Barrels XXIX: Barrels Go Hollywood

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Words in Abstract: 67
Pages: 20
Figures: 1

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Abstract:

Barrels XXIX brought together researchers focusing on the rodent barrel cortex and associated systems. The meeting revolved around three themes; thalamocortical interactions in motor control, touch in rodent, monkey and humans and the nature of the multisensory computations the brain makes. Over two days these topics as well as others focused on the function, cortical circuits and behavior that govern the rodent whisker-to-barrel cortex system were discussed.

Key Words: Barrel Cortex, Whiskers, Vibrissae, Physiology, Multisensory

On November 10, 2016, Barrels XXIX kicked off in Cammilleri Hall located in the Brain and Creativity Institute on the sunny campus of the University of Southern California in Los Angeles, California. The longest running annual satellite meeting to the Society for Neuroscience's meeting focused on issues concerning the development, function and behavior of the rodent somatosensory cortex and its related systems (see Appendix 1 for a complete schedule).

Barrels XXIX Day 1

Garrett Stanley (Georgia Institute of Technology & Emory University) chaired the first session on Thalamocortical Interactions in Motor Control. **Carl Petersen** (EPFL, Switzerland) presented a talk entitled 'Movement Initiation Signals in Mouse Whisker Motor Cortex'. Vibrissa motor cortex (vM1) was localized by expressing fluorescent tracers in Primary Somatosensory (S1) whisker cortex. These anatomical coordinates were used to guide injection of Channelrhodopsin in pyramidal cells or interneurons to bi-directionally control vM1 activity. Optogenetic stimulation of vM1 evoked rhythmic whisking within 25ms in quiescent, awake mice. Inactivation suppressed whisking in 45% of self-initiated whisking events. This inactivation during whisking reduced the amplitude of whisking and retracted the set-point of the whiskers. *In vivo* intracellular membrane potential (Vm) recordings in vM1 revealed a layer-specific pattern of activity during whisking. L2/3 neurons become hyperpolarized immediately following whisk onset, whereas in L5 this hyperpolarization preceded whisking. Spiking activity in L2/3 decreased in response to whisk onset, whereas most L5 cells increased their firing when whisking commenced. Vm in vM1 also showed phase locked fluctuations to whisking. To determine the role of S1 to M1 projections in whisking control, the postdocs leading this study activated and inactivated S1 whilst recording in vM1. Vm became hyperpolarized when S1 was inhibited, with a complementary reduction in spiking. S1 activation meanwhile drove a tri-phasic depolarization, hyperpolarization and rebound of Vm in L2/3 of vM1. Spiking also rebounded after a pause of ~180ms. Behaviorally, S1 stimulation evokes whisking but with a long latency (~300ms), which is abolished if vM1 was inhibited with muscimol. The authors concluded that vM1 issues whisking commands, while S1 provides an important source of tonic excitation.

In the second talk **Bernard Sabatini** (Harvard University) presented work implicating the parafascicular nucleus in action selection, in particular switching between actions. Prof Sabatini parsed action selection and evaluation into four key questions for the agent: What did I do? In what context did I do it? Should I do it again? Should I do it again now? To determine the neural circuits underlying these computations he and his colleagues developed a simple head-fixed licking task. Mice could lick for a water reward at one of two lick ports where water availability switched randomly between the ports every few trials. After learning, mice make only one or two incorrect licks before switching to the other, rewarded port. It is then possible to manipulate and record from different structures to determine which circuits are evaluating, choosing and executing licking. Muscimol injection into the striatum blocked contralateral licking, suggesting this is where licking execution is generated, but which structure drives the switch in licking direction? A series of elegant tracing and manipulation experiments showed that a region of the intralaminar thalamus may be a rodent analogue of primate parafascicular nucleus (PF). PF, not motor thalamus per se, provides the input to striatum that drives this switch in licking direction. Inhibition of PF caused contralateral licking bias, PF projections to the striatum are organized topographically, and cortical projections to PF originate from a distinct population than those that project to motor thalamus. Ongoing imaging and perturbation experiments will further delineate PF’s inputs and role in action choice and execution.

Naoki Yamawaki (Northwestern University) asked ‘Who talks to whom?’ with respect to cell type specific thalamus - motor cortex - thalamus connectivity. The strategy for Dr. Yamawaki’s experiments was to systematically label pre-synaptic axons and post-synaptic projection neurons, before performing targeted paired Vm recordings *in vitro* to determine connection strength between each corticocortical and thalamocortical cell population. Within the local circuit, intratelencephalic (IT), corticothalamic (CT) and pyramidal tract (PT) cortical neuron populations show preferential within-class connections. Between populations, IT and CT cells were reciprocally connected, IT cells projected to PT cells but not vice versa, whilst CT and PT populations did not connect to one another. Long range projections from Ventrolateral (VL) thalamus synapsed on to IT and PT (but not CT) cells in Layers 4, 5B and 6 of M1. Posteromedial (PO) thalamus meanwhile projected to L2/3, 4 and 5A. Corticothalamic projections are also cell type specific. CT cells in M1 make weak projections to VL, but strong projections to Ventromedial (VM), PO and Thalamic Reticular Nucleus (TRN). PT cells project to PO. Dr. Yamawaki also presented a comparison between M1 and anterolateral motor cortex (ALM), a premotor region important for motor planning. ALM showed strong projections to VM thalamus, with PT suppressing and CT facilitating VM. In summary there are highly convergent inputs from M1 through VM and PO ‘matrix’ thalamus, with less input to/from ‘core’ thalamic nuclei VL and VP.

To conclude the morning session **Dieter Jaeger** (Emory University) presented work on the physiology of Basal Ganglia output to motor thalamus, and the subsequent effects of perturbing these projections on cortical dynamics. *In Vitro*, Substantia Nigra pars Reticulata (SNr, an output nucleus of the Basal Ganglia) provides inhibitory projections to VM thalamus. However, the dynamics of this inhibition is critically dependent on stimulation timing. Prof. Jaeger described an experiment where the SNr-VM projection was optically inhibited with Archaerhodopsin-3 (Arch) as mice ran on a wheel in response to an air-puff stimulus. Reaction times were faster in this cued running task when the SNr was inhibited, and if inhibition preceded the air-puff it can drive running alone. The experimenters then switched to a bilateral air-puff-cued licking task and found that SNr inhibition biased choice even on interdigitated non-stimulation trials. To determine the larger-scale network effects of SNr perturbation, the same protocol was combined with wide field imaging of cortex. During the licking task the authors saw contralateral inhibition of S1 coincident with the air-puff, and a widespread increase in activity when SNr was optogenetically inhibited.

Following a break **Alison Barth** (Carnegie Melon University) chaired a session of short talks. **Christian Ebbesen** (Humboldt Universitat, Germany) presented his recently published work delineating the role of vibrissal motor cortex (VMC) in whisker movement control. Dr. Ebbesen sought to understand how VMC contributed to whisker movement during natural behavior by recording membrane voltage (Vm) and spiking in VMC from head-fixed rats during three conditions: free whisking, object touch and social touch (whisking against another rat). On average, firing rates were reduced in VMC during all three behaviors. Microstimulation revealed that VMC drives retraction of mean whisker angle (set point) and reduction in whisking amplitude, while inhibition of VMC gave the expected opposite result. A tentative conclusion was that VMC (vM1) refines whisker movement, for example by inhibiting unwanted movements during social touch.

Edward Zagha (UC Riverside) delivered a talk on ‘Modulation of sensory processing by cortical feedback pathways’, describing a model designed to explain earlier experimental results from his lab. During optogenetic M1 stimulation, the LFP and multi-unit activity in S1 cortex of anaesthetized mice showed higher amplitude and lower variance responses to whisker stimulation. To determine whether this result could be explained by a change in recurrent or long range projection activity, Dr. Zagha built a recurrent neural network model. The model consisted of ‘competitive ensembles’ of neurons, each representing a different group of neurons in the real circuit and modelled by a single function. By systematically exploring the excitation/inhibition balance within and between modules (by varying synaptic conductances in the model), it was possible to generate a range of simulated circuit behaviors. The model that best fit the experimental data suggests that the effect of M1 stimulation is both an increase of inhibition within S1, and a reduction of self-excitation.

In the final talk of the morning session **Julian Hoffman** (Tübingen, Germany) presented intriguing work exploring S1’s role in learning - but not executing - a trace eye blink conditioning task. In eye blink conditioning mice learn to blink in response to whisker stimulation (the conditioned stimulus) to avoid an air puff to the eye (the unconditioned stimulus), a behavior that is known not to be cortex-dependent. When a delay is introduced (the trace) between CS and US of as little as 500ms, the task becomes barrel cortex dependent. The question was what barrel cortex’s specific function was for the task. Electrophysiology during learning showed an LFP source signal in L5 and an L4 sink in naive mice, which was missing in mice who had learned the task. Single unit activity showed an initial response to the CS which dissipated during the development of the trace. Intriguingly, optogenetic inhibition of S1 prevents learning, but doesn’t affect expert performance. It may be, therefore, that S1’s role is as a teacher for subcortical structures.

After lunch in the California sunshine, the afternoon session comprised four wide-ranging talks on touch in primates, rodents, humans and machines. **Sliman Bensmaia** (University of Chicago) presented an overview of primate touch sensation before describing the creation of “TouchSim”: a system for simulating signals from the whole primate hand with millisecond precision. The motivation for this work is that recordings of primate afferents is mostly done one cell at a time. Even if it was possible to record from many neurons at once, since each receptive field in the skin is slightly different it is very difficult to control the stimulus precisely to each cell. Therefore to understand population responses - their magnitude and acuity - a realistic model must be built. TouchSim consists of a virtual hand, tiled with receptors at the known density for a rhesus monkey hand. A touch can then be simulated, fed through a model of skin mechanics before driving a simple spiking model of the receptors to respond. At an individual cell level, the model matches real data very well across a range of stimulus protocols. At the population level the model showed that vibration stimuli drive a 100-fold greater response in the nerve than a flutter stimulus due to the differential recruitment of cell types, and that a 20ms window was sufficient to decode stimuli. Next Dr. Bensmaia asked whether the standard model of motion detection from vision - the Reichardt detector - would work for touch. Previous work based on decoding motion from real data had been unsuccessful due to small differences in stimulus presentation between cells. In TouchSim, motion direction discrimination was possible within 200ms using the Reichardt detector model if information from different cell types was combined. This work is now being used to guide the development of new neuroprosthetic devices.

Mitra Hartmann (Northwestern University) returned to the whisker system for her talk, asking how rats might use their whiskers to perceive object shape. In principle, tapping with whiskers is similar to ‘enclosure’ behaviors humans make with their hands. In haptics, object properties are extracted during static grasps. Does whisking behavior also show static periods during object touch? Professor Hartmann presented detailed quantification of rat whisker movements as they explored a planar surface illuminated by a laser light sheet. Three extracted variables - number of vibrissa on the surface, head velocity, and the whisking cycle - are all ‘quasi-periodic’. As a result there are periods during each whisk where many whiskers are in contact with the surface at the same time whilst the rat’s head is almost stationary - the Sustained Collective Contact Interval (SCCI). SCCIs were observed for all touch episodes, for all whisks. During SCCIs, whisker and head movements are such that contacts are well approximated by quasi-static mechanical models. The quasi-static regime is important as it allows extraction of contact location from bending forces without having to monitor head and whisker geometry precisely at millisecond resolution from moment to moment. It was proposed that this approach would allow shape perception with whiskers to be robust to variation in head pose and whisker velocity.

Robot touch was the subject of **Gerald Loeb**'s (University of Southern California) presentation. Though tactile robots have a range of uses the motivation for this work was scientific - given that touch is difficult to study, engineering tactile robots can illuminate the gaps in our current understanding. Through a series of projects Prof. Loeb showed the progress made in his lab to engineer artificial sensors with human-like touch capabilities. Constructed from an electrode array wrapped in a silicone sheath filled with salt-water, the BioTac artificial fingertip can detect force, temperature and vibration to superhuman levels. Through careful choice of design and materials, the mechanical properties of the device allow peak frequency sensitivity to match human skin - an important consideration for prosthetic devices. An artificial fingerprint was shown to enhance sliding vibration amplitude threefold, improving slip detection. For identifying objects with touch, it was found that different finger movement forces and velocities were more appropriate for identifying different surfaces. But how might a person choose which movements to make? Bayesian exploration - where previous experience is combined with incoming data - was shown to work very well for robot touch. Finally, inspired by this robotic work, Prof. Loeb presented a hypothesis for how object percepts are encoded in the brain as combinations of a limited motor repertoire and incoming sensory information. Such a representation was found to reduce the dimension of a dataset comprising 500 different materials and 5 movement types to a 15 dimensional 'perceptual' space in a robot experiment.

Finally, session chair **Andrew Pruszynski** (Western University, Canada) presented his own lab's work on peripheral touch coding in humans. Peripheral neurons branch at their distal endings, and the functional consequences of this branching is unknown. One hypothesis is that this branching results in complex receptive fields similar to those found in the visual system that allow feature extraction. To test this hypothesis, microneurography of the median nerve was performed in humans using tungsten electrodes while a rotating textured drum was applied to the fingertip. This protocol allowed fine-grained receptive field (RF) mapping of the cell, revealing complex spatiotemporal RFs. A simple convolution of the RF with the stimulus could predict cell firing better than a simpler model with a Gaussian receptive field. This model could also be used to predict which surface edges a neuron could discriminate, showing that these cells' temporal response patterns were invariant for fingertip/object movement speed. However, when discriminating edge orientation the model suggested that there was a 'sweet spot' of movement speed. Do these fine-grained RFs influence behavior, and do people naturally use finger movement speeds suggested by the model? A carefully designed orientation discrimination experiment showed that this was indeed the case - people chose finger speeds in the 'sweet spot' suggested by the model. Further, when discriminating angled lines, participants should increase scanning speed with the cosine of the line tilt - a prediction that was also confirmed by experiment. Finally, Prof. Pruszynski asked, under what constraints do complex RFs appear. By collaborating with Google DeepMind, a two layer autoencoder neural network was built, and trained to discriminate tactile 'images'. Such a network, when given non-trivial tactile inputs, generated complex RFs as seen in real neurons. In experiments on the artificial network, complex RFs improved discrimination in difficult tasks, and in simple tasks corrupted by noise. An important clinical implication of this work is to show that sensitivity after nerve injury may be impaired if the complex pattern of innervation is not preserved.

Barrels XXIX Day 2

The second day of Barrels XXIX started off again under azure blue skies as registrants entered the USC Brain and Creativity Institute's Cammilleri Hall for a series of short talks moderated by **Randy Bruno** (Columbia University). **Naoya Takahashi** (Humboldt University) started off talking about dendritic dynamics and their role in sensory procession. First the audience was reminded that 'higher-order' feedback targets the apical dendrites residing in layer 1 and that these inputs are severely attenuated, but can be boosted via the activation of calcium dependent currents. To see if it is possible to determine detection of an object by the whisker via imaging the calcium transients in the apical dendrites, layer 5 neurons were transfected with GCAMP6s. Interestingly the magnitude of the calcium signal directly paralleled the psychometric curve for object detection. Pharmacologically manipulating Ca^{2+} spikes in the apical dendrite by blocking with baclofen resulted in poorer detection and increasing depolarization via channelrhodopsin activation increased detection. In sum the data suggests a causal link between Ca^{2+} levels in the apical dendrites of a subset of layer 5 neurons and the detection of objects by whiskers.

William Munoz (New York University) was the next to speak on layer specific reorganization of neocortical dendritic inhibition during active wakefulness. Utilizing *in vivo* channelrhodopsin-assisted patching, somatostatin positive neurons were recorded from all depths of the barrel column. Layer 2/3 somatostatin positive neurons were largely martinotti cells whose axons projected towards layer 1 and their activity was suppressed by active whisking. In contrast layer 4 non-martinotti cells did not have axons that projected to layer 1 and their activity increased in response to whisking. In layers 5 and 6 those somatostatin cells that projected to layer 1 decreased their activity in response to whisking whereas those that did not project to layer 1 increased their activity. The differential responses were due to modulation by cholinergic inputs or local inputs from VIP+ interneurons. Next **Jianing Yu** (HHMI Janelia Research Campus) continued the focus on *in vivo* recordings from GABAergic neurons. Mice were trained to localize the position of a pole within their whisking path while head fixed. In response to this task fast-spiking neurons increased their firing in response to both movement and touch. On average somatostatin positive neurons did not increase their firing in response to whisker movement, but did so in response to whisker touch, in many cases there was a long latency for these touch response (>10 ms). Taken together these results suggest that interneurons are recruited differentially depending upon task demands.

Continuing on the theme of control of interneurons, **Jochen Staiger** (University of Medicine Gottingen) focused on how parvalbumin and VIP positive neurons can influence the activity of martinotti cells. Utilizing glutamate uncaging *in vitro* it was shown that layer 2/3 martinotti cells whose axons target layer 1 receive many local inhibitory inputs whereas layer 5 marinotti cells receive local inhibitory input as well as some inhibitory inputs from layers 2/3. In general parvalbumin positive cells have a higher probability of synapsing on a martinotti cell than does a VIP+ neuron. Parvalbumin inputs on martinotti cells were shown to be depressing whereas VIP inputs facilitated at high frequencies. It was concluded that parvalbumin inputs provide strong somatic inhibition, therefore regulating the output of the cell, while VIP inputs target the dendrites and thus play a role in shaping the inputs experienced by the martinotti cell. The final speaker of this short talk session was **Shane Crandall** (Brown) who focused on the cellular organization of layer 6 in the mouse barrel cortex. There were two classes of pyramidal cells identified corticothalamic and corticocortical. It was shown that corticothalamic neurons tended to reside underneath the layer 4 barrels with the corticocortical cells displaying the inverse pattern (higher density under the septa). Using thalamocortical slice and optogenetic techniques it was shown that ventral posterior medial inputs from the thalamus are stronger onto corticocortical neurons. Similarly posterior medial thalamic inputs target corticocortical neurons and do not innervate corticothalamic neurons.

After a short break for sunlight and coffee another set of short talks was moderated by **Jochen Staiger** (University of Medicine Göttingen). First up was **David Margolis** (Rutgers University) who demonstrated that whiskers could be induced to move optically via channelrhodopsin expression in the periphery. Both whisker protractions and retractions could be induced and increasing the light intensity increased the magnitude of the induced movements. In comparison to traditional mechanical stimulation, cortical responses to light evoked movements were 5-7 ms slower. Next to speak was **Yan Yu** (Northwestern University) who demonstrated that rats can use their whiskers to discriminate airflows. Using an arena with multiple fans, it was shown that rats could quickly sense which fan was in operation and run to it in order to get a food reward. The session was concluded by **Robert Sachdev** (Humboldt Universitat, Germany) who focused on the issue of whisker tracking. The 'Air-Track' system was described which is a head-fixed setup wherein discriminanda, mazes and other objects which float on an air table can be maneuvered such that an animals' whiskers can interact with the objects, creating a three-dimensional virtual reality. Given that the rat's head is fixed, simultaneous videography allows for detailed recordings of the whiskers while they interact with this virtual world. In the future barrel cortex physiology will be done in conjunction with behavioral testing and high speed whisker videography.

The Barrels meeting concluded with a session on Cortical Multisensory Computations moderated by **Nader Nikbakht** (SISSA, Italy). He started off with an introduction defining the utility of multisensory perception, how cues across modalities can be combined and how these can synergistically work to inform decision making. The first speaker was **Brice Bathellier** (Unite Neuroscience Information Complexite, France). His talk focused on single modality and multisensory inputs in the mouse cerebral cortex, focusing on auditory and visual stimuli. There was a focus on how luminance intensity could impact sound perception and then how varying the timing of auditory stimuli could impact visual processing. It was found that a linear model could not adequately capture the observed results because it did not account for adaptation in the neuronal signal. Using stimuli that either ramped up or down luminesce, it was found that decreasing luminance resulted in auditory tones being perceived as softer and the inverse was seen when luminance was ramped up, with tones being perceived as louder. In sum at the single neuron level it was shown that there are interaction between primary auditory and primary visual cortex in the mouse.

Next was **Jan Drugowitsch** (Harvard University) who used human psychophysical data along with Bayesian decision theory to model heading determination. While it is often assumed that multimodal inputs are helpful in decision making, in a heading discrimination task, simultaneous visual and vestibular inputs did not improve performance on unimodal stimuli. In general, it was found that there was a tradeoff between speed and accuracy of heading determination. Ultimately, it was suggest that humans accumulate evidence across time and cues until a correct decision can be made.

Returning to animal models **Conrad Lee** (Australian National University) recorded from primary sensory cortex while presenting auditory and somatosensory cues. It was argued that the animal can prioritize sensory modalities depending on the context. Comparing reaction times on an auditory cue versus a whisker vibration it was show that the animals had faster reaction to whisker stimuli. When combined with an auditory cue the reaction time decreased and the number of false choices also decreased. Thus in this case the auditory cue enhanced the detection of a whisker stimulus. These results suggest that the rat may be a viable alternative to the primate for studying attention.

The session was concluded by the moderator **Nader Nikbakht** (SISSA, Italy) who focused on the neural mechanisms of visual-tactile integration in the rat. In general when analyzing the animals on a sensory discrimination task, combined stimuli resulted in a steeper psychometric curve then those seen in response to unimodal inputs. It was also shown that, as has been reported in human studies, rats show significant inter-animal variations in their ability to perform sensory discrimination tasks. Neuronal recordings from the posterior parietal cortex revealed that neurons residing in this area encoded object category and orientation and did so in response to multimodal stimuli. In, sum the session brought attention to the next step in our understanding in sensory perception, the fact that in general unimodal stimuli are not found in nature, but rather the organism is bombarded by simultaneous sensory inputs across many different input channels.

Following a spirited discussion the meeting adjourned until Fall 2017 when the Barrels meeting will return to the site of the field's founding; Johns Hopkins University for the 30th annual Barrels meeting.

Appendix I: Barrels XXIX Program

BARRELS XXIX

10-11 November 2016

Brain and Creativity Institute
University of Southern California, Los Angeles

Thursday, November 10

9:00 - 9:05	Welcome: **Joshua Brumberg**, Queens College, CUNY
	Thalamocortical Interactions in Motor Control
9:05 - 9:15	Introduction/Overview: **Garrett Stanley**, Georgia Tech
9:15 - 9:45	**Carl Petersen** EPFL *Neural circuits for goal-directed sensorimotor transformation*
9:45 - 10:15	**Bernardo Sabatini**, Harvard *The Intralaminar nuclei in mouse*
10:15 - 10:45	**Naoki Yamawaki**, Northwestern *Thalamo-cortico-thalamic circuits in the motor system*
10:45 - 11:15	**Dieter Jaeger**, Emory *A physiological investigation of the basal ganglia connection to motor thalamus and on to cortex*
11:15 - 11:45	**Discussion**
11:45 - 12:00	**Coffee Break**
	Short Platform Talks 1 **(**Moderator: **Alison Barth**)
12:00 - 12:15	**Christian Ebbesen, Guy Doron, Constanze Lenschow & Michael Brecht,** Bernstein and Humboldt-Universität *Vibrissa motor cortex activity suppresses contralateral whisker touch.*
12:15 - 12:30	**Edward Zagha**, UC Riverside *Modulation of sensory processing by cortical feedback pathways*
12:30 - 12:45	**Julian Hofmann, Bettina Joachimsthaler & Cornelius Schwarz,** Tübingen *The role of mouse barrel cortex in tactile trace eye blink conditioning*
12:45 - 1:00	**Discussion**
1:00 - 2:30	**Lunch Break**
	Touch in Rodent, Monkey, and Man
2:30 - 2:40	Introduction/Overview: **Andrew Pruszynski**
2:40 - 3:10	**Silman Bensmaia**, Chicago *Touchsim: Simulating tactile signals from the whole hand with millisecond precision*
3:10 - 3:40	**Mitra Hartmann**, Northwestern *"Grasping" with whiskers*
3:40 - 4:10	**Gerald Loeb**, USC and SynTouch *Understanding human haptics by building robotic systems*

4:10 - 4:40	**Andrew Pruszynski**, Western University, Canada *Feature extraction in the human tactile periphery*
4:40 - 5:00	**Discussion**
5:10 - 5:30	**Break**
5:30 – 8:00	**Poster Session**
6:30	**Dinner**

Friday, November 11

	Short Platform Talks 2 **(**Moderator: **Randy Bruno)**
9:00 - 9:15	**Naoya Takahashi & Matthew Larkum,** Humboldt University *Dendritic dynamics in sensory perception*
9:15 - 9:30	**William Muñoz, Robin Tremblay, Daniel Levenstein & Bernardo Rudy,** NYU *Layer-specific reorganization of neocortical dendritic inhibition during active wakefulness.*
9:30 - 9:45	**Jianing Yu, Ariel Agmon & Karel Svoboda,** HHMI Janelia *Cell-type-specific temporal dynamics of GABAergic interneurons in mouse barrel cortex during active sensation.*
9:45 - 10:00	**Mirko Witte, Florian Walker, Dirk Schubert, Michael Feyerabend, Martin Möck & Jochen Staiger,** University Medicine Göttingen *Temporally distinct inhibitory control of Martinotti cells by PV- and VIP-cells*
10:00 - 10:15	**Shane Crandall, Saundra Patrick, Scott Cruikshank & Barry Connors,** Brown *Infrabarrels: Ensembles of structurally and functionally distinct neurons in layer 6a of mouse somatosensory cortex.*
10:15 -10:30	**Discussion**
10:30 - 11;00	**Coffee Break**
	Short Platform Talks 3 **(**Moderator: **Jochen Staiger)**
11:00 - 11:15	**Sunmee Park, Akhil Bandi, Christian Lee & David Margolis,** Rutgers *New ways to wiggle whiskers: optogenetic control of whisker movement and active sensation.*
11:15 - 11:30	**Yan Yu*, Matthew Graff*, Chris Bresee, Yan Man & Mitra Hartmann,** Northwestern *Rat whiskers are used in airflow sensing*
11:30 – 11:45	**Mostafa Nashaat, Hatem Oraby, Laura Blanco, Sina Dominiak, Matthew Larkum** **& Robert Sachdev,** Humboldt Universität *Pixying Behavior: Real time optical tracking of whisker motion in a real-world floating maze.*
11:45- 12:00	**Discussion**

12:00-12:30	**Directed Discussion: Ideas, Theories, Techniques.**
12:30 – 2:00	**Lunch Break**
	Cortical Multisensory Computations
2:00 - 2:15	Introduction/Overview: **Nader Nikbakht**, SISSA
2:15 – 2:45	**Brice Bathellier**, CNRS *Uni and multisensory processing of looming and receding stimuli in mouse cortex*
2:45 – 3:15	**Jan Drugowitsch**, Harvard *Optimal multisensory integration under time pressure*
3:15 – 3:30	**Conrad Lee**, Australian National University *Neuronal correlates of sensory prioritization in rats*
3:30 - 4:00	**Nader Nikbakht, Davide Zoccolan & Mathew Diamond,** SISSA *Visual tactile integration in rats and underlying neuronal mechanisms*
4:00 – 4:15	**Discussion**
4:15	**Adjourn - Andrew Hires Party or travel to SfN at San Diego**

Acknowledgements:

Thanks to the Brain and Creativity Institute at The University of Southern California for being such welcoming hosts. Thanks to the University of Southern California, Department of Neuroscience for hosting the poster session. Thanks to the organizing committee: Joshua C. Brumberg, Randy Bruno, Mitra Hartman, S. Andrew Hires, David Kleinfeld, Daniel O’Connor, Robert Sachdev, Jochen Staiger and Mary Ann Wilson. Special thanks to Kathleen Diekmann for technical support.

Figure Legends:

Figure 1 Participants of Barrels XXIX sitting inside Cammilleri Hall located inside the Brain and Creativity Institute of The University of Southern California. Photo credit to Ivan Zawinul.