BBI

Brain and Behavior Initiative

3rd Annual BBI Seed Grant Symposium

NOVEMBER 19, 2019 | 4 PM | COLONY BALLROOM IN STAMP STUDENT UNION

Agenda

4:05 Welcome Remarks

4:10 Presentations of Results by FY18 Awardees

- *Precision Optogenetics: msec time resolution optical imaging and control of neuronal circuits*
  Behtash Babadi, Wolfgang Losert, and Monika Ritsch-Marte
- *Understanding the role of negative affect in psychosis using multimodal imaging and wearable sensors*
  Jack Blanchard, Alex Shackman, and Eun Kyoung Choe
- *A Multimodal Sensor Discovery Platform to Study the Molecular Events Underlying the Gut-Microbiome-Brain Axis*
  Reza Ghodssi, Bill Bentley, and Jens Herberholz
- *Central Nervous System Processing of Learned Vocal Communication Signals*
  Bill Idsardi and Bob Dooling

4:50 Break

5:00 Presentations of Results by FY18 Awardees

- *Role of epigenetic mechanisms in striatum in neuronal encoding of decision-making during incubation of methamphetamine craving*
  Anna Li and Matt Roesch
- *Cognitive and Neural Precursors to Semantic Word Learning and Math Development*
  Richard Prather, DJ Bolger, Marine Carpuat, and Joe Dien
- *Adapting Brillouin microscopy to the study of synaptic transmissio*n
  Giuliano Scarcelli and Josh Singer

5:30 Poster Session featuring FY19 Awardees

- *Moving beyond the "Yuck Factor": measuring brain responses to water reuse terms and determining if natural environmental images change responses*
  Rachel E. Rosenberg Goldstein and Edward Bernat
- *Nexus between sustainable buildings and human health: a neuroscience approach*
  Ming Hu and Edward Bernat
- *Neural representations of continuous speech and linguistic context in native and non-native listeners*
  Ellen Lau and Jonathan Simon
- *The impact of transcutaneous vagus nerve stimulation on therapy outcomes in aphasia*
  Kristin Slawson, Rochelle Newman, and Polly O'Rourke
- *The Impact of Race and Gender on Cyberbullying and Interventions among Middle School and High School Students*
  Rashawn Ray and Cixin Wang
- *Molecular connectomics of activity-dependent circadian circuit development*
  Colenso Speer, Najib El-Sayed, and Peter Nemes

Posters from the BBI Community

- *Capacitive Sensing of Triglyceride Film Reactions to Duodenal Contents*
  George E. Banis, Luke A. Beardslee, Justin M. Stine, and Reza Ghodssi; presented by Sanwei Liu
- *Modulating Creativity through Mindset*
  Nicole C. Catanzarite, Proma Rahman, Ethan Cheng, and Kevin N. Dunbar
- *Dynamic In Vitro Biosensing with Flexible Microporous Multimodal Cell-Interfacial Sensors*
  Ashley A. Chapin, Pradeep R. Rajasekaran, Jens Herberholz, William E. Bentley, and Reza Ghodssi
- *Inhibitory Nuclei in the Auditory Pathway of the Barn Owl*
  Anna Kraemer and Catherine Carr
- *Perception of Variation in Song Motifs by Birds and Humans*
  Adam R. Fishbein, Nora H. Prior, William J. Idsardi, Gregory F. Ball, Robert J. Dooling
- *Cholinergic modulation of local and top-down GABAergic inhibition in the olfactory bulb*
  Pablo Villar, Ruilong Hu, and Ricardo Araneda

6:55 Closing Remarks

FY18 Awardees

Precision Optogenetics: msec time resolution optical imaging and control of neuronal circuits

Behtash Babadi, Wolfgang Losert, and Monika Ritsch-Marte

The recent advent of optical electrophysiology methods has revolutionized the neuroscience field, allowing for both triggering and measuring of neuronal activity to understand and control how neuronal populations process information. The observation of neuronal activity via calcium imaging has limited time resolution of tens of msec, meaning that single action potentials (1-2 msec) cannot be easily detected. Optogenetic tools allow for reliable optical stimulation of neurons when a photoactivatable ion channel is expressed. However, triggering neuronal activity of multiple neurons with msec time resolution is usually not possible since the holographic optics used in advanced optogenetics experiments switch on a timescale of 10s of ms.

In this seed project, we plan to achieve msec time resolution optical imaging and control of neuronal circuits. We tackle both challenges by combining a novel analysis approach by Babadi that infers msec-level spikes from calcium imaging data with the fastest available spatial light modulation approaches invented by the Ritsch-Marte group at the University of Innsbruck. The Ritsch-Marte group is an unpaid consultant for our team. We will test fast stimulation with a loaned SLM and in vitro networks of neurons. Once developed the technique can be translated to 3D stimulation of neuronal activity with msec time resolution in awake, behaving animals.

Understanding the role of negative affect in psychosis using multimodal imaging and wearable sensors

Jack J. Blanchard, Eun Kyoung Choe, Alexandra M. Andrea, Kathryn A. DeYoung, Ryan D. Orth, Jason F. Smith, Melanie Bennett, Alan Anticevic, Young-ho Kim, Pramod Chundury, Alexander J. Shackman

Schizophrenia and other psychotic disorders—impose a staggering burden on public health and the global economy. Like other neuropsychiatric disorders, psychosis is complex and includes alterations in cognition, mood, and behavior. Recent work makes it clear that negative affect—a transdiagnostic construct encompassing indiscriminate threat processing; exaggerated stress sensitivity; and elevated anxiety, suspiciousness, and paranoia—is a key feature of psychosis and plays a central role in clinical presentation and course. Yet, the mechanisms that govern the experience and expression of negative affect in psychosis remain little explored and largely unknown. The overarching aim of this BBI-supported project is to use a novel combination of approaches—including cutting-edge neuroimaging techniques, wearable (actigraphy) and mobile sensors (GPS), and smartphone-based experience sampling to determine the relative contributions of anxiety-related brain circuits, sleep, and real-world behavior to pervasive negative affect (NA) in patients with psychosis and demographically matched controls. Subjects will complete two neuroimaging sessions, yielding a battery of psychometrically reliable fMRI metrics, including high-resolution measures of resting activity (perfusion) and functional connectivity as well as a novel measure of neural reactivity to dynamic socioemotional stimuli. These data will enable us to identify resting-state functional networks with unprecedented resolution on a subject-by-subject basis, to test whether alterations in those networks are associated with heightened negative affect, and to assess specific predictions (e.g., 'over-generalized' responding to affective neutral cues) about the function of the extended amygdala and other regions involved in translating socioemotional information into states of fear and anxiety. Wearable and mobile sensors and smartphone-based experience-sampling will enable us to extend our investigation from the clinic and laboratory to daily life, and to identify the real-world factors (e.g., urban environments), psychosocial processes (e.g., social isolation), and psychobiological factors (e.g., stress, sleep disruption) that underlie pervasive NA and paranoia in vulnerable individuals. Addressing these issues is important and promises to guide the development of more effective strategies for treating schizophrenia and other disorders marked by elevated levels of negative affect.

A Multimodal Sensor Discovery Platform to Study the Molecular Events Underlying the Gut-Microbiome-Brain Axis

Reza Ghodssi, Bill Bentley, and Jens Herberholz

Recent research in neural and cognitive sciences implicate the gut microbiome as a modulator of the human brain health and behavior. Studies using genetic profiling and bioinformatics in animal models show (1) a correlation between gut microbiome dysbiosis and behavioral and cognitive disorders, (2) co-

occurrence of gastrointestinal and neurological disorders such as inflammatory bowel disease and depression, and (3) correlation between microbiome composition and autism, schizophrenia, anxiety, stress, Parkinson's, and Alzheimer's. Recent results implicate bi-directional communication between the gut and brain, influenced by the gut microbiome, referred to as the Gut-Microbiome-Brain-Axis (GMBA). Germ-free rodent models are the current gold standard for studying the GMBA. From these animal models, serotonin-mediated vagal afferent signaling has been implicated as a significant GMBA communication pathway. However, current technology is unable to effectively study gut microbiome-triggered cellular and molecular signaling up close at the native time scales needed to fully understand the underlying mechanisms. To address this gap in knowledge, we propose and demonstrate an interdisciplinary discovery platform, a 3D-printed transwell housing with electrochemical sensors that interfaces microbiome, in vitro gut epithelium, and a crayfish ex vivo nervous system. The system consists of an impedance sensor and a potentiometric sensor, on the top and bottom of a porous substrate hosting cultured epithelial gut cells. The tissue-interfaced impedance sensor shows an exponential ~75% decrease in impedance at 10Hz upon tissue growth, due to an increase in the double layer capacitance from the cell-associated extra cellular matrix. The basolateral porous cyclic voltammetry sensors exhibit a diffusion-limited linear response to increasing concentrations of ferrocene dimethanol, a redox molecule used to model metabolite release (e.g., serotonin) from the basolateral side of the cultured gut cells. The next step is to integrate electrophysiologically recorded neural activity from single, identified crayfish neurons and measure their response to monitored serotonin release from the gut cells. This platform packages simplicity, novelty, and customizability, which is expected to yield high throughput real-time temporal information study signal transduction underlying the GMBA.

Central Nervous System Processing of Learned Vocal Communication Signals

Bill Idsardi and Bob Dooling

There is a rich history of behavioral and neurobiological research focused on the "syntax" of birdsong as a model for complex auditory perception, animal communication and even for human language. Zebra finches are one of the most widely studied songbird species in this area of investigation. They learn both the syllable structure and the syllable sequence of their song within a few weeks of hatching and they produce this single song throughout adulthood. It is reasonable to assume that adult zebra finches remain sensitive to both syllable structure and syllable order within their song in adulthood; however, results from behavioral and neurophysiological studies provide somewhat mixed evidence on exactly how sensitive zebra finches actually are to syllable order as compared to syllable fine structure. Budgies (a parrot species in comparison to the zebra finch songbird) display much better perceptual discrimination of syllable order. In this project, we investigate how well adult zebra finches can discriminate changes in syllable order relative to changes in syllable structure in their natural song motifs. Both male and female adult zebra finches are surprisingly poor at discriminating changes to the order of syllables (i.e. syllable shuffles) within their species-specific song motifs, but are extraordinarily good at discriminating changes to syllable internal structure (i.e., syllable reversals) in specific syllables. Neurophysiological recordings from multiple nuclei within the song system are differentially sensitive to various manipulations of natural song such as complete song reversal. We are investigating responses in auditory Field L and higher forebrain auditory fields CMM and NCM to the same song manipulations previously tested behaviorally (i.e. syllable reversals and syllable shuffles). We seek (1) to study the neural mechanisms for encoding the ordered communication sounds comprising avian "syntax", (2) to understand the neurobiological basis of auditory memory for complex acoustic stimuli, and (3) to identify the neurophysiological mechanisms accounting for the dramatic reduction in sensory plasticity in adult zebra finches.

Role of epigenetic mechanisms in striatum in neuronal encoding of decision-making during incubation of methamphetamine craving

Anna Li and Matt Roesch

Methamphetamine (Meth) addiction is a major health problem for which there are no approved pharmacological treatments. Two key challenges for treating Meth addiction is that drug cravings associated with drug paired environmental cues progressively increase during withdrawal, while the ability to make good reward-guided decisions worsens. Previously, we have shown a causal role for epigenetic mechanisms in drug craving in that overexpression of histone deacetylase 5 (HDAC5) in dorsal striatum (DS) increases Meth seeking after withdrawal. Here, we ask if overexpression of HDAC5 in DS also impacts reward-guided decision-making and associated neural correlates. We trained rats on a task during which they chose between two fluid wells that produced

rewards at different sizes or delays to reward. After training, we injected virus to overexpress HDAC5 and inserted recording electrodes into DS to record activity of single neurons. We predict that rats will be more impulsive on the task (i.e., selected more immediate reward over delayed reward) and that single neurons in DS will more strongly represent contingencies between actions and available options as opposed to outcomes associated with selected actions.

Cognitive and Neural Precursors to Semantic Word Learning and Math Development

Richard Prather, DJ Bolger, Marine Carpuat, and Joe Dien

The overall goal of this project is to characterize the neural and cognitive processes underlying the development of semantic word learning and relational arithmetic reasoning. Specifically, we will examine individual differences in semantic word learning, including relational arithmetic words (e.g. 'less, 'combine,' 'most'). Our proposed study addresses a fundamental gap in our understanding of how the acquisition of relational word knowledge underlies mathematics achievement in early childhood. Such tools may serve as diagnostic of weaknesses in knowledge and ability for children struggling with language in general, but more directly, math language. To pursue this goal, we propose a short-term longitudinal study to explore cognitive processes underlying the acquisition of semantic word knowledge and mathematical skills. Our long-term goal is to develop assessment tools and targeted interventions that will result in improving academic achievement in mathematical reasoning. We hypothesize that the semantic space model will capture critical developmental shifts in word knowledge and specifically for relational arithmetic words. We also hypothesize that individual's semantic models of relational arithmetic words will predict formal math assessment outcomes.

***Adapting Brillouin microscopy to the study of synaptic transmissio*n**

Giuliano Scarcelli and Josh Singer

The process of synaptic transmission—i.e., electrochemical signaling between two neurons—is the basis of nervous system function. Most studies of synaptic transmission rely on electrophysiological and fluorescence assessments. The physical mechanics of synaptic transmission, instead, are poorly studied and not well understood, and therefore, their study will provide fundamental insight into the nature of neural communication. To address this need, we will probe the mechanical properties of functioning retinal ribbon synapses using Brillouin microscopy. Brillouin spectroscopy has been widely used for material testing and environmental sensing since the 1970's; thanks to a newly developed spectrometer, it has turned into a mechanical imaging modality for single cells. In this proposal, we will push the spatio-temporal resolution of Brillouin microscopy to enable characterization of synaptic transmission. Retinal ribbon synapses are particularly well-suited to study by Brillouin microscopy owing to their relatively large size (are 100-1000 nm in length and 100-500 nm high) and the sustained nature of transmission from their synapses, within the temporal resolution achievable by Brillouin microscopy.

FY19 Awardees

Moving beyond the "Yuck Factor": measuring brain responses to water reuse terms and determining if natural environmental images change responses

Rachel E. Rosenberg Goldstein, Megan Gerdes, Spencer Fix, Anthony Vivino, Edward Bernat

As climate change and population growth increasingly stress the nation's freshwater resources, there is a critical need to expand the use of alternative water sources including recycled water. Although water experts understand the importance of water reuse (the beneficial use of recycled water), a documented challenge is consumers' negative perceptions, or the "yuck factor." Exposure to the environment, or images and videos of the natural environment, reduce anxiety and increase feelings of relaxation and happiness, and attention restoration. We hypothesize that natural environmental beauty images and videos could decrease negative perceptions of water reuse and other pressing environmental issues, including climate change. Our project is operating in two phases: in phase 1 we 1) examined neural responses to a variety of water reuse terminology and 2) evaluated the effects of water reuse promotional videos on individuals' responses to water reuse terms; in phase 2 we will 1) examine neural responses to terms related to climate change, water

challenges, sustainable food, and mental health and 2) evaluate the effects of natural environmental beauty still images and videos on individuals' responses to environmental terms. Our preliminary findings show that water reuse promotional videos were associated with EEG changes from pre- to post-video exposure for all water reuse word types, suggesting enhanced attention, engagement, and information processing. Additionally, water reuse promotional video exposure differentially impacted EEG changes for terms related to the specific reuse applications highlighted in the videos. These results suggest that promotional videos targeting specific aspects of water reuse can influence individuals' attention to, and engagement with, this important water conservation technique. Educational and stress-reducing images and videos could change the public's perceptions of critical environmental issues, paving the way for promoting behavioral and regulatory changes that could ameliorate these issues' impacts.

Nexus between sustainable buildings and human health: a neuroscience approach

Ming Hu and Edward Bernat

The building science community, particularly environmental scientists, have rightfully focused their efforts on reducing or eliminating exposures to indoor air contaminants. However, other more subtle but equally deleterious psychological or mental health effect—characterized by mood changes, increased stress, and decreased productivity—have been more difficult to measure consistently and are currently assessed post-occupancy, making remediation highly unlikely. The goal of this research project is to develop, test, and validate a data-driven approach using virtual reality (VR) and electroencephalogram (EEG) technology for assessing the effect of architectural building design features on occupants' emotional and cognitive functions—proxies for mental health and wellbeing. The project will provide technology-enabled, repeatable measures for quantifying the "soft" benefits of building design features thus providing an economically viable and repeatable assessment model, pre-build.

Neural representations of continuous speech and linguistic context in native and non-native listeners

Ellen Lau and Jonathan Simon

Much previous research has established that listeners and readers routinely generate context-based predictions that constrain perception and interpretation of language, but the form of this top-down/bottom-up interaction is still hotly debated. One critical question is how far down the processing hierarchy predictions are propagated—e.g. if 'I heard a dog…' predicts the word 'bark', does this modulate neural responses in units that represent lower-level speech sounds and acoustic features, as well as higher-level semantic units? This project aims to study this question for non-native speakers with difficulties in language comprehension. The method proposed here is poised to provide more accurate estimates of top-down influences on neural responses because it tackles longstanding limitations of standard approaches with respect to the format of the input (controlled vs. naturalistic) and the ability to estimate spatiotemporal response functions for multiple stages of processing simultaneously.

The Impact of Race and Gender on Cyberbullying and Interventions among Middle School and High School Students

Rashawn Ray and Cixin Wang

Over half of adolescents have been the victims of repeated online harassment by peers in the past year, more commonly known as cyberbullying. Victims suffer mental health consequences from this harassment, including depression, anxiety, lower self-esteem, and suicidal thoughts. Relative to traditional bullying, victims of cyberbullying are much more likely to commit suicide. In recent years, suicide rates have increased most significantly among Black boys. Despite the detriment of online aggression there is little research that addresses how the race and gender of victims impact the likelihood of bystanders to intervene. Our research aims to identify how reactions to cyberbullying and subsequent intervention strategies depend on who is being bullied. We test how the race and gender of victims impact 1) whether peers see behaviors as cyberbullying, 2) the likelihood of peer intervention, and 3) what strategies peers use to intervene. In addition to developing an educational plan that will be implemented by Prince George's County Public

Schools, the knowledge gained from this research will be used to develop a virtual reality bystander intervention program to improve mental health outcomes among youth, better understand how the physiology (as measured by heart rate, stress, and reaction time) of bystanders shape intervening, and reduce cyberbullying by understanding how the race and gender of victims dictate cyberbullying.

The impact of transcutaneous vagus nerve stimulation on therapy outcomes in aphasia

Kristin Slawson, Rochelle Newman, and Polly O'Rourke

Following a stroke, many individuals experience an extreme increase in their difficulties accessing the names for common objects—part of a general language difficulty known as aphasia. People with aphasia experience a loss of language and the hallmark feature of most aphasia syndromes is difficulty with word finding. Therapeutic treatment involves extensive re-training of difficult-to-access words. This project examines whether transcutaneous vagus nerve stimulation (tVNS) can improve the efficacy of clinical therapy. tVNS is a user-friendly, noninvasive method of stimulating the peripheral branches of the vagus nerve through an earbud worn by the user, and the ultimate goal of this treatment study is to determine if enhancements from tVNS would lead to faster rates of improvement in naming performance in individuals with aphasia.

Molecular connectomics of activity-dependent circadian circuit development

Colenso Speer, Najib El-Sayed, and Peter Nemes

A key challenge in neurobiology is understanding how synaptic organization establishes circuit function underlying cognition and behavior. Reconstructing brain circuits with synaptic resolution (“connectomics”) provides structural blueprints that help focus hypotheses about neuronal physiology and computation. Importantly, connectomes are not fixed, but instead undergo significant plasticity guided by molecular/genetic programs and sensory/environmental experience. To address a gap in our current understanding of mechanisms regulating connectome dynamics, we propose a new approach—molecular connectomics—combining the strengths of advanced transcriptomic, proteomic, and high-resolution imaging methodologies to investigate circuit plasticity across multiple biological scales (RNAs --> proteins --> subcellular compartments --> individual neurons --> multi-neuronal microcircuit ensembles). Using our platform, we will map molecular and structural plasticity within visual connectomes essential for circadian physiology/behavior, learning, and mood in the mammalian brain.

Posters

Capacitive Sensing of Triglyceride Film Reactions to Duodenal Contents

George E. Banis, Luke A. Beardslee, Justin M. Stine, and Reza Ghodssi; presented by Sanwei Liu

Ingestible capsule systems continue to evolve to overcome drawbacks associated with traditional GI diagnostic and therapeutic methods. However, none have been developed for measuring secreted enzymes, which normally require benchtop analyses. A target molecule of interest is pancreatic lipase (PL), which diminishes in response to a variety of pancreatic pathologies but require cumbersome procedures for measurement. Point-of-care (POC) devices for PL would reduce the measurement time and cost for patients, which require frequent sampling and analysis. This work presents a proof-of-concept demonstration of triglyceride-based coatings for monitoring duodenal analytes in an integrated capsule system. Previously, we reported a biomaterial film-based sensing strategy for measuring pancreatic trypsin with films made from gelatin. Localization within the GI tract was enabled by a pH-dependent packaging strategy to coat and selectively reveal sensors within the ingestible capsule platform. Bluetooth-capable microelectronics embedded within the capsule wirelessly transmit changes in capacitance corresponding to film morphology on sensor, translating information about *in situ* enzyme concentrations. Here, using these technologies, we investigate using triglyceride films to measure both PL activity and emulsification via bile acids (BA), which are elevated in GI secretions during BA malabsorption. We use stearin as a model triglyceride substrate to insulate sensor surfaces, a strategy that can be applied to additional target analytes to induce film-dissolving reactions. The triglyceride films react either with 0.01-1 mM lipase via hydrolysis or 0.07-7 %w/v bile acids via emulsification, leading to

measurable changes in capacitance and morphology. This represents a sensing strategy in ingestible systems for *in situ* analysis of gastrointestinal (GI) health. Ultimately, this platform provides opportunities for sensing additional characteristics, such as other enzymes or biologics, toward minimally invasive and ingestible diagnostics.

Modulating Creativity through Mindset

Nicole C. Catanzarite, Proma Rahman, Ethan Cheng, and Kevin N. Dunbar

The aim of the current study was to investigate creativity as a flexible ability rather than a fixed trait. Our past research has found assuming a stereotypically creative or uncreative occupation, coupled with a modifier word (eccentric poet, rigid librarian, or control condition), modulates performance on creativity tasks. The current study teased apart this effect by asking participants to assume a particular mindset (eccentric, simple, or control condition) with no reference to occupation. This experiment worked to determine if, in the absence of stereotypic occupation, modifier words can modulate creative ability. Creativity was measured though participants' fluency scores on a divergent thinking task. Specifically, we used an Alternate Uses Task in which participants were asked to come up with as many uses as possible for a series of everyday objects. We found that compared to the simple mindset and control conditions, assuming an eccentric mindset resulted in significantly higher fluency scores. Therefore, we propose that the bounds of creative ability are flexible and creative thinking can be encouraged through the use of selective modifiers.

Dynamic In Vitro Biosensing with Flexible Microporous Multimodal Cell-Interfacial Sensors

Ashley A. Chapin, Pradeep R. Rajasekaran, Jens Herberholz, William E. Bentley, and Reza Ghodssi

The Gut-Brain-Axis (GBA) is quickly growing as a field of scientific interest, and being recognized more and more to be at play in clinical disorders. Gastrointestinal (GI) inflammatory conditions, such as inflammatory bowel disease (IBD), tend to co-occur with neurological disorders ranging from mood disorders (e.g. depression and anxiety) to cognitive and developmental disorders (e.g. autism). These effects are recapitulated in animal models as well, such as germ-free mice which serve as the main model to study the effect of gut microbiome species on neural development and behavior. Research thus far has identified serotonin (5-HT) as a major signaling molecule underlying GBA communication. Enterochromaffin cells (ECCs) within the gut epithelium are the major producer of 5-HT in the body (nearly 95%) which respond to a variety of luminal mechanical, osmotic, and chemical factors associated with the microbiome, diet and irritants, and immune-modulating cytokines. ECCs are known to undergo secretory granule exocytosis to release the bulk of their 5-HT stores on the basolateral side of the epithelium, where 5-HT is available to stimulate enteric nerves to produce an effect on the surrounding enteric nervous system (ENS) and the brain. However, all available tools for studying 5-HT release from these cells target apical 5-HT as it is more accessible within the lumen of the gut. Here, we present an in vitro platform which can support growth of a model gut epithelium on a membrane-integrated cyclic voltammetry (CV) sensor with a carbon nanotube-(CNT) modified working electrode for selective sensing of neurotransmitter serotonin (5-HT). We achieve dynamic, concentration-dependent 5-HT sensing with a linear range of 0.5-10µM (r_2 = 0.934) and sensitivity of ~200µA/µM measured in cell media and cell supernatant. The membrane also supports cell-interfacial impedance electrodes to monitor physical cell coverage, demonstrating multimodal cellular and molecular sensing. This demonstrates the capability of our membrane-integrated sensor to detect 5-HT released from ECCs in future iterations of the system.

Inhibitory Nuclei in the Auditory Pathway of the Barn Owl

Anna Kraemer and Catherine Carr

The barn owl is a good auditory model with relatively simpler auditory brainstem circuitry compared to mammals (review in Nothwang 2016). We have used this system to understand how inhibition regulates the excitatory brainstem nuclei. The superior olivary nucleus (SON) appears to play a large role (Burger et al., 2011; Tabor et al., 2012), and is the source of most inhibitory projections to excitatory brainstem nuclei (Carr et al., 1989; Burger et al., 2005). Although hypothesized to be important for regulating the sound localization circuit in chicks in vitro (Yang et al. 1999; Monsivais et al. 2000; Yang et al. 2012; review in Burger et al. 2011) and in vivo (Nishino et al. 2008), there has been little research on the barn owl SON (Moiseff and Konishi 1983). Moiseff & Konishi (1983) recorded SON single units in barn owl and suggested that their search criteria were biased to the ipsilateral ear, since the majority of their units were EO responsive, or only responded to ipsilateral stimuli (Moiseff and Konishi 1983). We therefore recorded single units in barn owl SON, with

lesions to confirm the recording location. The majority of the units responded preferentially to binaural noise and rarely responded to tones, showing broad frequency tuning with low spontaneous firing rates. Response types were heterogeneous, and included off-responses, on-off responses, sustained, suppressed, primary-like, and chopper units. Because the SON projects to the three brainstem excitatory nuclei and the inferior colliculus, and has separate projections to the contralateral SON, these heterogeneous response types may represent separate SON neuronal populations, projecting to different nuclei (Burger et al. 2005). Further experiments are needed to gain insight into the different roles that the SON plays in regulating the activity in the auditory brainstem of the barn owl.

Perception of Variation in Song Motifs by Birds and Humans

Adam R. Fishbein, Nora H. Prior, William J. Idsardi, Gregory F. Ball, Robert J. Dooling

Perceptual comparisons between animals and humans are arguably the most intriguing in the area of vocal communication signals. Humans and vocal learning birds both produce vocal signals consisting of acoustically complex syllables arranged in species-typical sequences. In one widely studied species of songbird, the zebra finch, males learn to produce a song motif consisting of a fixed syllable sequence that is repeated several times in a song bout. These motif renditions sound very similar to the casual human listener, but variation among them can be detected with the use of song analysis techniques. Here, we used psychoacoustic methods to test how well zebra finches discriminate different renditions of natural song motifs and song syllables. We show that zebra finches are very sensitive to this subtle natural variation in song. This stands in contrast to past work showing that zebra finches, tested under similar conditions, are remarkably insensitive to variation in the sequential order of song syllables. These results suggest that zebra finches may be preferentially extracting information about the spectro-temporal content of individual syllables rather than sequential structure, which is generally opposite to the importance of sequential patterns in human language.

Cholinergic modulation of local and top-down GABAergic inhibition in the olfactory bulb

Pablo Villar, Ruilong Hu, and Ricardo Araneda

Precise regulation of an extensive network of interneurons in the olfactory bulb (OB) is crucial to odor processing. The largest population of inhibitory interneurons in the OB is the granule cell (GC), which are regulated by local and top-down excitatory and inhibitory inputs to fine-tune the encoding of odor signals by the OB. Local GABAergic neurons that reside in the GC layer, the deep short-axon cells (dSAC), are thought to provide inhibition of distal processes of GCs, thus controlling dendritic excitability of GCs (Eyre, et al 2008). In addition, long-range GABAergic projections from the magnocellular preoptic nucleus (MCPO) in the basal forebrain broadly innervate the GC layer of the OB, suggesting they provide proximal or perisomatic inhibition to GCs (Nunez-Parra, et al. 2013). Previous studies have shown that cholinergic modulation, specifically muscarinic, regulates GC excitability and affects olfactory discrimination, learning, and functional integration. Interestingly, the distribution pattern of BF cholinergic and GABAergic fibers shows extensive overlap in the GC layer, suggesting that in addition to its direct effect on GCs, acetylcholine can regulate their inhibition. Here, using whole-cell patch clamp electrophysiology in acute brain slices, we examined how inhibition of GCs is regulated by the activation of muscarinic acetylcholine receptors. Through the selective activation of M2/M4 mAChRs in the MCPO-GABAergic axon terminals, and M3 mAChRs on the dSAC, cholinergic modulation can produce a shift in the weight of top-down perisomatic vs. local distal GABAergic inhibition in GCs.

Who we are

The mission of the Brain and Behavior Initiative (BBI) at the University of Maryland is to revolutionize the interface between engineers and neuroscientists by generating novel tools and innovative approaches to understanding complex behaviors produced by the human brain.

We focus on the development of novel approaches to image neuronal function, the development of micro/nano system diagnostics and drug delivery technologies, and the development of big data methods in order to push the frontiers of our initial research themes, ranging from single neurons to mental health.

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