuhn**

Okinawa Institute of Science and Technology Graduate University, Japan

Chronic cranial window with access port allowing repeated cellular manipulations and electrophysiology

2:30–2:45 Discussion

2:45–3:00 Coffee Break

3:00–5:00 Cortical Dynamics during Touch Perception

3:00–3:10 Introduction/Overview: **Daniel O'Connor**, Johns Hopkins University

3:10–3:40 **Takayuki Yamashita**, École Polytechnique Fédérale de Lausanne, Switzerland

Physiology and function of cortico-cortical projection neurons in mouse barrel cortex

3:40–4:10 **Jerry Chen**, Universität Zûrich, Switzerland

Functional reorganization of long-range projection neurons in mouse barrel cortex during task learning

4:10–4:40 **Garrett Stanley**, Georgia Institute of Technology

How dynamic is encoding? Adaptive tradeoffs between detectability and discriminability

4:40–5:00 Discussion

5:00 Adjourn

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