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ORIGINAL ARTICLE

Barrels XXVIII take the Windy City by storm

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ABSTRACT
The 28th annual Barrels meeting was held prior to the Society for Neuroscience meeting in October 2015 at the Northwestern University School of Law in Chicago, Illinois. The meeting brought together researchers focused on the rodent sensorimotor system. The meeting focused on modern techniques to decipher cortical circuits, social interactions among rodents, and decision-making. The meeting allowed investigators to share their work via short talks, poster presentations, and a data blitz.

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Day 1: Thursday

The 28th annual Barrels meeting opened under the watchful eye of Abraham Lincoln, in the Hogwarts-inspired Lincoln Hall on the campus of Northwestern University School of Law in Chicago, Illinois (Figure 1). The meeting was hosted on Thursday 15 October and Friday 16 October 2015. The Barrels meeting annually brings together investigators from around the world focusing on issues related to the rodent whisker-to-barrel cortex system. This year's meeting focused on three main topics: techniques and insights on deciphering cortical circuits, the neural underpinnings of social behavior and communication, and finally the neural basis of decision-making.

The first session on circuit breakers was introduced and moderated by **Jochen Staiger** (Georg-August Universität). The initial speaker, **Troy Margrie** (University College London), focused on defining specific circuit elements and then, based on knowledge of how they integrated into cortical circuits, began to build up to a functional analysis. Specifically, using four intrinsic parameters (which included spike adaptation rates, levels of "sag" current, and action potential threshold) cortico-cortical vs. cortico-thalamic neurons could be differentiated within layer VI of primary visual cortex in the mouse. Receptive field mapping showed that cortico-thalamic neurons were much more tuned and that cortico-cortical cells received much more depolarization in response to visual stimuli. Using rabies virus *in vivo* it was possible to infect individual cells and then determine some of their pre-synaptic patterns. Following adequate incubation time, sections were then cut on a vibratome and using a 2-photon microscope it was possible to show that cortico-cortical cells had more local inputs than cortico-thalamic neurons which got a lot of their inputs (∼25%) from higher-order visual areas, including the retrosplenial cortex which encodes head direction. Putting the mouse on a turntable that allowed rotation demonstrated that the resting membrane potential of cortico-thalamic neurons is modulated by head direction in the horizontal axis.

The next speaker was **Joanna Urban-Ciecko** (Carnegie Mellon University). Using whole-cell recordings she was able to show that functional connectivity can be regulated by the activity of somatostatin-positive GABAergic interneurons *in vitro*. The spontaneous activity of the slice was modified using different artificial cerebral spinal fluid compositions. It was found that when the cortical network was active, pyramidal to pyramidal cell connections displayed paired pulse facilitation and when the network was relatively silent these same connections showed paired pulse depression. Using optogenetics to activate a population of somatostatin-positive interneurons, it was shown how these cells can rapidly stop excitatory neurotransmission in the brain.

The final speaker of the session was **Ian Wickersham** (Massachusetts Institute of Technology). His talk focused on advances in monosynaptic racing largely using rabies viruses. By modifying the virus correctly, it is possible to get monosynaptic labeling of the pre-synaptic targets without confounding the labeling of polysynaptic inputs which were indistinguishable in earlier versions of the technique. A further advance of the viral vectors is their relative lack of toxicity to the host neurons. Through utilization of these techniques investigators can determine the nature of the pre-synaptic inputs to a specific neuron of interest.

Following a coffee break there where three short talks moderated by **Hillel Adesnik** (University of California,

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Figure 1. Meeting attendees. Under the watchful eye of Abraham Lincoln, the Barrels XXVIII attendees listen to the latest advancements in the rodent whisker-to-barrel system.

Berkeley). Leading off was **Chia-Chien Chen** (University of California, Santa Cruz) who used a synthesis of behavioral studies and *in vivo* 2-photon imaging to assay the role stress has on learning and memory of motor tasks and the resultant impact on dendritic spines. Using the pillar task, wherein mice must use their whiskers to detect novel vs. familiar objects, it was shown that stress decreases performance. The 2-photon imaging revealed that stress does not impact the formation of new spines, but does increase the rate of elimination of spines, especially those found in clusters. Having the mice housed in enriched environments ameliorates some of the impacts of stress. **Marcel Oberlaender** (Institute for Biological Cybernetics, Tübingen, Germany) followed up by using retrograde tracers to label distinct populations of layer V cells. It was determined that 37% of layer V pyramidal cells in barrel cortex project to the pons, 25% project to the spinal trigeminal nucleus, 22% to the posterior medial nucleus of the thalamus, and 15% to the superior colliculus. Cell attached recording *in vivo* showed that posterior medial projecting neurons had high levels of spontaneous activity and robust whisker-evoked responses. The neurons that projected to the pons had lower spontaneous activity and responded to the whisker stimulus throughout the deflection, including the hold phase. Those neurons that project to the spinal trigeminal nucleus have reliable early and sustained responses. In conclusion, the data demonstrate that the long-range target of a neuron's axon is correlated with neurons' receptive field properties and levels of spontaneous activity. Finally, the morning session was concluded with a talk by **Xiang Yu** (Chinese Academy of Sciences). She showed that early enrichment leads to higher spine densities by 2 months of age, but by 3 months they have overall lower spine densities, but a higher proportion of spine morphologies that are associated with mature animals. In general, it was found that the proportion of mature spines was inversely correlated with overall spine density. Using knockouts of various cytoskeletal linking proteins, it was shown that beta-catenin plays a pivotal role in spine maturation.

Post lunch, the afternoon session addressed the topic of social behavior and communication. The session was moderated by **Adi Mizrahi** (Hebrew University, Israel). The first speaker was **Ann Clemens** (Bernstein Center, Germany) who discussed the neuronal responses to social facial touch. Initially, data were presented showing how rodents and other animals use their whiskers to socially interact. She and her colleagues found that there are sex-related differences in this interaction which evoked action potential (AP) firing in the barrel cortex. They conducted *in vivo* recordings in head-fixed "subject" rats while they were interacting with a "stimulus" rat. The differences in the firing patterns were cell-type dependent and seen in fast-spiking interneurons and not in regular-spiking cells. They also studied the effect of estrus phases on the spiking patterns during social touch in females. Interestingly, during estrus the response to social touch was lowest while the baseline firing was highest. Consistent with these findings was immunocytochemical evidence that showed that the estrogen receptor was colocalized in the barrel cortex with the Ca^{2+}-binding protein parvalbumin, which is expressed by fast-spiking interneurons. Their current work explores the molecular mechanisms underlying this cyclical pattern and Dr Clemens also discussed some preliminary data and approaches in this regard.

The next speaker was **Gul Dolen** (Johns Hopkins University). Her work was based on the mechanistic understanding of the pathogenesis of social dysfunctionality in neuropsychiatric disorders (particularly autism) and its underlying neural encoding. Using genetic modulation for blocking the oxytocin (OT) receptors in the nucleus accumbens (NAc) in mice, her group established that only the inputs from dorsal raphe nucleus are vital for social interactions. This was tested using the social conditioned place preference paradigm wherein the OT-receptor blocking was confirmed electrophysiologically. Subsequently, in Venus reporter mice, they observed the localization of NAc OT on inputs from dorsal raphe nucleus. Thus, she suggested the following mechanism: OT when released in NAc subsequently acts on the terminals of axons that originate from the dorsal raphe nucleus thereby inducing a release of serotonin. This in turn led to glutamate release which eventually resulted in long-term depression (LTD). It is known that LTD is correlated to social interaction as animals living socially exhibit stronger LTD than their isolated counterparts. Together, these data suggest the social reward mechanism to be the result of coordinated OT and serotonin activity in the NAc of mice.

The following speaker was **Bianca Jones Marlin** (New York University) who discussed how OT regulates the maternal behavior of pup retrieval via enhancing the auditory cortical responses in mouse mothers. She began by illustrating the pup retrieval behavior which was seen in the case of experienced mothers in response to distress calls from newborn pups when they were separated. Virgin females did not exhibit this behavior. However, only the virgin females co-housed with dams or those subjected to central administration of OT displayed the retrieval behavior. She and her colleagues then looked into the expression patterns of the OT receptor via antibody (OXTR-2) labelling. Interestingly, they observed the expression to be significantly higher in the left auditory cortex and to be true for both the groups, dams and virgins, thereby implying OT-receptor expression to be independent of experience. They hypothesized that a distinct specific neural circuit, augmented with OT receptors, would thus be adapted for pup distress calls. Using electrophysiology, they subsequently looked into neuromodulatory effects of OT. It was seen that the immediate effect of OT pairing (either topical OT application or optogenetic OT activation) in virgin females decreased inhibitory post-synaptic currents (IPSCs) and increased reliability of potentiated excitatory post-synaptic currents (EPSCs). However, 45 min post pairing there was significant strengthening of IPSCs. This delayed balancing was crucial for spike time precision in OT paired virgins (also in experienced dams) which sensitized them for pup retrieval. In conclusion, she suggested that the maternal pup retrieval was a result of OT-mediated delayed balancing of inhibition with excitation of auditory cortex.

The day's talks ended with **Adi Mizrahi's** (Hebrew University, Israel) talk on plasticity in the primary auditory cortex (A1) with a focus on coding of natural sounds. Having emphasized the role of pure tones in understanding the general mechanisms of auditory cortex, he suggested its plausible role in understanding natural sounds. With a view to gain insights into this, he discussed the spectrotemporal receptive field (STRF) which is a two-dimensional function used to analyze the tuning properties of individual auditory responsive neurons. Knowing from previous work that STRF-based models account for a small fraction of cortical responses to natural sounds, he discussed the two main underlying reasons: (i) non-linearity of neuronal responses in auditory cortex; and (ii) context sensitivity of neuronal responses (i.e., same stimulus when presented in varied context exhibit different responses). To account for context sensitivity, he suggested the role of inhibitory mechanisms in the auditory cortex and synaptic depression (which was seen in both thalamocortical and cortico-cortical synapses) amongst other additional mechanisms. Moving from single neuronal coding to population coding, Professor Mizrahi focused on tonotopic maps in A1 across species. While the presence of such tonotopic maps in mouse A1 was debated by different groups of studies, Professor Mizrahi suggested the presence of coarse grain level tonotopy in mouse A1. He also stated that the tonotopy at lower levels of the auditory reception pathway is majorly a consequence of decomposition of frequencies. Surprisingly, A1 was different and did not seem to have frequency-decomposition-based tonotopy. It was then suggested that novel organization patterns rather than smooth tonotopic maps may be employed by A1 for processing of complex sounds. In conclusion, Professor Mizrahi proposed that the processing in auditory cortex might be based on general mechanisms which are indifferent for all sounds (simple and complex; natural and artificial). Following the talks, a dinner and poster presentation was hosted that allowed conference attendees to see the latest results while feasting.

Day 2: Friday

The second day began early with four short talks moderated by **Marcel Oberlaender** (Institute for Biological Cybernetics, Tübingen, Germany). **Mitra Hartmann** (Northwestern University) led off a lab tag team by presenting every member of the audience with a 3D-printed, scaled model of a mouse's whisker as a means to visualize all of the forces present during each whisk cycle and every contact event. Her student **Lucie Huet** followed up by showing that the best way to approximate the bending moment at the whisker base is to compute the curvature at the base, and that measuring global or average curvature did not perform nearly as well. Finally, **Anne Yang** presented data showing that the force propagated at the base of the whisker is dependent upon the intrinsic curvature of the whisker itself, and therefore identical deflections presented by piezos will not result in two whiskers transmitting the same mechanical information. **Andrew Hires** (University of Southern California) spoke next and demonstrated that a conical model of a whisker performs very poorly at replicating whisker kinetics during touch. He showed that one can account for a much larger percentage of the variance of a whisker's kinetics by allowing the bending stiffness to vary along the length of the whisker. He hypothesized that this could be the result of an inhomogeneity in Young's modulus along the length of the whisker, which is proportional to the fourth power of the radius of the whisker. When he measured each whisker's radius he actually found that a whisker's radius does not linearly decrease along its length, rather the whisker is thinner in the middle than a linear relationship would suggest, lending some credence to his hypothesis. Afterward, **Jason Ritt** (Boston University) described a study investigating how rodents choose to palpate objects in their environment and how much primary somatosensory cortex (S1) contributes to this behavior. By having the mice perform a simple tactile search behavior, he found that mice employ a strategy that modulates whisking to counteract head motion and sustain repeated contacts, but only when doing so is likely to be useful to the mouse. Secondly, he replicated previous results showing that optogenetically stimulating S1 in quiescent animals produces retractions, but further showed that whisk-locked stimulation regularizes whisking and increases whisk frequency. Additionally, he demonstrated that the phase of this whisk-locked stimulation is extremely important in how it affects the mouse's whisking, with even a 20-ms difference in stimulation time producing very different behaviors. **Rasmus Petersen** (University of Manchester, UK) concluded the morning session by describing a generalized linear model (GLM) based approach for predicting the spiking activity of trigeminal ganglion neurons during natural whisking, using whisker angle and curvature measured via high-speed photography. He found that the vast majority of units were fitted better by a curvature-based model, and furthermore incorporating angle information did not improve the fit. By fitting a GLM based on the whisker's acceleration during free whisking, he also showed that 50% of units were sensitive to acceleration, with a heterogeneous mix of these units being tuned for a specific direction of the acceleration.

After a group discussion and break for coffee, there were five more short talks moderated by **Solange Brown** (Johns Hopkins University). **Tess Oram** (Weizmann Institute of Science, Israel) spoke first and described her strategy to identify the perceptual functions of the ventral posterior medial (VPM) and posterior medial (POm) thalamic nuclei. She identified thalamic units in each of these pathways by injecting either Cre-on or Cre-off channelrhodopsin into GPR26-Cre mice that were allowed to freely move in a cage. She found that the firing rates of neurons in both pathways were modulated by head acceleration and orientation, but that they were especially modulated by head velocity. Additionally, she showed that VPM neurons were strongly modulated by vibrissal touch and that this modulation did not significantly interact with head-motion-induced modulations. **Clarissa Whitmire** (Georgia Institute of Technology) followed up by showing that neurons in the leminsical thalamus (VPM), which typically burst fire synchronously in response to touch, decrease their burstiness and synchrony as a result of adaptation. She demonstrated this by using piezos to deflect whiskers of an anesthetized mouse while modulating the amount of underlying noise being played through the piezos. Afterward **Scott Pluta** (University of California, Berkeley) moved up to the primary somatosensory cortex where he presented results showing a new inhibitory pathway in cortical microcircuit. While selectively silencing layer 4 (L4) excitatory neurons with halorhodopsin, he showed that regular-spiking neurons in layer 5 (L5) increased their firing rates. Conversely, when he activated channelrhodopsin in L4 excitatory neurons, L5 regular-spiking neurons decreased their firing rates. He found that this is likely due to a previously undiscovered direct connection from L4 excitatory neurons onto L5 fast-spiking interneurons. This translaminar circuit helps to sharpen the spatial tuning of L5 pyramidal neurons. Next **Vishalini Sivarajan** (Aachen University Hospital, Germany) described work where she patched and labeled non-fast-spiking inhibitory neurons in L4. She clustered her neurons based on where they project and found three distinct clusters: infragranular projecting, supragranular projecting, and intralaminar projecting neurons. One major surprise was that some of the intralaminar projecting neurons also projected laterally to surrounding columns. Secondly, she clustered the neurons based on electrophysiological properties and again found three distinct groups: high adapting, low threshold spiking, and late spiking. However, there is no correlation between the clusters identified with the two methods. Finally, to finish off the morning sessions **Guanxiao Qi** (Aachen University, Germany) advanced our understanding of L4 connectivity even further by measuring the connection probability between excitatory neurons and other neurons in L4. Paired whole-cell recordings revealed that the connection probability of an excitatory neuron being connected to another excitatory neuron within the same barrel is 30%, while the probability of an excitatory neuron connecting to an excitatory neuron in a neighboring barrel is 10%. This is contrasted with his finding that there is a 60% connection probability of an excitatory neuron connecting onto an inhibitory neuron within the same barrel, as opposed to a 20% connection probability onto inhibitory neurons in neighboring barrels. The degree of transbarrel connectivity was quite surprising and is sure to play a pivotal role in shaping L4 neurons' receptive field properties.

The final session of the meeting focused on decision-making. Moderator **Eddie Zagha** (Yale University) introduced the topic with a summary of three key challenges facing neuroscientists studying decision-making: (1) designing choice-based behavioral tasks; (2) recording neural activity during these tasks; and (3) identifying a framework to "read-out" and model the neural computations that underlie effective decision-making in animals.

The first speaker, **Mathew Diamond** (Scuola Internazionale Superiore di Studi Avanzati, Italy) described work using a vibrotactile delayed comparison task to study temporal integration in both rats and humans. In this task, subjects were presented with two successive vibrating stimuli to the whiskers or fingertips. Stimuli were irregular and noisy, as each time point in a stimulus was generated by randomly sampling a velocity value from a normal distribution. On each trial, subjects had to discriminate which stimulus had been generated from a higher variance distribution. Diamond and colleagues also varied the duration of stimuli, and found that this could confound judgment of variance; for both rats and humans, longer stimuli were perceived to be of higher variance ("longer feels stronger"). This suggests that the brain may be summating velocities over time to perform this task. Supporting this interpretation, psychophysical performance was well-described by a model in which tactile inputs were temporally summated with a primacy bias. Finally, extracellular recordings in rats revealed potential neural correlates of these perceptual processes. Some neurons in primary somatosensory cortex appeared to be performing a computation very similar to the predicted summation, while neurons in premotor cortex displayed choice-related activity that was biased by stimulus duration in a manner similar to the behavior itself.

The next speaker, **Daniel O'Connor** (Johns Hopkins University), described a technically impressive study examining the evolution of choice-related activity across multiple stages of the whisker somatosensory pathway. In this study, mice performed a detection task, licking for a reward in response to a whisker stimulus. Calcium imaging and whole-cell recordings in the barrel cortex revealed that many neurons displayed activity encoding the mouse's choice on a trial-by-trial basis, in addition to encoding the stimulus itself. This choice-related activity was evident in the spiking of only a subset of these neurons, though choice-related subthreshold activity was evident in the membrane potential of nearly all whole-cell recordings. Extracellular recordings revealed that this choice-related activity was totally absent in primary mechanoreceptor neurons of the trigeminal ganglion, but that transient and weak choice-related activity could be seen in the spiking of neurons in the ventral posteromedial nucleus of the thalamus. However, this brief increase in thalamic activity could not account for the robust and prolonged choice-related activity seen in the cortex, since mimicking this transient activity via optogenetic stimulation of thalamus only briefly increased cortical activity. Calcium imaging of the boutons of axonal projections from secondary somatosensory cortex to barrel cortex revealed that these appear to convey choice-related activity, which likely contributes to the choice-related activity seen in barrel cortex.

Following this, **Cornelius Schwarz** (Universität Tübingen, Germany) gave a talk on active sensation in the whisker system. He opened the talk by postulating that the haptic scanning performed by whiskers or hands bears many similarities to active sensing modalities such as echo-location or electrosensation, since it involves the active transfer of energy to the environment. This type of sensing can be optimized through strategies that control how scanning energy is transformed into forces affecting the sensory organ. To study which parameters of these forces are used by the brain, a variety of tactile stimuli trains were presented to the whiskers of rats. These stimuli were designed to mimic the slip–stick whisker movements that occur during natural whisking. Notably, rats could use instantaneous kinetic parameters (i.e., the waveform) of these stimuli in a discrimination task, in addition to the frequency and intensity of the stimuli. Schwarz closed the talk with a look at how brainstem anatomy might contribute to a closed-loop system for controlling whisker-based active sensing.

The final speaker of the meeting was **Jianing Yu** (Janelia Research Campus), who described his work on the role of inhibition in filtering inputs from the whiskers during active sensation. A fundamental problem for any actively sensing system is to distinguish signals caused by self-motion (reafference) from signals originating from the external world (exafference). Using whole-cell recordings from neurons in layer 4 of the barrel cortex of awake mice, Jianing and colleagues observed that while (putatively excitatory) regular-spiking neurons were not strongly driven by the reafference generated by the act of whisking, and instead responded selectively to exafferent signals generated when a whisker contacts an object. In contrast, fast-spiking inhibitory interneurons fired in response to both whisking and touch. This led to the hypothesis that feedforward inhibition from fast-spiking neurons might counteract slow excitatory inputs created by whisking, allowing regular-spiking cells to respond only to touch. Supporting this notion, optogenetic suppression of fast-spiking cells unmasked whisking responses in layer 4 excitatory neurons, and this whisking-related activity reduced the signal-to-noise ratio of touch responses.

This brought down the curtain on the 28th annual Barrels meeting with a resolve to meet again in fall 2016 prior to the Society for Neuroscience meeting on the campus of the University of Southern California.

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Disclosure statement

The authors report no conflicts of interest.

Appendix: Schedule

Barrels XXVIII

15–16 October 2015, Northwestern University Law School, Chicago, IL

Thursday, 15 October

8:45–9:00	**Continental Breakfast, Name Tag Pickup**
9:00–9:05	Welcome
	Joshua C. Brumberg, The Graduate Center and Queens College, CUNY
	Gordon Shepherd, Jr., Northwestern University
9:05–12:00	**Circuit Breakers**
9:05–9:15	Introduction/Overview: **Jochen Staiger**, Georg-August Universität
9:15–9:45	**Bobby Kasthuri**, Boston University
	Towards a saturated anatomical description of the brain
9:45–10:15	**Troy Margrie**, University College London, UK
	Cellular dissections of function and connectivity of neuronal circuits
10:15–10:45	**Joanna Urban-Ciecko**, Carnegie Mellon University
	Functional connectivity is regulated by SOM interneurons spontaneous activity
10:45–11:15	**Ian Wickersham**, Massachusetts Institute of Technology
	Advances in monosynaptic tracing
11:15–11:30	**Coffee Break**
11:30–12:00	Discussion
12:00–1:00	**Short Platform Talks 1**
	Moderator: **Hillel Adesnik**, University of California, Berkeley
12:00–12:15	**Chia-Chien Chen, Ju Lu, and Yi Zuo**
	University of California, Santa Cruz
	Stress-induced abnormality of dendritic spine dynamics in the mouse barrel cortex
12:15–12:30	**Gerardo Rojas-Piloni, Jason M. Guest, Robert Egger, Andrew S. Johnson, and Marcel Oberlaender**
	Max Planck Florida Institute for Neuroscience, Jupiter, FL and Max Planck Institute for Biological Cybernetics, Tübingen, Germany
	Deconstruction of sensory stimuli in L5 of rat barrel cortex via parallel long-range pathways to disjoint subcortical targets
12:30–12:45	**Wen-Jie Bian, Wan-Ying Miao, Shu-Ji He, Zilong Qiu, and Xiang Yu**
	Institute of Neuroscience, State Key Laboratory of Neuroscience, CAS Center for Excellence in Brain Science, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai, China
	Coordinated spine pruning and maturation mediated by inter-spine competition for cadherin/catenin complexes
12:45–1:00	Discussion
1:00–2:30	**Lunch Break**
2:30–5:10	**Social Behavior and Communication**
2:30–2:40	Moderator: **Robert Froemke**, New York University
2:40–3:10	**Ann Clemens**, Bernstein Center, Germany
	Social facial touch and fast-spiking interneurons of the female barrel cortex
3:10–3:40	**Gul Dolen**, Johns Hopkins University
	Social reward: Basic mechanisms and autism pathogenesis
3:40–4:10	**Peggy Mason**, University of Chicago
	Determinants of socially selective helping in rats
4:10–4:40	**Adi Mizrahi**, Hebrew University, Israel
	Targeting natural plasticity in auditory cortex
4:40–4:50	**Coffee Break**
4:50–5:10	Discussion
5:10–5:30	**Data Blitz**
	Moderator: **Joshua C. Brumberg**, The Graduate Center and Queens College, CUNY
5:30–8:00	**Poster Session**
6:30	**Dinner**

Friday, 16 October

8:45–9:00	Continental Breakfast
9:00–11:00	Short Platform Talks 2
	Moderator: **Marcel Oberlaender**, Max Planck Institute for Biological Cybernetics
9:00–9:15	**Lucie A. Huet[1], Anne E. T. Yang[1], Sara A. Solla[2, 3], Todd D. Murphey[1], John Rudnicki[1], and Mitra J. Z. Hartmann[1, 4]**
	[1]Department of Mechanical Engineering, [2]Department of Physics and Astronomy, [3]Department of Physiology, and [4]Department of Biomedical Engineering, Northwestern University, Evanston, IL
	Kinematic and kinetic signals in the vibrissal trigeminal system
9:15–9:45	**Samuel Andrew Hires[1], Jonathan Sy[1], Vincent Huang[1], Isis Wyche[1], Xiyue Wang[1], Adam Schuyler[1], and David Golomb[2]**
	[1]Department of Biological Sciences, Neurobiology Section, University of Southern California, Los Angeles, CA and [2]Department of Physiology and Cell Biology, Faculty of Health Sciences, Ben-Gurion University, Be'er-Sheva, Israel
	Beyond cones: An improved model of whisker bending
9:45–10:00	**J. B. Schroeder, V. J. Mariano, G. I. Telian, and J. T. Ritt**
	Department of Biomedical Engineering, Boston University
	Closedloop optogenetic stimulation reveals primary somatosensory cortex participation in whisk timing
10:00–10:15	**D. Campagner[1], M. Evans[1], M. Bale[2], A. Erskine[3], and R. S. Petersen[1]**
	[1]University of Manchester, [2]Univesity of Sussex, and [3]University College London
	Prediction of trigeminal ganglion activity during object exploration in awake mice
10:15–10:30	Discussion
10:30–11:00	**Coffee Break**
11:00–12:30	**Short Platform Talks 3**
	Moderator: **Solange Brown**, Johns Hopkins University
11:00–11:15	**Tess Oram, Ehud Ahissar, and Ofer Yizhar**
	Weizmann Institute of Science, Rehovot, Israel
	Head-motion modulation of the activity of optogenetically tagged neurons in the vibrissal thalamus
11:15–11:30	**Clarissa J. Whitmire[1], Christian Waiblinger[1, 2, 3], Cornelius Schwarz[2, 3], and Garrett B. Stanley[1]**
	[1]Wallace H. Coulter Department of Biomedical Engineering, Georgia Tech and Emory, Atlanta, GA, [2]Systems Neurophysiology, Werner Reichardt Centre for Integrative Neuroscience, and [3]Department of Cognitive Neurology, Hertie Institute for Clinical Brain Research, University of Tübingen, Germany
	Information coding through adaptive control of synchronized thalamic bursting
11:30–11:45	**Scott Pluta*, Alexander Naka*, Julia Veit, Gregory Telian, Lucille Yao, Richard Hakim, David Taylor, and Hillel Adesnik**
	University of California, Berkeley
	A direct translaminar inhibitory circuit tunes cortical output
11:45–12:00	**Guanxiao Qi[1] and Dirk Feldmeyer[1, 2, 3]**
	[1]Institute of Neuroscience and Medicine, Research Centre Jülich, Jülich, Germany, [2]Department of Psychiatry, Psychotherapy and Psychosomatics, Aachen University, Aachen, Germany, and [3]Jülich-Aachen Research Alliance-Brain, Aachen, Germany
	Inter-barrel synaptic connections involving layer 4 spiny neurons and interneurons in rat barrel cortex
12:00–12:15	**Vishalini Sivarajan[1], Guanxiao Qi[1], and Dirk Feldmeyer[1,2]**
	[1]Depaertment of Psychiatry, Psychotherapy and Psychosomatics, Aachen University Hospital, Aachen, Germany and [2]Forschungszentrum, Juelich, Germany
	Morphological and functional characterization of non-fast-spiking GABAergic interneurons in layer 4 microcircuitry of rat barrel cortex
12:15–12:30	Discussion
12:30–2:00	**Lunch Break**
2:00–4:30	**Decision-Making**
2:00–2:10	Introduction/Overview: **Edward Zagha**, Yale University
2:10–2:40	**Mathew Diamond**, SISSA, Trieste, Italy
	Temporal integration in a vibrotactile delayed comparison task: From sensory coding to decision in humans and rats
2:40–3:10	**Daniel O'Connor**, Johns Hopkins University
	Circuit analysis of choice-related activity in mouse somatosensory cortex
3:10–3:40	**Cornelius Schwarz**, Universität Tübingen, Germany
	What is encoded by active whisker scanning and how is it modified by scanning parameters?
3:40–4:10	**Jianing Yu**, Janelia Research Campus
	Thalamocortical feedforward inhibition gates tactile input during active somatosensation
4:10–4:30	Discussion
4:30	**Adjourn**