BBI

Brain and Behavior Initiative

BBI Seed Grant Symposium

SEPTEMBER 14, 2017 | 4 PM | MCKELDIN LIBRARY, SPECIAL EVENTS ROOM

Agenda

4:10 Opening Remarks

4:20 FY16 Award Presentations

- *Understanding the effect of age and duration of deafness on speech recognition in Cochlear Implant users.* Samira Anderson, Matthew Goupell, and Katrina MacLeod
- *A novel use of catanioinic vesicles to modulate nervous system function and behavior.* Philip R. DeShong, Erica R. Glasper, Jens Herberholz, and Farrah N. Madison
- *Development of an ultra-fast 2 photon microscope by beam multiplexing: GRID Imaging.* Ramani Duraiswami, Nail Gumerov, Patrick Kanold, and Wolfgang Losert
- *The retina as a novel biomarker for schizophrenia.* Bongtae Han, Elizabeth Quinlan, and Joshua Singer
- *Wireless measurement of neuronal currents using spin-torque nano-oscillators.* Ricardo Araneda, Jens Herberholz, Benjamin Shapiro, and Edo Waks
- *Investigating the Maryland Way.* Leah Bush and Sheri Parks

5:20 BREAK

5:35 Student Presentation – *Synapto Engineering team: Diagnosing Alzheimer's disease using EEG devices.* Dhruv Patel, Christopher Look, Megha Guggari, David Boegner, Anoop Patel, and Megan Forte

5:45 FY17 Award Presentations

- *Dance and EEG: Neural correlates of expressive movement.* Pamela Abshire, Karen Bradley, Adriane Fang, Brad Hatfield, and Jonathan Simon
- *Biobehavioral links among social anxiety, risk-taking, and substance use.* Erica Glasper, Sarah Racz, and Andres De Los Reyes
- *Identifying candidate genes associated with sensorineural hearing loss in a novel vertebrate model.* Karen Carleton, Robert Dooling, and Farrah Madison
- *Characterizing biological changes associated with shifts in reproductive strategy - connecting genes, physiology, behavior and fitness.* Heidi Fisher and Erica Glasper
- *New representations in neuronal ensembles during initial language acquisition neurobiology of phoneme, syllable and word learning in an animal model.* Jonathan Fritz and Bill Idsardi
- *Unraveling the neurogenetic architecture of human preference in mosquitoes.* Megan Fritz, Quentin Gaudry, and Carlos Machado
- *Computing with trajectories: Novel methods for understanding spatiotemporal function MRI data.* Joseph Jájá, and Luiz Pessoa
- *Impact of meditation experience on the brain-body connection: Behavioral, physiological, and neural measures of stress-resilience.* Stephanie Kuchinsky and Robin Puett
- *Control of cross-modal sensory plasticity by intrinsically photosensitive retinal ganglion cells.* Patrick Kanold, Robert Layne, and Joshua Singer

6:30 Closing Remarks

FY16 Awardees

Understanding the effect of age and duration of deafness on speech recognition in Cochlear Implant users. Samira Anderson, Matthew Goupell, and Katrina MacLeod

Thirty-five million people (11%) in the US have hearing problems and one million develop moderate to profound hearing losses. Many who do not benefit from hearing aids receive a cochlear implant (CI) to partially restore their hearing (~100,000 individuals). However, CIs do not work equally well for all individuals (Gifford et al., 2008). The gap in knowledge is severe; it is unknown how to program CIs for individuals in an effective and time-efficient manner, undermining our ability to provide the best hearing health services. Our preliminary data suggest that an individualized approach can be achieved based on how well the electrodes of the CI interface with the surviving neurons of the auditory nerve (AN). Neural survival is related to age and duration of deaf-ness. Therefore for a CI to be maximally effective, it needs to be programmed differently depending on the pa-tient's age and hearing history. Our long-term goal is to understand the effect of age and duration of deafness on speech recognition in CI users, and develop the evidence/tools for maximizing hearing performance for in-dividual patients. To investigate the relationship between neural survival and the ability to encode the slow speech-like acoustic modulations, we will use an innovative approach of synthesizing results from studies in-volving human perception (Goupell), human electrophysiology (Anderson), and animal cellular physiology (MacLeod). Our central hypothesis is that poor neural survival reduces neural modulation depth, which impairs encoding of slow speech-like amplitude modulations conveyed by the fast electrical carrier pulses (>900 Hz) delivered by the CIs. We predict that the physiological properties that govern information transmission between AN and its target, the cochlear nucleus (CN), may explain this outcome. Temporal modulation coding depends on the convergence of nerve inputs with variable thresholds (Joris et al., 2004). Synaptic-level adaptation per-forms input-specific gain control which enhances modulation coding, but poor neural survival compromises this enhancement.

A novel use of catanioinic vesicles to modulate nervous system function and behavior. Philip R. DeShong, Erica R. Glasper, Jens Herberholz, and Farrah N. Madison

Breakthroughs in biomedical science often require the development and application of new techniques. New technology often breaks down existing barriers and transforms scientific thinking. Our multidisciplinary approach, which bridges the life and physical sciences, will apply an innovative new technology to gain a better understanding of the neural workings underlying social behavior. We use catanionic vesicles to transfer specific neuromodulators into the brain of behaving animals. By targeting specific neuronal circuits and nuclei, in species with both simple and complex nervous systems and behaviors, we will gain a greater understanding of how brain regions function in concert to produce behavior.

Development of an ultra-fast 2 photon microscope by beam multiplexing: GRID Imaging. Ramani Duraiswami, Nail Gumerov, Patrick Kanold, and Wolfgang Losert

The application of new imaging modalities has revolutionized neuroscience and is a key technology going forward. In particular the use of calcium indicator has enabled the observation of many neurons in vitro as well as in vivo. A crucial development was the use of 2-photon imaging which allowed the visualization of calcium dynamics deep in the tissue of an active behaving animal with single cell resolution. Thus the activity of many neurons could be sampled simultaneously. In addition, photoactivatable ion channel now allow us to use focused light to trigger neuronal firing events reliably. Two of the PIs Kanold and Losert are pushing this technology to the limit, imaging populations of neurons and developing a new tool to trigger

the firing of multiple neurons simultaneously using spatial light modulator shaped light fields. The underlying assumption is that information resides in populations of neurons, and thus both measurement and triggering of populations is necessary to understand and control how the brain processes information. The neuroscience aim is simple and powerful: image how small populations ("crowds") of neurons process sensory information, and test this information flow by optically triggering populations of neurons in the auditory cortex of awake, behaving animals to see if animals behave as if a sensory stimulus was present. In a sense we are aiming to implant the activity corresponding to a percept into the brain.

The next logical step in neuroscience is to understand in detail what all the different circuits in the brain are and how they function under behavioral conditions. Thus the challenge for measuring and controlling brain activity is to image even larger populations of neurons and interfere with and control the activity of populations of neurons as animals perform a task. Thus we have to image large populations of neurons in 3D, analyze their activity in real time, and manipulate subpopulations of neurons in a controlled manner. We propose to take two important first steps towards tackling this enormously complex challenge.

The retina as a novel biomarker for schizophrenia. Bongtae Han, Elizabeth Quinlan, and Joshua Singer

This is a proposal to develop a novel, non-invasive and cost-effective assessment of central nervous system (CNS) function in schizophrenia, a common psychiatric illness affecting ~ 1% of the population. Our long-term goal is to develop objective assessments of nervous system function to allow for predictive diagnosis and for evaluation of CNS responses to psycho-pharmacotherapy that are independent of subjective behavioral studies. We propose that the retina, an accessible part of the nervous system, can be used to evaluate dysfunction in dopaminergic neuromodulation, the best candidate for the neural basis of schizophrenia. We propose that retinal functions can be used as a biomarker for the positive, negative, and pharmacologically intractable symptoms of schizophrenia. Two pilot observation in transgenic mice with aberrant dopamine (DA) signaling and a schizophrenic phenotype (COMT mice; 5) support this hypothesis: 1) dark-adapted electroretinograms (ERGs) differ between wild-type (WT) and COMT mutant mice, and ERG waveforms in the two groups exhibit differential sensitivity to antagonists of D1 DA receptors (D1Rs); 2) retinal vasculature, which develops under the influence of intrinsically-photosenitive retinal ganglion cells (ipRGCs) and DA modulation, is altered in the COMT mouse.

The goal of this seed grant is to assess a full range of retinal functions to identify those that are most predictive, prognostic, or linearly correlated with the emergence of schizophrenia and to the positive responses to antipsychotics. To do this, we will assess ERG responses to a range of visual stimuli, and the retinal circuit mechanisms responsible for ERG abnormalities will be studied by multi-electrode and single-cell recordings from retinal explants. Meeting our goal requires development of a novel visual stimulation apparatus to survey a wide range of retinal functions. The data collection enabled by this seed grant will provide the necessary preliminary data for a subsequent "big idea" proposal to the NIMH: testing the rigor, sensitivity and predictive value of retinal functions as a biomarker for schizophrenia.

Wireless measurement of neuronal currents using spin-torque nano-oscillators. Ricardo Araneda, Jens Herberholz, Benjamin Shapiro, and Edo Waks

In contrast to light, microwave frequency signals can safely and efficiently penetrate through deep tissue and the skull, and are thus ideal for studying the inner workings of the brain. An important example of microwave-enabled study is functional magnetic resonance imaging (fMRI), which has shed tremendous insight on

human cognition. However, fMRI cannot directly measure neuronal action potentials. Rather, it detects blood oxygenation status, which is an indirect and slow measure of brain activity. Furthermore, fMRI cannot temporally resolve individual neuronal activation or spatially resolve small groups of neurons, and thus can only study collective effects in large areas of the brain. The ability to non-invasively detect currents from individual neurons or small clusters of them remains one of the grand challenges of neuroscience, and an essential step to understand the inner workings of the brain.

We propose a novel approach for non-invasive measurements to read out action potentials across the whole brain from single neurons. We will take advantage of recent advances in nanoscale spintronic devices to create injectable nano-reporters that will measure weak electrical signals in the brain and convert them to microwave signals that can be detected wirelessly outside the body. To achieve this transduction, we will utilize a nano-sized device called a spin-torque nano-oscillator (STNO). This device is a variant of the giant magneto-resistor, which earned the Nobel Prize in 2007. When current flows through the STNO, it induces microwave frequency magnetic field oscillations via a process known as spin-transfer torque. Thus, if the oscillator is directly driven by a voltage generated from a neuronal action potential, it will broadcast this signal as a microwave field that can be detected wirelessly by an antenna.

The goal of this seed project will be is to demonstrate that STNOs can wirelessly report single action potentials from a neuron. As part of an ongoing NSF Brain EAGER grant, members of our team have already experimentally demonstrated that STNOs can act as wireless reporters for small currents and can be detected at a stand-off distance of nearly 10 mm. The currents in these experiments originated from a weak external source, and we have not yet applied this technique to measuring neuronal signals. In order to take this critical next step, which would open an entire new field of spintronics based neurosensing, we must answer two fundamental questions. First, we must show that single neurons can provide sufficient currents to power STNOs without additional amplifiers. And second, we must demonstrate that we can localize STNOs signals to single-cell spatial resolution. The goal of this BBI seed grant is to answer these two questions, and to do so we have assembled a team of experts in spintronics, electromagnetics, bioengineering, biology and neuroscience. Our team members include Edo Waks (Electrical and Computer Engineering), Benjamin Shapiro (Bioengineerig), Ricardo Araneda (Biology), and Jens Herberholz (Psychology). We will also collaborate with our industrial partner, Dr. Irving Weinberg (Weinberg Medical Phyics). We anticipate that success in this seed project would enable us to apply for substantial follow-on NIH funding (RO1 & STTR/SBIR).

Investigating the Maryland Way. Leah Bush and Sheri Parks

This project investigated the “Maryland Way” of multidisciplinary BBI collaboration through multiple interviews with principal investigators, graduate assistants, post doctoral researchers, seed grant managers, and meeting observation. The “Maryland Way” has been successful on a number of levels: inspiring multi-disciplinary work, providing demonstrated value for graduate students and post-doctoral researchers, and creating pressure to perform well in attempting to position each grant for larger federal funding. Three best practices for multidisciplinary collaboration emerged: consistent and continued involvement by seed grant managers, consistent and frequent communication between all parties, and developing communication self-awareness. Mediation could provide a valuable tool for teams experiencing communication challenges. Ultimately, the seed grant program provides opportunities to explore innovative research questions, develop communication skills, work with researchers across disciplines, and perhaps even re-consider the nature of science from a collaborative perspective.

Student Presentation.

Synapto Engineering team: Diagnosing Alzheimer's disease using EEG devices. Dhruv Patel, Christopher Look, Megha Guggari, David Boegner, Anoop Patel, Megan Forte

Synapto aims to revolutionize Alzheimer's Diagnosis through emerging portable EEG technology by making it faster, cheaper, and more accessible. We use artificial intelligence with clinical data to predict whether a patient has Alzheimer's or not.
Alzheimer's diagnosis is currently reactive; it is only done after symptoms appear. We look to make a tool affordable and able to diagnose pre-symptomatically and proactively.

FY17 Awardees:

Dance and EEG: Neural correlates of expressive movement. Pamela Abshire, Karen Bradley, Adriane Fang, Brad Hatfield, and Jonathan Simon

While it has been undeniably important and productive in prior work to deconstruct the constituent neural correlates when dancers are observing and thinking about dance, we believe that it is critically important to begin to understand what happens in the brain when dancers are actually dancing. It is generally accepted that sensorimotor function involves many brain structures that are, collectively, processing sensory information, mapping it to motor outputs, generating internal models of expected sensation, and comparing these models to observations. The existing studies of neural responses in dance have explored a tiny subset of the rich response repertoire that we expect to see when subjects are moving as well as thinking. The primary reason this has not been attempted previously is technical in nature: movement artifacts are expected to degrade the quality of EEG measurements. Prior work by PI Bradley (Cruz-Garza et al., Front. Hum. Neurosci., 2014) establishes an important proof of principle for active EEG measurement that we hope to improve upon in this work. Prior research by PI Hatfield has successfully recorded event-related potentials and EEG during treadmill walking (manuscript in preparation). PIs Abshire and Simon will build upon their established 2-year collaboration (B. Senevirathna et al., IEEE ISCAS 2016; N. Bertoni et al., IEEE ISCAS 2016) in ambulatory EEG (aEEG) recording to address these technical challenges. This collaboration has produced a prototype low cost, lightweight 8-channel aEEG system that provides high quality recordings over extended periods of time.

Biobehavioral links among social anxiety, risk-taking, and substance use. Andres De Los Reyes, Sarah Racz, and Erica Glasper

Substance use disorders among emerging adults present a dangerous, costly problem to the United States. Among emerging adults, substance use disorders often involve engagement in chronic, risk-taking behaviors. One relatively understudied at-risk group includes those experiencing social anxiety, traditionally characterized by inhibited, risk-avoidant behavior. Yet, recent work from our group and others reveals a subtype of social anxiety that expresses disinhibited social anxiety, typified by engagement in risk-taking behaviors. Those displaying disinhibited social anxiety may be a key at-risk group, because these individuals engage in risk-taking behaviors to avoid distress in social settings (e.g., speaking with others at work or parties). This risk-taking allows them to temporarily reduce their distress and enter social situations, but at the expense of developing a maladaptive regulation strategy. However, two key questions remain: (1) Can we objectively distinguish inhibited social anxiety from disinhibited social anxiety? and (2) What are the long-term substance use and health outcomes of these social anxiety subtypes? If we can objectively distinguish social anxiety subtypes, then we can develop targeted treatments. This is important because

current social anxiety treatments focus exclusively on reducing inhibition and risk avoidance.

Identifying candidate genes associated with sensorineural hearing loss in a novel vertebrate model. Robert Dooling, Karen Carleton, Farrah Madison

Hereditary sensorineural hearing loss and deafness has devastating consequences for speech development, speech production and the efficiency of acoustic communication throughout life. Research advances in this area are hampered by lack of an adequate animal model. Humans are unique among mammals in having a complex vocal repertoire that develops through learning. Fortunately, many bird species rely on hearing and an external acoustic model to develop their species specific vocalizations. Here we investigate the Belgian Waterslager Canary (BWC), which, in spite of the capacity for hair cell regeneration, has an inherited sensorineural loss. We think the BWC provides a unique vocal learning animal model for hereditary sensorineural hearing loss that can ultimately illuminate important genetic variables involved in communication problems arising from hereditary sensorineural hearing loss.

Characterizing biological changes associated with shifts in reproductive strategy -connecting genes, physiology, behavior and fitness. Heidi Fisher and Erica Glasper

Reproduction is arguably the most critical component of an organism's fitness and is also one of the most costly. Each stage of reproduction is thus marked by a change in resource allocation as priorities shift from development to fertilization and eventually to parental care. The biological changes associated with these transitions are well characterized in mothers, but significantly less understood in fathers, in large part because traditional laboratory-reared species (e.g., Mus or Rattus) do not exhibit bi-parental care. Model species that demonstrate life-strategies that are more similar to humans offer a novel opportunity to study the biological changes associated with shifts in male reproductive strategy. Using an innovative, integrative approach, we will identify how changes in gene expression in neural and reproductive tissues regulate the physiological and behavioral changes associated with shifts in male reproductive strategy – from achieving fertilization to ensuring offspring survival. This study draws on expertise from a multidisciplinary team including a behavioral neuroendocrinologist and an evolutionary biologist, and capitalizes on our combined experience with bi-parental Peromyscus rodents. Importantly, the results from this work will form the foundation of two funding opportunities focused on public health (National Institutes of Health [NIH]) and evolutionary mechanisms (National Science Foundation [NSF]).

New representations in neuronal ensembles during initial language acquisition neurobiology of phoneme, syllable and word learning in an animal model. Jonathan Fritz and Bill Idsardi

The brain is extraordinarily plastic and has a remarkable ability to quickly learn new sensory categories, new sensorimotor associations, new concepts and to rapidly adapt to new behavioral challenges. This amazing adaptive plasticity is key to our ability to learn the sounds of spoken languages, a critical early step in language acquisition. The research in this proposal is directed towards understanding the neural basis of adaptive plasticity and dynamic information processing in brain networks at a neuronal and neural network level by using an animal model (the ferret) to focus on how complex sounds in spoken language are learned, associated with meaning and stored in long-term auditory memory. Within the first year of life infants learn speech sounds (phonemes) in their native language, how to extract phonemes in a speaker-invariant way, to increase their discrimination for sounds of functional importance in their language and to ignore non-native phonemes. That is, infants tune in to the sounds of their language, and tune out irrelevant foreign language sounds that they have not been exposed to. Computational models and human brain imaging techniques converge in finding representational changes of phonemes

that enhance language acquisition. But not only do infants learn language-specific phonemes, they also combine them into complex syllables and words. How they do this is a real mystery. At a single cell, ensemble, network and behavioral level, the research in this proposal will investigate the underlying neurobiological mechanisms of this adaptive transformation during phoneme learning, category formation, and recognition of different syllable sequences. We have chosen an animal model to explore the neurobiological mechanisms for auditory perception of speech sounds. Although animals do not have the capability for spoken language, they do have a sophisticated auditory system and an ability to discriminate complex communication sounds. Moreover, there is mounting evidence that the same basic perceptual mechanisms are used in recognition of speech sounds both in animals and humans. Phoneme and syllable sequence learning involve a perceptual mapping from highly variable acoustic speech signals to invariant abstract category representations. Such learning requires the interaction of multiple abilities (auditory processing, category formation, attention and reward) across many brain networks including areas of auditory cortex (primary and higher order AC areas), prefrontal (PFC), premotor and parietal cortex. In order to fully understand the neural basis of phoneme and syllable sequence learning at the front-end of speech perception, a systems approach to the brain is needed to understand the flow of information by recording simultaneously from these multiple areas in order to determine their functional contributions and dynamic interactions during learning and indiscrimination behavior after acquisition.

Unraveling the neurogenetic architecture of human preference in mosquitoes. Megan Fritz, Quentin Gaudry, and Carlos Machado

Preference for one host species over others, or specialization, has been recognized as a key component of a mosquito's capacity to transmit disease for more than 5 decades. Whereas opportunistic host-feeding patterns can lead to pathogen spillover from non-human into human hosts, specialist mosquitoes transmit pathogens very efficiently between individuals of their preferred host species. Feeding patterns are derived from mosquito sensation and response to a variety of factors: host odors, CO2, warmth, humidity, visual cues, and even features of the environment. Yet the causal genetic mechanisms that underlie sensation, recognition and response to host-specific cues remain largely undiscovered. Identification of such causal genetic mechanisms will begin to elucidate the neural frame work required for vectors to locate their vertebrate hosts, and thereby transmit pathogens. We propose to identify genomic regions involved in human recognition using well-characterized laboratory populations of Culex mosquitoes, which are closely related vectors of West Nile virus, the most important mosquito-borne disease transmitted throughout North America. PI Fritz has collected and currently maintains vigorous laboratory colonies of Cx. pipien sand Cx. molestus, which exhibit divergent host-seeking behaviors in replicated behavioral assays. Cx. pipiens seeks birds, whereas Cx. molestus seeks mammals, and often humans. Our goal is to conduct a preliminary characterization of the genetic and chemical basis of human host recognition in Culex mosquitoes. This work will provide preliminary data for an NIH R01 proposal whose ultimate goal will be to conduct fine genetic mapping to elucidate the neuro-genetic architecture required by Culex mosquitoes for sensing and recognizing human hosts. Numerous chemosensory receptors have been characterized in an effort to understand how mosquitoes sense cues from the environment and their vertebrate hosts. Only recently, however, have two olfactory receptor (OR) genes been clearly associated with host preference in mosquitoes. Loss of function mutations introduced into orco, a gene encoding an essential olfactory co-receptor, resulted in the inability of Aedes aegypti to respond to host-specific cues, indicating that ORs are involved in human specialization. Furthermore, nucleotide variants within the coding region of AaegOr4, a sulcatone receptor, explained a portion (but not all) of the variation in the strain-specific human preferences of specialized Ae. aegypti. Sulcatone has been recognized as one

component of human odor. Yet generalist mosquito Cx. quinquefasciatus, which feeds indiscriminately on avian and human hosts, does not respond to sulcatone in laboratory assays. What remains unclear is whether specialized Culex, like human-feeding Cx. molestus, use sulcatone for human recognition, and whether the role of ORs (including sulcatone receptors) in human recognition isconserved across mosquito taxa. If conserved, collaborations with UMD chemistry and neurobiology faculty could be cultivated to develop novel repellent and attractant compounds that prevent mosquito-borne disease transmission.

Computing with trajectories: Novel methods for understanding spatiotemporal function MRI data. Joseph Jájá and Luiz Pessoa

Understanding brain function requires embracing dynamics head on. Yet, most research adopts a static and fairly localized approach to analyzing brain data. The research proposed here will develop dynamic and distributed methods to understanding brain function. Understanding brain dynamics has been a goal of theoreticians and experimentalists alike for at least half a century. A “standard hypothesis” is that neuronal computations rely on neural networks that converge to steady-state attractors, namely, states in which signals remain relatively constant for a time. We propose a significant departure from this approach which we call computing with trajectories. Importantly, our approach allows us to move not only beyond single-region but also pairwise (two-region) analyses (the latter is the case in graph-theory approaches). Because of the sluggishness of the hemodynamic response, it may seem that fMRI is not suitable to the investigation of dynamics. Whereas it is true that fMRI cannot capture dynamics within typical experimental trials, we have shown that brain networks reorganize as a function of context (signaled by threat/reward cues; and during behavioral “extended states” (e.g., being in a threat state for tens of seconds. Naturalistic viewing during movie watching also offers ample opportunity to investigate the dynamics of large-scale network interactions. Furthermore, we anticipate that the methods developed here will also be applicable in other domains, including MEG and calcium-imaging data, which have higher temporal resolution.

Impact of meditation experience on the brain-body connection: Behavioral, physiological, and neural measures of stress-resilience. Stephanie Kuchinsky and Robin Puett

More than half of US adults report unsuccessful stress management and stress-related health issues (American Psychological Association, 2011). Stress is a well-established risk factor for cardiovascular (CV) disease (e.g. Rozanski et al.,1999), the leading cause of death in the US (Centers for Disease Control and Prevention, 2016). Stress-resilience research has recently focused on the impact of the human microbiome, identifying a gut microbiome-brain axis. Gut microbiota activate neural pathways in the brain, influencing how the body responds to stress (e.g. elevated anxiety and inflammation; Zhang et al.,2013) both of which can lead to compromised CV health (Hussein et al.,2013, Tully et al.,2016). This relationship is bidirectional (see Figure 1) such that neuropsychological stress responses also change gut microbiota (e.g. Foster & Neufeld, 2013). By examining neurophysiological (i.e. microbiome) and behavioral outcomes, this research will pave the way to an enhanced understanding of the complex, interactive physiological processes by which meditation could impact stress resilience and identify populations for which meditation is maximally beneficial (e.g., older adults).An American Heart Association review (Brook et al.,2016) underscored the need for well-designed research regarding meditation’s impact on cardiovascular health to inform clinical treatment guidelines. Our proposed research addresses significant gaps on meditation’s physiological impact, via the gut microbiome-brain axis, on stress resilience and related cardiovascular impacts.

Control of cross-modal sensory plasticity by intrinsically photosensitive retinal ganglion cells. Patrick Kanold, Robert Layne, and Joshua Singer

Early blindness enhances auditory function [e.g. improving frequency discrimination performance and sound localization abilities 1,2]. Changes in transmission at thalamocortical synapses in both auditory and somatosensory cortex have been observed following visual deprivation, demonstrating a synaptic basis for this phenomenon 3,4. As well, auditory deprivation alters thalamocortical transmission in primary visual cortex, indicating that this cross-modal plasticity is a common feature of sensory areas of the brain 4. Here, we test the hypothesis that non-image-forming vision, mediated by intrinsically photosensitive retinal ganglion cells (ipRGCs), mediates the influence of visual stimulation on auditory system synaptic function. The photosensitivity of ipRGCs, which also receive conventional input from rod and cone photoreceptors, relies on aphotopigment called melanopsin. ipRGCs project to a number of subcortical brain areas that mediate physiological responses to environmental illumination5,6.The diverse influences of ipRGC activity on non-visual circuits, exemplified by light-dependent regulation of cognition, mood, and affect (e.g. depression associated with nighttime shift work or shortened days in winter)7, 8, underlie our postulate that ipRGCs serve as light detectors regulating light-dependent plasticity in auditory circuits. Two lines of evidence support our hypothesis. One, is general observation of retinal inputs to significant auditory centers and specific observation of ipRGC input to multi-modal subcortical areas, including the zona incerta (ZI) of the subthalamus, which in turn projects to primary auditory cortex (A1)9-12.Two, the superchiasmatic nucleus, perhaps the best-known non-image-forming retinorecipient brain area (the master circadian clock ofthe central nervous system), directly or indirectly regulates the output of major neuromodulatory centers like the locus coeruleus, raphe nuclei, and ventral tegmental area, which in turn modulate auditory function 6.Testing our hypothesis that ipRGCs are responsible for light-dependent plasticity in auditory circuits will permit us for the first time examine to synaptic plasticity non-image-forming visual circuits. Information generated through our work will extend our understanding of how environmental light regulates sensory perception and complex behaviors. The proposed project will provide the necessary preliminary data for a subsequent R01 submission to the NICHD: testing the effects of ambient light on nervous system development.

Who we are

The mission of the Brain and Behavior Initiative (BBI) at the University of Maryland (UMD) is to revolutionize the interface between engineers and neuroscientists by generating novel tools and approaches to understand 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 that span from single neurons to mental health.

Follow us on social media

@bbiumd

bbi.umd.edu