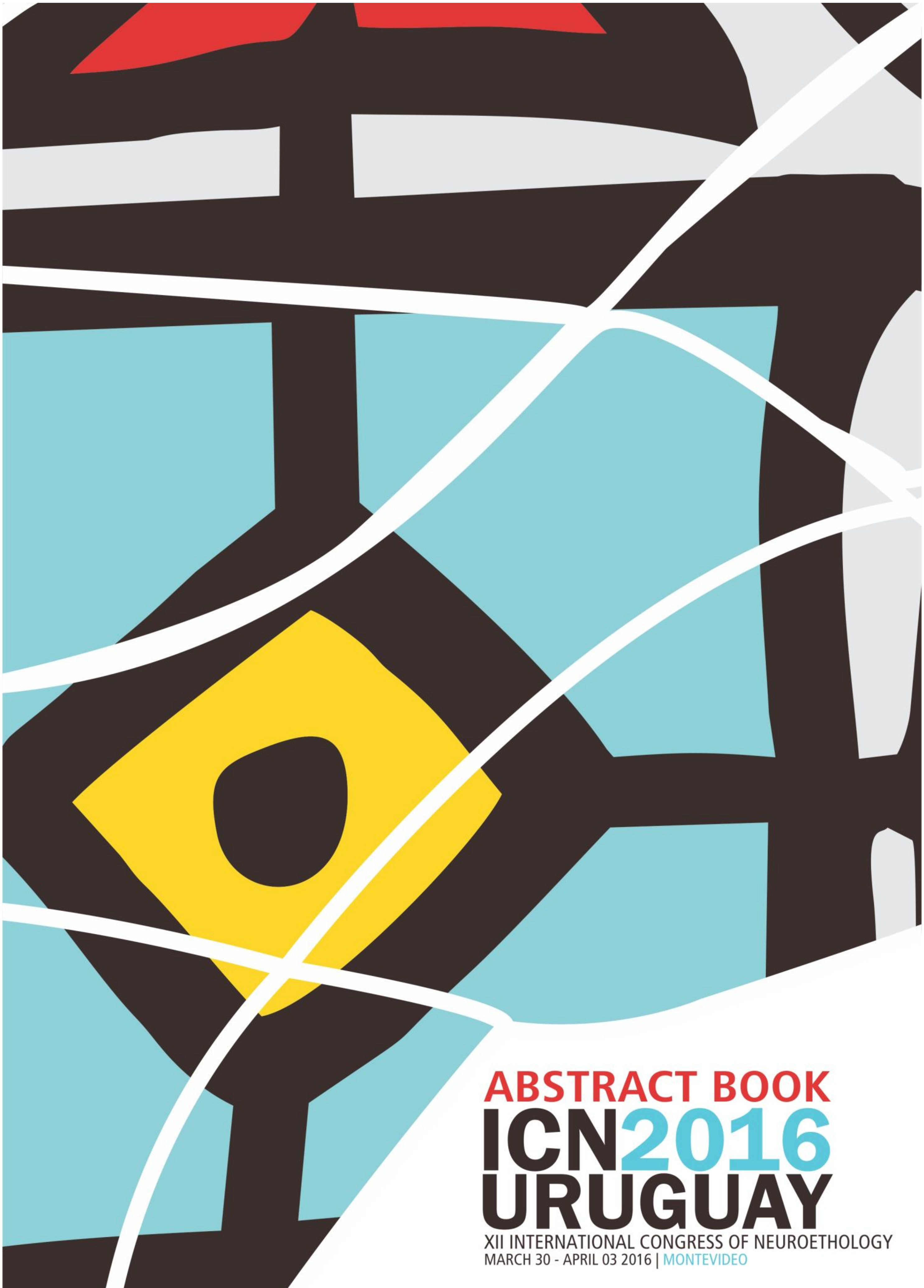

# ABSTRACT BOOK

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## UNDERSTANDING THE RELATIONSHIP BETWEEN GENES AND SOCIAL BEHAVIOR: LESSONS FROM THE HONEY BEE

**Gene Robinson[1]**

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The study of genes and social behavior is still a young field. In this lecture, I will discuss some of the first insights to emerge that describe the relationship between them. These include the surprisingly close relationship between brain gene expression and specific behavioral states; social regulation of brain gene expression; control of social behavior by context-dependent rewiring of brain transcriptional regulatory networks; and evolutionarily conserved genetic tool kits for social behavior that span insects, fish and mammals.

### Social Behavior

Keywords :behavioral evolution; genomics; neural systems

## MERGING OF OUR SENSES: BUILDING BLOCKS AND CANONICAL COMPUTATIONS

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A fundamental aspect of our sensory experience is that information from different modalities is often seamlessly integrated into a unified percept. Many studies have demonstrated statistically optimal cue integration, although such improvement in precision is small. Another important property of perception is accuracy. Does multisensory integration improve accuracy? We have investigated this question in the context of visual/vestibular heading perception. Humans and animals are fairly accurate in judging their direction of self-motion (i.e., heading) from optic flow when moving through a stationary environment. However, an object moving independently in the world alters the optic flow field and bias heading perception if the visual system cannot dissociate object motion from self-motion. The moving object induced significant biases in perceived heading when self-motion was signaled by either visual or vestibular cues alone. However, this bias was greatly reduced when visual and vestibular cues together signaled self-motion. These findings demonstrate that vestibular signals facilitate the perceptual dissociation of self-motion and object motion, consistent with recent computational work which suggests that an appropriate decoding of multisensory visual-vestibular neurons can estimate heading while discounting the effects of object motion. These findings provide direct evidence for a biological basis of the benefits of multisensory integration, both for improving sensitivity and for resolving sensory ambiguities. The studies we summarize identify both the computations and neuronal mechanisms that may form the basis for cue integration. Diseases, such as autism spectrum disorders, might suffer from deficits in one or more of these canonical computations, which are fundamental in helping merge our senses to interpret and interact with the world.

### Orientation & Navigation

Keywords :multisensory; optic flow; vestibular

## RESPONSE BASED ANALYSES OF BEHAVIOR OVERLOOK OTHER IMPORTANT BEHAVIORAL CHANGES: INTEGRATING HABITUATION INTO ONGOING BEHAVIOR

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University of British Columbia,Vancouver,Canada[1]

Traditionally researchers who study habituation have focused on a single dimension of the behavior (i.e. response probability or magnitude). Our high throughput behavioural analyses of habituation of two different responses for wild-type and mutant strains of C. elegans have changed this view. First we have shown that there are a number of independent components (habituation rate and final level for probability, duration and speed) of habituation of the tap response that show different forms of plasticity and, for the most part, are mediated by different genes. In addition, for both tap and photoactivation of the ASH neurons the response does not occur in a vacuum- there are changes in ongoing behavior that complement the response decrement. Interestingly, as some aspects of behavior decrement others appear to sensitize. When the changes in the components of behavior are integrated it facilitates dispersal allowing the animal to move away from the area. This offers a new way to think about the role of habituation and sensitization in the context of overall behavioral strategies. These findings also have implications for other response-based measures of learning and memory.

### Behavioral Plasticity

Keywords :habituation; non-associative learning; c. elegans

## CONFIDENCE IN RATS, HUMANS, AND MATHEMATICS

**Adam Kepecs**[1]

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Confidence manifests itself to us as a feeling but it leads a double life. Besides subjective confidence, it is widely studied in computational sciences as an objective statistical quantity, the estimated probability that a chosen hypothesis is correct. This raises the possibility that we can define confidence from first principles in statistics to provide a formal foundation for the scientific inquiry into subjective confidence. I will describe an approach incorporating mathematical models and human psychophysics that enabled us to study confidence in rats. Then I will discuss how rats can be asked to behaviorally report their confidence and our explorations into the neurobiological basis of confidence judgments.

### Computational Modeling

Keywords :computational science; statistics;

## THE HUNGRY FLY: TASTE RECEPTORS, CIRCUITS, AND THE CONTROL OF FEEDING BEHAVIOR

**Anupama Dahanukar**[1]

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Animals rely on their taste systems to select foods for consumption and can regulate both the quality and quantity of food intake to achieve nutrient homeostasis. We use the model insect Drosophila melanogaster to understand the molecular and cellular mechanisms by which tastants are encoded by sensory neurons and the logic by which sensory neuron activity is translated to feeding behavioral output. One focus is on a large family of 68 Gustatory receptors (Grs) expressed in complex combinatorial patterns in sweet and bitter taste neurons. In previous studies, we have used genetic and evolutionary analyses to identify the roles of specific Grs in detecting sweet tastants. Ongoing efforts are directed towards functional analysis of various Grs in detecting sweet and bitter compounds, and investigating receptors for other categories of tastants. Recently we have also uncovered mechanisms that integrate tastant information in sensory neurons, in part by our finding of combinatorial mechanisms for sweet and bitter ligand recognition by individual Grs using a unique ectopic expression system for “decoding” taste receptors. Molecular and cellular investigations of taste sensory function are complemented with efforts to identify neural circuits that convey taste information using anatomical and functional screens, which resulted in the identification of second order neurons in a sweet taste circuit. We are also identifying genes and circuit networks involved in food choice, which suggest that taste circuit function may be modulated by qualitative changes in nutrient demand.

### Sensory: Olfaction and Taste

Keywords :drosophila; chemoreceptors; feeding

## NEUROBIOLOGY OF VISUALLY GUIDED PREY AND PREDATOR BEHAVIORS IN CRABS

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In nearly all active moving animals vision constitutes the most important source of external information for organizing the behavior. Visual abilities likely originated to avoid obstacles during navigation and to detect and anticipate predator assaults. In order to escape from a predator, animals need to recognize the menace, localize it in space and determine the trajectory of attack. They also usually survey the environment in search of potential shelters. Additionally, they may count on memorized experiences about similar events. With all this information plus the time conferred by distant visual detection, animals make decision on the appropriate strategy to save their lives. Thus, upon the sight of a predator they can choose to freeze, to escape or to confront. And If for example they choose to escape, further decisions implicating the moment, direction and speed of run should be made. These abilities to process substantial amount of information, make complex decisions, form long-term memories and organize complicated motor patterns, exist even in animals with small brains. Some of them offer particular advantages for the neuroethological approach. In this talk I will present results from our investigations on the abilities of the crab Neohelice (previous Chasmagnathus) granulata to deal with visual danger stimuli, and the role of a group of motion-sensitive giant neurons in these behaviors. I will also show preliminary results on the prey capture abilities of the crab. Our studies comprise behavioral analyses in the field and the laboratory, neuroanatomy, in vivo intracellular electrophysiology and calcium imaging, and modeling.

### Sensory: Vision

Keywords :motion detection; neuron; escape

## BRAIN DIVERSITY IN EVOLUTION: WHAT CHANGES, WHAT DOESN'T - AND WHAT DOES IT MATTER?

**Suzana Herculano-Houzel**[1]

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What does brain size mean? It was long assumed that all mammalian brains were made the same, with numbers of neurons that were always proportional to brain size, such that two brains of similar size should have similar numbers of neurons, and larger brains should have more neurons than smaller brains. Following a similar logic, bird brains were also expected to pack small numbers of neurons. This talk will review direct evidence on the numbers of neurons that compose the brains of dozens of mammalian and bird species, and offer a new view on what different brains are made of - and how large numbers of neurons, regardless of brain size, might be the most limiting factor to the cognitive capabilities of a species.

### Anatomy & Neuroanatomy

Keywords :brain size; number of neurons; evolution

## EVOLUTION OF OLFACTORY CIRCUITS

**Richard Benton**[1]

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Animals adapt their behaviors to specific ecological niches, but the underlying genetic and cellular basis of nervous system evolution is poorly understood. We have compared the olfactory circuits of the specialist fly species Drosophila sechellia, which feeds and breeds exclusively on the acid-rich fruit of Morinda citrifolia, with its generalist cousins D. melanogaster and D. simulans, which are associated with a wide range of fermenting fruits. We have identified both loss and gain of sensory responses to acids in D. sechellia and link these to single nucleotide differences within a tandem cluster of olfactory receptor genes. Peripheral functional differences are accompanied by regulatory and developmental modifications that shape the species-specific neuroanatomical organization of acid-sensing pathways. These traits can explain the distinct preferences of these species toward important odor cues in the environment, thereby linking chemosensory ecology to adaptive genetic changes influencing nervous system structure and function.

### Evolution

Keywords :olfaction; evolution; drosophila

## OF HAIRY AND FEATHERED PRIMATES – NEUROETHOLOGY OF NUMERICAL COMPETENCE IN MONKEYS AND CROWS

**Andreas Nieder[1]**
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Judging the quantity of items in a set is an abstract form of categorization that provides a survival advantage to humans and animals alike. Findings in animal cognition, developmental psychology and anthropology indicate that numerical skills are rooted in non-verbal biological primitives. To decipher the neuroethological and evolutionary foundations of number representations, we study behaving monkeys and crows in combined psychophysical/neurophysiological studies. Monkeys and corvids are particularly interesting with respect to their outstanding cognitive capabilities based on independently and distinctly evolved endbrain structures. In primates, the sophisticated circuitries in the six-layered neocortex endow them with the highest levels of cognition. Interestingly, this six-layered neocortex is found to be lacking in non-mammalian vertebrates, such as birds, given that the last common ancestor of mammals and birds lived 300 Mio. years ago. Still, corvid intelligence rivals primates. Our comparative approach allows for comparison of the neurophysiological solutions evolution independently found for similar ecological demands based on convergent evolution. Recently collected behavioral and neuronal data show an impressive correspondence of neuronal mechanisms found in the corvid brain with those described earlier in the primate brain: Neurons are tuned to individual preferred numerosities, and neuronal discharges prove to be relevant for both species' correct performance. Both the neuronal and the behavioral tuning functions are best described on a logarithmic number line, arguing for a non-linearly compressed coding of numerical information, just as predicted by the psychophysical Weber-Fecher Law. Our data suggest that this way of coding numerical information has evolved at least twice during the course of evolution, irrespective of the precise origin and anatomical structures found in intelligent vertebrate brains, based on convergent evolution. This suggests that the realized neuroethological representations constitute a superior solution to a common computational problem. A comparative approach is indispensable for deciphering these and other evolutionary stable neuronal mechanisms and codes. Acknowledgment: This lecture is sponsored by the Alexander von Humboldt-Foundation and the The German Academic Exchange Service (DAAD).

### Anatomy & Neuroanatomy

Keywords :monkey; crow; counting

## THE SHOCKING PREDATORY STRIKE OF THE ELECTRIC EEL

**Kenneth Catania[1]**
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Electric eels (Electrophorus electricus) stand out as one for the most powerful electrogenic species. Much of their body is composed of electrocytes that can produce over 600 volts of electricity delivered in high-frequency volleys. I will review recent investigations that show electric eels can use their high-voltage to remotely control prey muscles. This strategy allows eels to either induce prey movement, revealing cryptic prey, or arrest prey movement, facilitating capture. In addition, electric eels use their high-voltage output for active electrolocation during their explosive strike. This is reminiscent of echolocating bats using a "terminal feeding buzz" to obtain high temporal resolution as they home in on flying insects. Finally, electric eels maximally electrify struggling prey by curling to locally intensify their dipole field during high-voltage volleys. This behavior induces involuntary fatigue in challenging prey that might otherwise escape.

### Sensory: Electrosensory

Keywords :gymnotidae; evolution; behavior

## CYCLING IN THE BRAIN: MOLECULAR MICROCIRCUITS FOR LEARNED VOCALIZATION

**Stephanie White**[1]

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Songbirds, parrots and hummingbirds learn a significant portion of their vocalizations in a manner that exhibits key parallels to speech development. Parallels include reliance on critical periods, cortico-basal ganglia circuitry, ongoing auditory inputs, hormonal factors and genes such as the language-related forkhead transcription factor FoxP2. Using behavioral paradigms, we found that songbirds actively regulate their own levels of FoxP2 within Area X, the basal ganglia sub-region dedicated to vocal learning. We paired this ethological approach with modern systems analytic techniques and found that singing activates distinct ensembles of gene expression in Area X that are not similarly co-activated in adjacent tissue comprised of similar cell types. Thus, 'molecular microcircuitry' exists alongside anatomic and synaptic microcircuitry that, together, functionally specify the brain. Disruption of these changes in FoxP2 impairs song learning and implicates behavior-driven cycling of neurogenetic modules in learned vocal communication.

### Social Behavior

Keywords :birdsong; neurogenetics; sensorimotor

## BAT ECHOLOCATION VS. MOTH HEARING: EVOLUTION OF TACTICS AND COUNTERTACTICS

**Emanuel Mora[1]**

Research Group in Bioacoustics and Neuroethology, Havana University,Havana,Cuba[1]

The arrival of echolocating bats in the Paleocene posed such a strong predatory pressure on moths, that it is widely accepted that ultrasonic hearing in these insects was originally in place as a defense mechanism against bat predation. When moths countered to the bat´s echolocation with ears tuned to ultrasonic frequencies and evasive flying maneuvers, some bats responded by moving the frequency of their calls away from the peak sensitivity of moth ears. Certain bats in the Caribbean however, specialized in hunting moths by using distinctive echolocation strategies that allow them to overcome moth hearing in the mid-frequency range, where moths hear best. Molossus molossus alternate call frequency to fool tone-deaf moth hearing. By performing as if flying away for the moth's ear, this bat masks its acoustic tracking behavior. Multiharmonic call design used by mormoopids is another strategy that allowed these other species to detect and classify insects while minimizing their acoustic conspicuousness. But the evolution of moth hearing also allowed the prey to counteract against the high frequencies used by bats. Combining distortion-product otoacoustic emissions and electrophysiology techniques, we have discovered that the moth´s ear undergoes a mechanism of dynamic tuning, therefore able to match its frequency of best audition with that of the echolocation of sympatric bats.

Within the ongoing bat-moth acoustic arms race, echolocation diversified into sophisticated strategies, but in response to echolocation, the moth ears already counteracted.

**Sensory: Audition**

Keywords :bat-moth coevolution; echolocation; dynamic hearing

# BIODIVERSITY OF FISH-HUNTING CONE SNAILS: CORRELATING GENETICS AND PHARMACOLOGY TO BEHAVIOR

**Baldomero Olivera**[1]

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There are over 100 different species of cone snails (Conus) that envenomate fish as their primary prey. Each lineage has a subset of characteristic prey capture strategies. Two of the largest fish-hunting cone snail species, Conus geographus and Conus striatus, display entirely different behavior when attempting to capture their fish prey. The two species are well understood with respect to the molecular pharmacology of their venom components; in addition, an extensive transcriptome analysis is available for the venom ducts of both species. Thus, these are the two species of cone snails that have been comprehensively characterized, making it feasible to integrate their behavior associated with prey capture to the underlying genetics and molecular phylogeny of their venoms. There are both striking contrasts and strong similarities between the two species and they are probably the best understood of the 12,000 species of venomous snails found in the marine environment with regard to how their venom components complement their prey capture behavior. (Research of the author supported by GM48677 from the National Institute of General Medical Sciences)

## Genetics, Epigenetics & Behavior

Keywords :prey capture; venom;

## DETECTION OF FLORAL ELECTROSTATIC FIELDS BY BUMBLEBEES

**Daniel Robert**[1]

University of Bristol,Bristol,United Kingdom[1]

Insects use a diversity of senses to organise their lives in space and time. Pollinating insects use many cues emanating from flowers, such as color, shape, pattern, humidity and chemical volatiles. We report on an additional, previously unappreciated sensory capacity in bumblebees (Bombus terrestris): the detection of floral electric fields. We show that these floral fields act as informational cues, and that they can be affected by the visit of naturally electrically charged bees. Like visual cues, floral electric fields exhibit variations in pattern and structure, which can be discriminated by bumblebees. We also show that such electric field information contributes to the complex array of floral cues that together improve a pollinator's memory of floral rewards. Floral electric fields arise from complex interactions with the surrounding atmosphere, an interaction between plants and their environment that not well understood. Because floral electric fields can change within seconds, this new sensory modality -electrostatic field detection- may facilitate rapid and dynamic communication between flowers and their pollinators.

### Sensory: Electrosensory

Keywords :electrostatics; electroreception; pollination

## THE EVOLUTIONARY ORIGINS OF HUMAN COGNITIVE DEVELOPMENT: INSIGHTS FROM RESEARCH ON CHIMPANZEES

**Tetsuro Matsuzawa**[1]

Kyoto University,Kyoto,Japan[1]

I compare cognitive development in humans with that of chimpanzees. Humans and chimpanzees are largely similar at early developmental stages, however, there remain several crucial differences. Chimpanzees lack the social referencing ability and have been very rarely observed to engage in general imitation and active teaching. Young chimpanzees possess exceptional working memory capacities often superior to those of human adults. In contrast, their ability to learn the meaning of symbols is relatively poor. Human infants are typically raised by more than one adult, not only the mother, but also the father, siblings, grandparents, and the other members of the community. The human infant is characterized by the stable supine posture of the neonate that enables face-to-face communication via facial expressions, vocal exchange, manual gestures, and object manipulation because both hands are free. The stable supine posture makes us human. The development of social cognition in humans may be integrally linked to this mother-infant relationship and the species-specific way of rearing the children. In sum, based on the parallel effort of the fieldwork and the laboratory work of chimpanzees, I present possible evolutionary and ontogenetic explanations for aspects of cognition that are uniquely human.

### Cognition

Keywords :human cognition; social cognition;

## OPTIMAL CODING BY MIXED-DIMENSIONALITY NEURONS ACROSS BEHAVIORAL MODES: INSIGHTS FROM HEAD-DIRECTION CELLS IN BATS

**Arseny Finkelstein[1]; Nachum Ulanovsky[1]; Misha Tsodyks[1];Johnatan Aljadeff[2]**

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Ethologically relevant stimuli are often multi-dimensional and can be represented using neural tuning-curves with different shapes and dimensionalities. Recently we found that head-direction (i.e. orientation of the head in azimuth and pitch) is encoded in the bat brain by two major neuronal classes: (i) "pure" 1D cells, which encode azimuth or pitch independently via pure-azimuth and pure-pitch subpopulations; and (ii) conjunctive 2D azimuth×pitch cells, which encode head azimuth and pitch jointly. Together, these two populations form an apparently redundant representation. Here, we show that such mixed-dimensionality coding by pure and conjunctive populations is in fact necessary for efficient representation of head-direction in different behaviorally-relevant regimes. Specifically, we found that conjunctive cells are advantageous when the stimulus changes quickly (e.g. during maneuvering when the bat makes fast turns), whereas pure cells represent the stimulus more efficiently at longer times (e.g. during long-range flights when the bat tends to fly in straight lines with little directional modulations). More generally, our results suggest that the optimal dimensionality of neuronal tuning-curves can strongly depend on the system's dynamic variables, such as the time available for decoding. We propose that these findings will likely be important to elucidate neural coding in many other neural circuits that process multidimensional stimuli – and might explain why mixed-dimensionality representations are common in sensory-, motor-, and higher cognitive systems across many species.

### Computational Modeling

Keywords :bat; head-direction; navigation

## NEUROMODULATORS STABILIZE NEURAL NETWORK FUNCTION OVER A BROAD TEMPERATURE RANGE

**Carola Staedele[1,2]; Wolfgang Stein[1]**

Illinois State University,Normal,USA[1]; Ulm University,Ulm,Germany[2]

All physiological processes are influenced by temperature. This is a particular problem for the nervous system as temperature changes can disrupt the well-balanced flow of ions across the cell membrane that is necessary for maintaining nerve cell function. Possessing compensatory mechanisms that counterbalance detrimental temperature effects is especially important for poikilothermic animals, because they do not actively maintain their body temperature and can experience substantial temperature fluctuations. Using the well-studied gastric mill central pattern generator in the stomatogastric nervous system of the crab, Cancer borealis, we show a hitherto unknown mechanism of how temperature-induced changes in rhythmic neural networks are compensated. In the isolated nervous system, a modest temperature increase of 3°C abolished rhythmic activity. In vivo, the neuronal circuits were temperature-compensated and functioned across a wide temperature range. Dynamic clamp recordings in the isolated system show that the breakdown was due to a temperature-induced increase in leak currents in rhythm generating neurons. Despite this apparent sensitivity of the isolated system to temperature changes, the rhythm could be stabilized by activating extrinsic neuromodulatory inputs from descending projection neurons, a strategy that we found was indeed implemented in intact animals. Our data indicate that the released peptide modulator effectively acted as a negative leak current and counterbalanced the temperature-induced leak to rescue neuronal oscillations. Thus, temperature compensation does not need to be implemented within the network itself but can be conditionally provided by extrinsic neuromodulatory input and counterbalances temperature-induced modifications of circuit-intrinsic properties.

### Motor Systems

Keywords :temperature; neuromodulation; central pattern generator

## REPRESENTATION OF WHISKER SELF-MOTION IN THE EARLY STAGES OF THE VIBRISSAL SYSTEM

**Avner Wallach[1]**

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In order to attribute spatial meaning to sensory information, the state of the sensory organ must be represented in the nervous system. In the rodent's vibrissal system, the whisking-cycle phase has been identified as a key coordinate, and phase-based representation of touch was reported in the somatosensory cortex. Where and how phase is extracted in the ascending afferent pathways has been unknown. While tackling such questions is preferable in awake, behaving animals, systematic exploration of the kinematic state-space is more plausible in anesthetized ones. Existing methods of recreating whisker motion under anesthesia, however, fell short of imitating the full range of natural whisking behavior. Using a novel closed-loop motion control interface we were able to recreate a wide range of natural-like movements in anesthetized rats, and to characterize the response of different neuronal populations to these movements.

Surprisingly, whisking phase was found to be encoded in a frequency- and amplitude-invariant manner already by the vibrissal mechanoreceptors. For naturally-constrained whisking dynamics, such invariant phase coding can be obtained by tuning each receptor to a restricted kinematic sub-space. This whisker-state representation is conveyed to the brainstem, where it is differentially processed by the various secondary afferent populations. This study, conducted in Prof. Ehud Ahissar's lab at the Weizmann Institute of Science, demonstrates how complicated perceptually-relevant processing is performed by the low-tiers of the nervous system.

### Sensory: Mechanosensation

Keywords :mechanoreceptor; whisking dynamics;

## MULTIMODAL SENSORY INTEGRATION UNDERLYING DECISION-MAKING IN FLYING DROSOPHILA

**Sara Wasserman[1]**

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A hallmark of the brain is that a singular input does not always elicit the same output; rather a given input might produce a variety of outputs depending on the internal or external state of the animal. Drosophila melanogaster assess and integrate their external and internal states to modulate their behavioral responses to sensory signals. I explore how neuronal circuits coordinate this modulation; yet remain sufficiently stereotyped to reproduce adaptive behavioral responses. I combine molecular, genetic, optogenetic and opto-physiological techniques with ‘virtual reality’ electronic flight simulators to activate or inactivate identified neurons or groups of neurons to probe the genes, neurons, neuromodulators, and circuits that coordinate context-dependent behavior. I will discuss how behavioral state alters the valence of CO2, how environmental state, such as the presence of odor, alters the gain of the visual system, and how internal physiological state alters both olfactory and visual modalities.

### Sensorimotor Integration

Keywords :context dependent behavior; decision-making; drosophila

## DEEP HOMOLOGY IN THE NEUROMOLECULAR MECHANISMS UNDERLYING VERTEBRATE SOCIAL BEHAVIOR

**Hans Hofmann**[1]

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All animals evaluate the salience of external stimuli and integrate them with internal physiological information into adaptive behavior. Natural and sexual selection impinge on these processes, yet our understanding of behavioral decision-making mechanisms and their evolution is still very limited. Based on neurochemical, tract-tracing, developmental, and gene expression studies we delineated homology relationships for the nodes of a Social Decision-Making (SDM) Network that is conserved across 88 species representing five vertebrate lineages, suggesting that behaviorally relevant brain regions are remarkably conserved over 450 million years of evolution. Complex social behavior has often evolved independently many times, with monogamy as a prominent example. We hypothesized that, as novel behavioral traits arose independently in diverse lineages, similar neural and molecular mechanisms – a shared “genetic toolkit” - were likely recruited repeatedly. To test this hypothesis, we used comparative transcriptomics to discover numerous orthologous gene groups, particularly those involved with signal transduction, that appear to have been recruited repeatedly and independently in convergent evolutionary transitions to monogamy. These analyses suggest that the diversity of social behavior in vertebrates can be explained, in part, by variations on a theme of conserved neuromolecular mechanisms.

### Social Behavior

Keywords :social decision making; transcriptomic;

## GENE-FUNCTION ANALYSES OF MOLECULAR NETWORKS RELEVANT FOR LEARNED BEHAVIORS IN BIRDS AND FRUIT-FLIES.

**Constance Scharff[1]**
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Spoken language and birdsong share a number of striking parallels, at the behavioral, neural, molecular and genetic level. Comparing the biologically tractable cognitive abilities necessary for language and for birdsong is a fruitful endeavor to identify, which properties are shared and which are unique to each. I will review evidence for the relevance of the FoxP gene family and its associated molecular network for speech and its role in modulating variability in the songbird basal ganglia circuit relevant for the acquisition and production of birdsong. However, I will argue that the similarities between human language and songbirds are not limited to sensorimotor processes – but may extend to other structural and functional properties. Many questions regarding the similarities between spoken language and birdsong remain unanswered, but increasing evidence suggests that human and non-human communication systems may rely on conserved molecular toolkits that act as genetic modules. These may specify the neural circuits subserving these particular behaviors, and organize their function. Elucidating these genetic modules in different animal models may inform the evolution of language and other complex traits.

### Communication

Keywords :language; cognition;

## COMMUNICATION NETWORKS IN ZEBRAFISH: NEUROMOLECULAR MECHANISMS AND COGNITIVE ABILITIES FOR SOCIAL COMMUNICATION

**Rui Oliveira**[1,2]
ISPA - Instituto Universitário,Lisboa,Portugal[1]; Instituto Gulbenkian de Ciência,Oeiras,Portugal[2]

Group living animals must be able to express different behavior profiles depending on their social status. Therefore, the same genotype may translate into different behavioral phenotypes through socially driven differential gene expression. However, how social information is translated into a neurogenomic response and what are the specific cues in a social interaction that signal a change in social status are questions that have remained unanswered. Moreover, social interactions occur within social networks, where unintended receivers are present, as well as opportunities to collect information from third parties interactions. Thus, the potential for both audience effects and social eavesdropping in social status assessment is present. This talk has four main goals: (1) to present zebrafish as a genetically tractable model organism where the molecular and neural mechanisms underlying social behavior can be studied; (2) to present evidence for the occurrence of social effects in zebrafish, namely winner-loser effects, audience effects and social eavesdropping; (3) to show how mutual assessment of fighting ability drives changes between status- specific neurogenomic states; and (4) to show how social status is encoded by functional connectivity of a social decision-making network in the brain.

### Social Behavior

Keywords :genomics; social behaviour; zebrafish

## ANCESTRAL IMPRINTS ON DESCENDANT NERVOUS SYSTEMS

**Brian Dias[1]**
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Traumatic experiences impact not only the generation that directly experiences the trauma, but also descendant generations that follow. How this occurs and what effect such trauma might have on the development of neuropsychiatric disorders in descendant generations is less studied. Training F0 adult mice (ancestral generation) to associate an odor (Acetophenone) with mild foot-shocks allowed us to ask how an environmental cue associated with an aversive outcome in the ancestral generation is perceived by descendant generations at the level of behavior and neuroanatomy. Fear conditioning F0 male mice to Acetophenone caused subsequently conceived odor naïve F1 male offspring to display behavioral sensitivity to Acetophenone. Acetophenone is detected by the M71 odorant receptor and we find that the F1 generation has larger M71 glomeruli in the olfactory bulbs as a consequence of a higher number of M71-expresssing Olfactory Sensory Neurons in the olfactory epithelium. To begin to explain these results, we queried methylation of the gene encoding the M71 receptor (Olfr151) and found that it is hypomethylated in the sperm of F0 males that had been fear conditioned with Acetophenone. We conclude that ancestral olfactory experience affects olfactory neuroanatomy and consequently behavior in the descendant generation via an epigenetic mechanism. This work allows us to appreciate how ancestral trauma contributes to the development of neuropsychiatric disorders such as phobias, and Post Traumatic Stress Disorder (PTSD) in descendant generations. Our current efforts are aimed at preventing such behavioral and neuroanatomical imprints of such ancestral olfactory conditioning and will be the focus of this presentation.

**Sensory: Olfaction and Taste**

Keywords :olfaction; olfactory experience; post traumatic stress disorder

## FUNCTION AND DEVELOPMENT OF THE OPTIC TECTUM CIRCUITRY IN THE ZEBRAFISH LARVA

**German Sumbre[1]**
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Spontaneous neuronal activity is spatiotemporally structured, influencing brain computations. Nevertheless, the neuronal interactions underlying these spontaneous activity patterns, and their biological relevance, remain elusive. We addressed these questions using two-photon Ca2+ imaging of intact zebrafish larvae to monitor the spontaneous activity fine-structure in the tectum. The spontaneous activity was organized in topographically compact assemblies, grouping functionally similar neurons rather than merely neighboring ones, reflecting the tectal retinotopic map despite being independent of retinal drive. Assemblies represent all-or-none-like sub-networks shaped by competitive dynamics, mechanisms advantageous for visual detection in noisy natural environments. Notably, assemblies were tuned to the same angular sizes and spatial positions as prey-detection performance in behavioral assays, and their spontaneous activation predicted directional tail movements. Therefore, structured spontaneous activity represents “preferred” network states, tuned to behaviorally relevant features, emerging from the circuit's intrinsic non-linear dynamics, adapted for its functional role. Furthermore, the spontaneous activity structure also emerged in “naive” tecta (tecta of enucleated larvae before the retina connected to the tectum). We thus suggest that the formation of the tectal network circuitry is genetically prone for its functional role.
This capability is an advantageous developmental strategy for the prompt execution of vital behaviors, such as escaping predators or catching prey, without requiring prior visual experience.

### Sensorimotor Integration

Keywords :spontaneous activity; zebrafish; neuronal circuit dynamics

## SALIENCY MAP IN THE ARCHER FISH OPTIC TECTUM

**Ronen Segev[1]; Mor Ben-Tov[1]; Opher Donchin[1]; Ohad Ben-Shahar[1]**

Ben Gurion University,Beer Sheva,Israel[1]

From detecting food to locating lurking predators, visual search -- the ability to find an object of interest against a background -- needs to be accurate and fast to ensure survival. This led to the development of a parallel search mode, pop-out, which enables fast detection time that is not dependent on the number of distracting objects. Until recently, behaviorally, pop-out has been observed only in mammals, where its neural correlates are found as early as V1 in contextually modulated cells that encode aspects of saliency. This computation enables the target to pop-out due to its salient features. Using a set of behavioral experiments we recently showed that archer fish can also utilize this important parallel search mode by exhibiting pop-out of moving targets. We then explore neural correlates of this behavior using electrophysiological recordings of single cells and report the presence of contextually modulated cells in the optic tectum. These findings indicate that similar neural computations may facilitate pop-out behavior in the mammalian cortex and fish optic tectum, suggesting a universality of pop-out mechanisms across vertebrates.

### Anatomy & Neuroanatomy

Keywords :archer fish; visual search; optic tectum

## CIRCUITS AND COMPUTATIONS UNDERLYING STIMULUS SELECTION IN THE OWL MIDBRAIN

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Animals are constantly faced with a barrage of information in the form of sensory inputs and cognitive influences. In order to behave adaptively, however, they must select and preferentially analyze only the most important subset at any instant while ignoring everything else. In my talk, I will describe results from a series of experiments in the barn owl that measure and manipulate neural responses to competing stimuli in midbrain areas encoding topographic maps of space, specifically the optic tectum (OT). The results shed new light on key questions in multisensory competition and stimulus selection: How does the OT signal the strongest ("most important") stimulus at any instant? What neural mechanisms mediate this selection? How is location-invariance of this selection achieved? This work can inform the search for the mechanistic underpinnings of a broad range of critical behaviors that require selection, such as attention control, perceptual categorization, and decision-making.

### Sensorimotor Integration

Keywords :superior colliculus; spatial attention; owl

## THE CENTRAL ROLE OF THE PRIMATE SUPERIOR COLLICULUS IN CODING SALIENCY, PRIORITY, AND ORIENTING

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The midbrain superior colliculus (SC) forms a key node in the orienting network within the primate brain. The superficial layers of the SC (SCs) receive direct retinal input and extensive input from visual cortex and are interconnected with other visual areas of the brain. The intermediate layers of the SC (SCi) receive convergent input from cortical and subcortical structures to coordinate orienting and they project to the brainstem premotor circuitry. Models of visual attention postulate the existence of a visual saliency map which received feature based inputs to construct a topographic map of visual conspicuity (saliency) across the image. The concept of a priority map defines a combined representation of bottom-up saliency and top-down relevance to the observer. The dominant view holds that saliency and / or priority are encoded across a distributed network of predominantly cortical brain areas. However, we instead hypothesize that the SCs represents a bottom-up saliency map and the SCi represents a priority map. To support these hypotheses, we have used structured visual tasks, as well as free viewing of dynamic video to investigate the role of the SC in coding of saliency and priority. Across very different behavioural conditions we demonstrate that neurons in the SCs signal saliency and neurons in the SCi signal priority. This result is more consistent with the conserved phylogenetic role of the SC in coordinating orienting movements to optimize visual behaviour.

### Anatomy & Neuroanatomy

Keywords :superior colliculus; saliency; saccade

## UNIVERSAL MECHANISMS OF SOUND PRODUCTION AND CONTROL IN BIRDS AND MAMMALS

**Coen Elemans**[1]
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As animals vocalize, their vocal organ transforms motor commands into vocalizations for social communication. The physical mechanism of sound production and mechanical properties of this vocal organ determine the range and constraints for neural control. In birds, the physical mechanisms by which vocalizations are produced and controlled remain unresolved because of the extreme difficulty in obtaining in vivo measurements. Here, we introduce an ex vivo preparation of the avian vocal organ – the syrinx - that allows simultaneous high-speed imaging, muscle stimulation and kinematic and acoustic analyses to reveal the mechanisms of vocal production in birds across a wide range of taxa. Remarkably, we show that all species tested employ the myoelastic-aerodynamic (MEAD) mechanism, the same mechanism used to produce human speech. Thus despite different evolutionary origins, laryngeally vocalizing mammals and syringeally vocalizing birds have converged on the same physical mechanism for vocalization. Furthermore, we show substantial redundancy in the control of key vocal parameters ex vivo, which suggests that also in vivo vocalizations may not be specified by unique motor commands. We propose that such motor redundancy can aid vocal learning and is common to MEAD sound production across birds and mammals.

### Motor Systems

Keywords :birdsong; neuromechanics;

## VARIABILITY IN ACTION: BASAL GANGLIA-FOREBRAIN CIRCUITS IN VOCAL LEARNING AND PLASTICITY

**Mimi Kao**[1]

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Many complex motor skills, such as speech or playing a sport, are not innately programmed, but are learned through a process of trial and error that involves motor exploration and performance evaluation. Songbirds provide one of the few animal models for speech learning. Like humans, they must hear the sounds of adult conspecifics during a sensitive period, and they must hear their own voices when learning to vocalize. They also possess a discrete network of brain regions required for song learning, including a basal ganglia-thalamo-cortical circuit known as the anterior forebrain pathway (AFP). Variable burst firing in this circuit is thought to generate variability in song output, which could subserve motor exploration. In addition, experimental manipulations that abolish burst firing in the AFP also eliminate song plasticity, suggesting that burst firing is an essential mechanism by which this circuit changes song. Here, I will describe evidence that neurons in this circuit have access to feedback signals but only gradually change their activity in response to feedback perturbations. Moreover, changes in the timing and amount of bursting in this circuit are sufficient to drive song plasticity and consolidation of the song motor program. Together, our findings support the hypothesis that the precise timing and pattern of AFP activity can shape the degree of stereotypy versus variability in song performance. Because the AFP is a simplified circuit that contributes to a single behavior, it may prove particularly useful for further testing mechanisms whereby basal ganglia-thalamo-cortical circuits contribute to normal and disordered learning.

### Communication

Keywords :basal ganglia; motor variability; vocal learning

## HORMONE-DEPENDENT VOCAL COMMUNICATION OF SONGBIRDS

**Manfred Gahr[1]**
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Vocal communication including singing of songbirds is controlled by a multi-area circuit that is composed of steroid hormone-sensitive neuron populations. Most of these areas express androgen receptors, the target of testosterone; the song area HVC expresses in addition receptors for estrogens. Testosterone and its estrogenic derivatives affect vocal communication dynamics as well as song pattern. Testosterone and estrogen act locally in HVC to change gene expression in a species-specific manner since genomic hormone-sensitivity differs between songbird species. These hormone-driven changes of gene expression are area-specific, fast and concern many genes. In the canary, among these genes, one hub-gene is BDNF that induces singing with high repetition rates (a sexy song features) if locally overexpressed in HVC. In concert with other testosterone-dependent gene networks, elevated levels of BDNF facilitate differentiation of large song syllable repertoires. Further, we report on the dynamics of hormone-dependent gene expression in relation with neurophysiological properties of song areas.

### Behavioral Plasticity

Keywords :testosterone; singing; neural plasticity

## BIOMECHANICAL MODELS TO STUDY THE NEURAL BASES OF BIRDSONG PRODUCTION

**Ana Amador**[1]
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Songbirds are a widely studied example of vocal learning that allows integrating neural and peripheral recordings with a complex behavior. Although neural activity has been related to song acoustics in auditory playback experiments, the neural code for processing and generating birdsong remains elusive. To address this issue, we worked with a minimal physical model for birdsong production, having as an output a synthetic song. Each syllable was coded in terms of physiological parameters birds can control, defining in this way motor gestures. To validate this model, we assessed responses of the premotor forebrain nucleus HVC to song playback in sleeping and anesthetized birds, as HVC neurons exhibit highly selective responses to the bird's own song (BOS). Remarkably, the biomechanical model was able to elicit responses strikingly similar to those for BOS. The analysis of neural activity in terms of the song production model allowed the emergence of a novel hypothesis of motor control in songbirds. We confirmed this result with HVC recordings in singing birds, showing the pertinence of working with a low dimensional model that represents an approximation of peripheral mechanics but captures relevant features of behavior.

### Sensorimotor Integration

Keywords :birdsong; sensorimotor control; nonlinear dynamics

## NOT THE ABC, BUT THE IEGS OF FISH LEARNING – INDICATION FOR AN NVOLVEMENT OF THE TELENCEPHALON IN SELECTED COGNITIVE TASKS

**Vera Schluessel[2]; Theodora Fuss[2]**

University of Bonn,Bonn,Germany[1]; University of Bonn,Bonn,Germany[2]

While there has been an upsurge in behavioral studies on fish cognition, only few studies have tried to uncover the relevant neuronal substrates involved. Here, learning and memory functions were assessed in sharks and cichlids with respect to selected visual discrimination abilities. Behavioral experiments were complemented by immediate-early gene expression studies using egr-1 and c-fos. In sharks, immunocytochemistry revealed a significant up-regulation of egr-1 mRNA expression levels in a small telencephalic region. Expression patterns between different training regimes (early and late learning stages, long-term memory retention) showed distinct variations in size and strength. Although up-regulation in individuals exposed to acute stress occurred within the same telencephalic region, egr-1 labeling patterns were significantly different compared to individuals subjected to tasks demanding cognitive engagement. Egr-1 activity was virtually absent in control sharks, which were not stimulated prior to sacrifice. In the cichlids, expression of egr-1 and c-fos in was not limited to the telencephalon but occurred extensively throughout most of the brain. Moreover, expression patterns did not vary significantly in size or strength within the three experimental groups (control, stress, early learners), prohibiting identification of relevant neural substrates for learning. The observed differences between the shark groups (but not the cichlids) support previous results in other species, indicating that the egr-1 response may be evolutionarily conserved and therefore useful for identifying neural responses in a wide variety of organisms. Results also strengthen findings from lesion experiments on sharks, showing that even without a neocortex, selected cognitive functions are processed in the telencephalon.

**Learning & Memory**

Keywords :; ;

## ORGANIZATION OF THE TELENCEPHALON OF WEAKLY ELECTRIC GYMNOTIFORM FISH: THE NEURAL BASES OF SPATIAL LEARNING

**Leonard Maler[1]; James Jun[1]**

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The ability to navigate over large distances is a ubiquitous ability of many animals. In some cases, the long distance visual sense may be sufficient to account for navigation; however, when the spatial scale of navigation exceeds that of the sense input, more complicated strategies must be employed. In mammals, there is extensive evidence for the role of the hippocampus in visual spatial learning and memory. We have shown that spatial learning occurs in electric fish and likely utilizes primarily the electrosense. Because we suspect that, as in mammals, the pallium is essential for spatial learning, we examined the detailed circuitry of the gymnotiform telencephalon. The telencephalon of gymnotiform fish is relatively small in comparison to its highly developed brainstem electrosensory system and cerebellum. It is, nonetheless, highly differentiated and numerous subdivisions of both the ventral (subpallium) and dorsal (pallium) telencephalon can be readily distinguished. Recent studies in zebrafish and gymnotiform fish have demonstrated conservation of basal ganglia structures across mammals and teleosts. In teleost fish, the pallium develops in a very different manner from that of amniotes and it has been difficult to discern precise homologies of important regions such as hippocampus and cortex. We have mapped pallial circuitry in great detail and have found that, based on the connections of dorso-lateral, dorso-dorsal and dorso-central pallium, there are striking parallels between these structures and both mammalian hippocampus and cortex. We propose that the spatial learning is due to the same pallial circuitry in teleosts and mammals.

### Learning & Memory

Keywords :spatial learning; memory; telencephalon

## COMBINATION OF COGNITIVE SKILLS IN ARCHERFISH

**Stefan Schuster[1]**

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Archerfish are renowned for their ability of shooting down aerial prey with a precisely aimed jet of water. In recent years it has become evident that an impressive range of capabilities comes packed with shooting. The first part of my talk will describe some of these capabilities, discuss how these compare with other more established 'cognitive' species and whether the combination in one species is unusual. The second part attempts to demonstrate why it is useful to study 'cognitive' features in fish and how their design helps to dissect the mechanistic basis of nontrivial aspects of decision-making.

### Cognition

Keywords :decision making; ;

## CONSERVED FUNCTION OF THE CORTICOBASAL GANGLIA CIRCUITS IN THE ZEBRAFISH DECISION-MAKING

**Merlin Lange[1]; Hisaya Kakinuma[1]; Ryo Aoki[1]; Tanvir Islam[1]; Hitoshi Okamoto[1]**

RIKEN,Wako,Japan[1]

Action selection among several choices to adapt animal behavior is a fundamental cognitive process, well conserved in animal kingdom. It has been documented that neuronal circuits of the corticobasal ganglia are critical for decision-making. We have elucidated that zebrafish Danio rerio, has partially the equivalent structure as the mammalian corticobasal ganglia. Particularly we identified a dorsal area of the zebrafish telencephalon crucial for the long-term memory retrieval, similar to the cortical mnemonic activity in the mammalian brain (Aoki et al., Neuron 2013). Furthermore our results support the idea that the fish brain can code a negative reward expectation value during active avoidance learning (Amo et al., Neuron 2014). I will introduce unpublished data about our current knowledge on the zebrafish corticobasal ganglia neuroanatomy and function. Combining viral transsynaptic tracing and transgenic animal we are able to precisely map the synaptic connection in zebrafish brain. Then, using the calcium indicator GCaMP7, we recorded the brain activity in the striatum during a Go-NoGo task. The result suggests that the activity of the zebrafish indirect striatal neurons, a key component of the corticobasal ganglia, is enhanced during the NoGo action selection. Our data support the existence in zebrafish of a conserved network anatomically and functionally homologous to the mammalian corticobasal ganglia circuit, playing a key role in decision-making.

### Decision Making

Keywords :decision-making; telencephalon; zebrafish

## NEURAL CIRCUITS UNDERLYING ODOR VALENCE AND INTENSITY PERCEPTION IN DROSOPHILA

**Silke Sachse[1]**

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To internally reflect the sensory environment, animals create neural maps encoding the external stimulus space. From that primary neural code relevant information has to be extracted for accurate navigation. Feature extraction and integration of stimulus modalities have mainly been studied in the visual system, while they remain unknown in the olfactory system. Drosophila melanogaster provides an excellent model system for deciphering olfactory processing mechanisms, since their olfactory system displays remarkable similarities to mammals but is less complex and highly genetically tractable. Like other sensory systems, the olfactory system employs a spatio-temporal map to translate the chemosensory space into neuronal activity patterns in the antennal lobe. Output neurons convey the olfactory information via two processing pathways to the mushroom body calyx and the lateral horn (LH), a brain center that is assumed to be involved in innate olfactory behavior. We are analyzing how different odor features as identity, hedonic valence and intensity are functionally coded and integrated in the LH.

The talk will summarize our recent insights into coding strategies of the parallel processing pathways of the Drosophila olfactory circuitry.

**Sensory: Olfaction and Taste**

Keywords :olfactory circuitry; odor coding; lateral horn

## PLASTICITY IN THE MOUSE OLFACTORY BULB FOLLOWING MOTHERHOOD

**Adi Mizrahi**[1]
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Motherhood is a dramatic event common across the mammalian line of descent. Motherhood is accompanied by new maternal behaviors aimed at insuring the wellbeing and survival of the offspring. Maternal behaviors are most likely associated with how specific neuronal circuits process information, but these are not well characterized. Here, we studied the functional changes in the olfactory system in mothers, focusing on the main olfactory bulb (OB) of mice. Using in vivo two-photon calcium imaging we show that the output of mitral cells (MCs) becomes sparse in mothers resulting in increased odor selectivity. MCs in mothers also show increased delayed temporal patterns of response. Gene profiling and slice electrophysiology show that maternal changes in MCs result from an increased inhibitory drive. To track the mechanism of circuit changes we tested two interneuron populations, parvalbumin expressing (PV) and dopaminergic interneurons. PV-expressing inhibitory interneurons but not dopaminergic neurons show more odor-evoked responses in mothers as compared to virgin mice identifying the PV neurons as a site of plasticity contributing to MCs sparsening. Moreover, MCs changes are long lasting and could be induced, in part, by the mere experience with the pups. The functional plasticity in the OB of mothers provides a novel substrate for understanding odor coding and plasticity during the maternal state.

**Sensory: Olfaction and Taste**

Keywords :; ;

## PARALLEL PROCESSING OF ODOR INFORMATION IN HONEYBEES

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Honeybees are excellent model systems to study olfactory processing due to their dual olfactory pathway. Two sets of anatomically isolated projection neurons (PNs) connect antennal-lobe olfactory glomeruli from two hemilobes via a lateral and medial tract in opposite sequence with higher order olfactory centers, the mushroom bodies (MB) and lateral horn. Using simultaneous multi-electrode recordings from PNs of both tracts, we found that both PN populations respond to similar odorants, but with different physiological properties. Whereas lateral-tract PNs respond fast with broad odor tuning, medial-tract PNs respond odorant specific and with ~14ms longer response latencies. Imaging studies indicated that glomeruli in both hemilobes receive largely redundant sensory input (e.g. Carcaud et al. 2012) further supporting the concept of parallel olfactory processing. Interestingly, lateral- and medial-tract PNs display mirror-image like anatomical trajectories resembling delay-line like neuronal circuits. To investigate the role of temporal coding, we analyzed levels of spike coincidences of PNs. Odor driven coincidences were present within and between PNs tracts with highest levels in medial-tract PNs. Remarkably, correlation of PN coincidence levels with their odor tuning revealed a clear difference between both tracts with low correlation levels in lateral-tract PNs and high levels in medial-tract PNs. These results indicate that both parallel processing and coincidence coding occurs in the dual olfactory system of the honeybee, which integrates well into the current understanding of synaptic integration and plasticity in the MB calyx. Supported by DFG (SPP 1392) to WR.

### Sensory: Olfaction and Taste

Keywords :olfaction; mushroom body; coincidence

## PARALLEL PROCESSING OF SULFATED STEROID ODORANTS IN THE DUAL OLFACTORY SYSTEM OF AN ANURAN AMPHIBIAN

**Ivan Manzini[1]; Thomas Offner[1]; Thomas Hassenklöver[1]; Timothy Holy[2]; Xiaoyan Fu[2]; Alfredo Sansone[1]**

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Chemical communication is widespread in amphibians, but if compared to later diverging tetrapods the available functional data is limited. Amphibians represent a transitional stage in the evolution of the olfactory system. Most species have anatomically separated main and vomeronasal systems, but recent studies have shown that in anurans their molecular separation is still underway. Sulfated steroids function as migratory pheromones in lamprey and have recently been identified as natural vomeronasal stimuli in rodents. Here we identified sulfated steroids as the first known class of vomeronasal stimuli in the amphibian Xenopus laevis. We show that sulfated steroids are detected and concurrently processed by the two distinct olfactory subsystems of larval Xenopus laevis, the main olfactory system and the vomeronasal system. Our data revealed a similar but partially different processing of steroid-induced responses in the two systems. Differences of detection thresholds suggest that the two information channels are not just redundant, but rather signal different information. Furthermore, we found that larval and adult animals excrete multiple sulfated compounds with physical properties consistent with sulfated steroids. Breeding tadpole and frog water including these compounds activated a large subset of sensory neurons that also responded to synthetic steroids, showing that sulfated steroids are likely to convey intraspecific information. Our findings add to the evidence that sulfated steroids are conserved intraspecific stimuli functioning in phylogenetically distant classes of tetrapods living in aquatic and terrestrial habitats.

### Sensory: Olfaction and Taste

Keywords :main olfactory system; vomeronasal organ; amphibian

## MIRROR NEURONS IN MACAQUE MONKEYS. FROM BASIC MECHANISM TO THE EXTENDED NETWORK

**Pier Francesco Ferrari[1]**

Mirror neurons (MN) have been originally found, and investigated for years, in macaque monkeys. They have been found in the rostral part of the ventral premotor cortex (PMv) and in the convexity of the inferior parietal lobule. Their pattern of activity and the anatomical connections with other cortical areas showing similar properties or more general self-other responses (i.e. M1, AIP, SII, ventrolateral prefrontal cortex, and mesial cortex) support the idea of an Extended Mirror Neuron Network and that MN could be involved in imortant behavioral and cognitive processes, such as imitation and action recognition. More recent studies expanded our knowledge on the mirror mechanism and of MN functional role. By recording these neurons under different context we found that during action observation their activity is modulated by different social and contextual cues: value of the grasped object, space where the actions is performed, gaze of the observed agent, etc. Indeed, the variation of mirror neurons activity under different experimental conditions suggest that environmental factors and experience can induce critical changes on how this mechanism respond to and decode social stimuli. The existence of a similar mechanism in other primate species and in birds points to a common evolutionary pathway in which action and perception became critically coupled in order to support important cognitive functions in social cognition and communication. MN thus may provide an original and unitary account of basic aspects of primate social cognition and behavior, and offer new insights on the evolution of parietal and premotor area.

### Motor Systems

Keywords :social cognition; macaque; imitation

## ACTION EXECUTION AND OBSERVATION IN THE CHIMPANZEE BRAIN

**Erin Hecht[1]**

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Primate species show differences in social learning, suggesting different neural adaptations for observing and reproducing others' behavior. Most non-human primates emulate, or copy observed actions' end results. Humans are unique in our capacity to imitate, or copy both end results and the specific methods used to achieve them. Chimpanzees are capable of imitation but typically emulate. To investigate underlying neural mechanisms, we measured regional cerebral glucose metabolism while chimpanzees produced and observed grasping actions. Like humans and unlike macaques, chimpanzees "mirrored" both transitive and intransitive action. However, chimpanzee activation was largely focused in prefrontal cortex, while humans showed more activation in parietal, premotor, and occipitotemporal regions. These results may explain why chimpanzees are capable of copying observed actions' movements, but nonetheless show a bias toward copying goals. Our diffusion tensor imaging studies offer a potential underlying neuranatomical substrate for these functional differences, in that connectivity within this network was skewed toward frontal cortex in chimpanzees and toward occipitotemporal and parietal cortex in humans. Furthermore, chimpanzees with greater ventral premotor and lateral occipital activation during grasping observation performed better on tests of action-copying and tool use. Together, these results suggest that adaptations to this circuitry may underlie the evolution of different types of social learning behaviors in primates.

### Motor Systems

Keywords :primates; mirror neurons; social learning

## SINGLE-CELL LEVEL, MIRROR NEURONS IN MARMOSETS FRONTAL CORTEX AND NEUROANATOMY

**Noritaka Ichinohe**[1]
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Mirror neurons respond when executing a motor act and when observing others' similar act. So far, mirror neurons have been found only in macaques, humans, and songbirds. To investigate the degree of phylogenetic specialization of mirror neurons during the course of their evolution, we determined whether mirror neurons with similar properties to macaques occur in a New World monkey, the common marmoset (Callithrix jacchus). The ventral premotor cortex (PMv), where mirror neurons have been reported in macaques, is difficult to identify in marmosets, since no sulcal landmarks exist in the frontal cortex. We addressed this problem using "in vivo" connection imaging methods. That is, we first identified cells responsive to others' grasping action in clear landmark, the superior temporal sulcus (STS), under anesthesia, and injected fluorescent tracers into the region. By fluorescence stereomicroscopy, we identified clusters of labeled cells in the ventrolateral frontal cortex, which were confirmed to be within the ventrolateral frontal cortex including PMv after sacrifice. We next implanted electrodes into the ventrolateral frontal cortex and STS and recorded single/multi-units under an awake condition. As a result, we found neurons in the ventrolateral frontal cortex with characteristic "mirror" properties quite similar to those in macaques. This finding suggests that mirror neurons occur in a common ancestor of New and Old World monkeys and its common properties are preserved during the course of primate evolution.

### Social Behavior

Keywords :new world monkey; superior temporal sulcus; in vivo connection imaging

## STEREO VISION AND PREY DETECTION IN THE PRAYING MANTIS

**Vivek Nityananda[1]; Ghaith Tarawneh[1]; Jenny Read[1]**

Praying mantises are specialized visual predators and are the only insects known to have stereo vision. While earlier work on stereo vision in mantises demonstrated that it enables them to judge distances to prey, we know little of the underlying mechanisms of insect stereo vision or whether it helps mantises detect targets in complex visual scenes with multiple or camouflaged targets. We used a recently developed method for presenting insects with virtual 3D targets to test how stereo vision in the praying mantis might help them detect targets in such scenes. In two different experiments, we found that the mantises were significantly more likely to strike at targets with disparity cues that indicated closer targets compared to control targets with the opposite disparity. In a third experiment, we presented mantises with a target stimulus comprised of smaller dots. In different conditions, these dots were either correlated (black corresponding to black, white corresponding to white) or anti-correlated (black corresponding to white and vice versa) in the two eyes. If mantis stereo relies on a correlational mechanism similar to primate stereo, we would expect them to perceive and strike at nearby prey in the correlated condition but not in the anti-correlated condition. We instead found that mantises struck at both correlated and anti-correlated stimuli. We thus conclude that while mantis stereo does enable them to detect and differentiate between prey in complex visual scenes, it possibly relies on a simpler target matching system rather than correlating the visual scenes of both eyes.

### Sensory: Vision

Keywords :stereo vision; praying mantis; predation

## ITD MAPS AND TEMPORAL PRECISION

**Catherine Carr**[1]
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The interaction between predators and prey produces strong selection on the mechanisms underlying target detection. Barn owls are nocturnal predators that rely on accurate sound localization for prey detection. They use interaural time differences (ITD) for detection of sound source location in azimuth, and encode ITDs using a place map in the nucleus laminaris (NL). The map is composed of neurons that serve as labeled lines tuned for preferred spatial locations. This presentation will focus on the neural adaptations for accurate sound localization in azimuth, and upon the benefits of a place map for accurate target detection. Adaptations include a hypertrophied map in NL, with an over-representation of frontal space (Carr et al., 2015). Other adaptations include coding strategies to create microsecond delays from neural elements that are both noisy and slow. The microsecond precision needed to construct maps of ITD is achieved through precisely regulated phase delays, rather than by regulation of absolute latency, consistent with the observation that NL neurons respond over a wide range of integer multiples of their preferred interaural phase difference (Christianson & Pena, 2006). Thus latencies from ear to the point of coincidence detection need only be adjusted within a stimulus period, creating a flexible yet precise system for detection of sound source sound location (Carr

et al. 2015).

**Sensory: Audition**

Keywords :sound localization; temporal; owls

## ARE FEATURE DETECTION AND OPTIC FLOW ANALYSIS SEGREGATED IN CRABS?

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Visually-guided prey-capture behaviors, alike predator-avoidance behaviors, require analyzing the retinal motion generated by the external moving target (prey or predator), as well as the panoramic optic flow self-generated during the chasing or escaping performance. While the first is required to classify, pinpoint the location and track the potential prey or predator, the second is needed for an accurate control of the course of these actions. In insects, neurons involved in object motion processing have been described in the lobula (third optic neuropil). On the other hand, neurons involved in optic flow analyses have been described in the lobula plate (a tectum like neuropil). The crab Neohelice granulata offers methodological advantages for the study of visual information processing, including the possibility of recording intracellularly the neuronal response to visual stimuli in the intact animal. After years of recordings, we have shown that giant neurons from the lobula are tuned to object motion, but not to flow field motion. Crabs do respond to optic flow: they display strong compensatory eye movements to panoramic displacement (optomotor response) but where this information is processed is unknown. Recently, the presence of a neuropil alike the lobula plate was identified in crabs. Here we describe the characteristics of this neuropil, its neuronal components and preliminary results on the behavioral consequence of lesion experiments. Our results support the idea that, in the crab, the information of object motion and of optic flow field are segregated and processed in the lobula and lobula plate, respectively.

**Sensory: Vision**

Keywords :lobula plate; optomotor response; neuroanatomy

## NEURAL CIRCUITS FOR PREY CAPTURE IN ZEBRAFISH LARVAE

**Julie Semmelhack**[1]
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Zebrafish larvae rely on their visual system to hunt and capture prey objects, such as paramecia. Detection of a small moving object evokes a series of stereotyped orienting turns and swims that allow the larva to approach the prey, followed by a more propulsive swim coupled with jaw opening to create suction and consume the paramecium. We have begun to dissect the neural circuits involved in the initial orienting phase of prey capture.

Using a head-fixed preparation, we can present visual stimuli while recording tail movements, and objectively classify the behavior using a machine learning algorithm. We were thus able to vary the stimulus parameters and determine the ideal prey stimulus. To identify the brain areas mediating this behavior, we used two photon imaging to record population responses in retinal ganglion cell (RGC) axons. In zebrafish, RGC axons terminate in ten arborization fields (AFs). We found that RGC axons that innervate one AF, AF7, responded robustly and specifically to the ideal prey stimulus. This region is innervated by just two types of RGCs, which also send collaterals to the optic tectum. Laser ablations of the AF7 RGC axons dramatically reduced prey capture, suggesting that this area plays an important role in the behavior. The final phase of prey capture, the strike, is triggered when the larva is quite close to its prey. We are now characterizing this behavior and the stimuli that evoke it, with the goal of understanding how larvae are able to gauge the distance to the target.

### Sensory: Vision

Keywords :prey capture; zebrafish; target detection

## EVOLUTIONARY ECONOMICS: DECISION-MAKING UNDER UNCERTAINTY IN CHIMPANZEES, BONOBOS, AND HUMANS

**Alexandra Rosati[1]**

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What are the origins of economic behavior? Human decision-making is marked by systematic biases, but it is unclear whether these patterns are due to cultural experience with monetary markets, or are shaped by biological dispositions that might be shared with other species. Comparative studies of decision-making in our closest living relatives—chimpanzees (Pan troglodytes) and bonobos (Pan paniscus)—are critical to disentangle the roots of human choice. I will present evidence that humans and nonhuman apes share similar patterns of decision-making in several contexts, including risk aversion (willingness to accept variability in payoffs to acquire better rewards), ambiguity aversion (willingness to chose options when lacking information), and framing effects (responding differently to choices presented as a loss or a gain). However, reward currency also modulates human decision-making: people respond differently to choices about evolutionarily novel rewards such as money, compared to choices about biologically-central rewards such as food. Together, this evidence indicates that human economic behaviors have evolutionary roots as far back as the last common ancestor with nonhuman apes, but humans may also have specialized psychological skills for dealing with novel types of abstract rewards.

### Cognition

Keywords :decision-making; cognitive evolution; economics

## WHAT INSECTS CAN TELL US ABOUT THE ORIGINS OF CONSCIOUSNESS

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How, why and when consciousness evolved remain hotly debated topics. Addressing these issues requires a comparative analysis of conscious phenomena cross the animal phylogeny. Toward that goal here we develop an argument from comparative functional neurobiology that insects have the capacity for the most basic form of consciousness: subjective experience. Subjective experience means a capacity for having an experience of the world that is unique to the agent having the experience; it does not mean reflecting on the nature of the experience. In vertebrates the capacity for subjective experience is supported by the midbrain rather than the cortex. Interacting structures of the vertebrate midbrain create an integrated and egocentric neural simulation of the state of the mobile animal in space, which is sufficient to meet the functional definition of a subjective experience. The mushroom body, central complex and lateral protocerebrum in the insect brain perform analogous functions and generate a unified neural model of the state and position of the insect in the environment. Therefore we argue the insect brain also supports a capacity for subjective experience. In both vertebrates and insects this form of behavioural control system provides an efficient solution to basic problems of sensory re-afference and navigation. We propose the most basic form of consciousness evolved to enable effective navigation in mobile animals with spatial senses, and that this capacity emerged quite early in animal evolutionary history.

### Cognition

Keywords :subjective experience; central complex; mushroom body

## TEMPORAL MEMORY IN INDIVIDUAL NEURONES IN THE CEREBELLUM

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A hypothesis made famous by Cajal and Hebb is that learning in the nervous system consists in strengthening or weakening of synaptic strength. This idea has been enormously influential as can be seen in the focus on long-term potentiation and depression in current memory research. A problem with this approach has been that it cannot easily account for timing of neural responses. An example is Pavlovian eyeblink conditioning. Repeated pairings of a tone and an air puff to the eye causes acquisition of a conditioned blink that is adaptively timed, that is, the conditioned blink is maximal at the time of the expected air puff. It is known that this learning takes place in the cerebellum where adaptively timed pauses in Purkinje cells drive the overt behavior. The learning mechanism usually invoked to account for these pauses has been long-term depression of parallel fibre to Purkinje cell synapses. The timing was thought to depend on delays in the input signals to the cell. Recent results suggest instead that the timing information is stored within the Purkinje cell by a novel learning mechanism. This forces a revision of our view of timing in the cerebellum and also undermines the traditional Cajal-Hebb paradigm. It also undermines the associationist view of cognitive function.

### Synaptic Plasticity

Keywords :memory; timing; cerebellum

## INFORMATION THEORY AND STOCHASTIC MODEL SELECTION IN ASSOCIATIVE LEARNING AND MEMORY

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Two information-theoretic principles, maximum entropy, and minimum description length found a computational model of associative learning that explains cue competition (assignment of credit), response timing, and the parametric invariances. State cues and point cues are linked, respectively, to two stochastic distributions, the exponential and the BernoulliGauss. The stochastic model selected by the computational model specifies the relative code lengths for the most efficient encoding of the data and best predicts the data not yet seen. Its hazard function predicts the timing of conditioned behavior. The minimum-description-length approach to stochastic model selection (Rissanen 1999) enables the computational model to find the stochastic model that maximally compresses the data and best predicts the future.

### Learning & Memory

Keywords :associative learning; computational model; cue competition

## NEW ZEALAND KIWI AND ITS AUDITORY, VISUAL AND OLFACTORY SPECIALIZATIONS FOR A NOCTURNAL LIFE

**Jeremy Corfield**[1]
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At some point in the evolutionary history of the New Zealand kiwi bird, selection favored a shift to a nocturnal and ground dwelling niche. With this shift came a unique set of sensory capabilities. Using anatomical, histological and biomedical imaging techniques, I have gained an insight into the sensory world of kiwi. The kiwi visual system is somewhat underdeveloped, with reduced eye sizes, brain regions and visual fields, presumably indicating poor vision. However, the laminar organisation of the retina indicates a specialization for vision in low light levels. The morphology of the inner ear suggests hearing with an increased sensitivity to a high frequency band between 4 – 6 kHz. Whether this corresponded to a biologically important sound, such as the vocalizations of prey, is yet to be determined. Kiwi have a dense cluster of pressure sensitive mechanoreceptors at their beak tip and large brain regions receiving this information, suggesting a specialisation to detect soil dwelling invertebrates. The relative size of olfactory processing regions, such as the olfactory bulbs, are larger than any bird that has been examined to date, suggesting an excellent sense of smell. The mass of the kiwi telencephalon is larger than expected based on their body size, possibly a result of increased sensory integration. Kiwi sensory ecology is unique among birds and illustrates an example of convergent evolution, where kiwi and rodents have evolved similar adaptations to exploit forest floor habitats at night.

### Anatomy & Neuroanatomy

Keywords :sensory ecology; kiwi; neuroanatomy

## THE QUANTUM ROBIN: LIGHT-DEPENDENT MAGNETORECEPTION IN MIGRATORY BIRDS

**Henrik Mouritsen[1]**
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Migratory birds can use a magnetic compass to find their way, but how do they sense the reference direction provided by the geomagnetic field? In the past years, evidence has mounted that migratory birds use a light-dependent, radical pair-based mechanism to sense the axis of the geomagnetic field lines (Mouritsen & Hore 2012). I will first introduce the light-dependent, radical pair-based mechanism and suggest how this mechanism can help birds sense the Earth's magnetic field. Then, I will present molecular, neuroanatomical, biophysical evidence, and behavioural evidence that strongly support the above hypothesis. Finally, I will present a recent study, where we could show that the magnetic compass of night-migratory birds is sensitive to anthropogenic electromagnetic time-dependent fields, which are ca. 1000 times weaker than the current WHO guideline limits (Engels et al.
2014). A number of recent results strongly indicate that the basic sensory mechanism underlying the magnetic compass of night-migratory songbirds should be based on fundamentally quantum mechanical principles rather than classical physics. References:

Engels et al. (2014) Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird. Nature 509, 353-356. Mouritsen & Hore (2012) The magnetic retina: light-dependent and trigeminal magnetoreception in migratory birds. Current Opinion in Neurobiology 22, 343-352.

### Sensory: Magnetoreception

Keywords :magnetic sense; quantum biology; bird migration

## NEW DEVELOPMENTS IN THE CHEMICAL ECOLOGY IN A SEABIRD MODEL: THE LEACH'S STORM-PETREL (OCEANODROMA LEUCORHOA)

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Genes of the Major Histocompatibility Complex (MHC) operate in adaptive immune response and are compelling genetic markers for self versus non-self recognition. Studies of MHC-based mate choice in natural populations are often limited by sample size, leading to error. To test whether MHC Class IIB operates in scent-based mate choice, we conducted a large-scale, multi-year demographic study of Leach's storm-petrels in Nova Scotia, Canada. We genotyped partial genomic fragments of two MHC Class IIB gene duplicates (Ocle-DAB1 and Ocle-DAB2) in nearly 1500 birds to characterize the MHC variability in a natural population and test for evidence of MHC-based disassortative mating. We used randomization tests to compare observed and bootstrapped means of four MHC similarity metrics (pairwise heterozygosity differences, band-sharing coefficients, mean amino-acid substitutions, maximum amino acid substitutions) in 327 established pairs and found no significant evidence of disassortative mating (HZ: $p=0.47$; band-sharing: $p=0.32$; mean AA: $p=0.27$; maximum AA: $p=0.35$). This sample size is unprecedented in any MHC study investigating disassortative mating in a wild population and reduces the probability of incurring a Type 1 error. Using a simple two-choice bioassay, we further show that test subjects can discriminate personal odors of conspecifics when MHC class IIB genotype is held constant ($n=24$, $p<0.01$, binomial test), suggesting that factors other than MHC class IIB contribute to personal odor discrimination in this species.

### Ecology

Keywords :olfaction; mhc; bird

## BIGGER THAN IT LOOKS? SOUND LOCALIZATION CUES GENERATED BY BIRDS' HEADS

**Christine Koeppl**[1]

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There is a long tradition of using birds as animal models in research on the neural mechanisms of sound localization. Classic work on the barn owl has provided seminal insights into the processing of interaural time differences, used by many animals (including humans) for sound localization in the azimuth. Recently, however, it has become increasingly obvious that these mechanisms might differ between birds and mammals (Grothe and Pecka, 2014), and possibly also between different avian species (Palanca-Castan and Köppl, 2015). This has renewed interest in the neuroethological context and the selective pressures on sound localization in the different species studied. One important factor that has long been recognized is the interplay between head size (as the major determinant of physical localization cues) and hearing range. An intriguing but complicating feature in birds is the presence of internal coupling (through skull spaces) of their middle ears. This can, in principle, result in improved binaural localization cues and thus has important implications for the neural coding of those cues. This talk will discuss new evidence for an enlargement of interaural time differences experienced by the chicken through this mechanism. A further recent study (Schnyder et al., 2014) showed significant cues to sound source elevation being generated by the chicken head. Together, this suggests that many birds may enjoy more informative cues to sound location than was previously thought: their heads are effectively bigger than their physical size suggests.

**Sensory: Audition**

Keywords :azimuth; interaural time difference; bird

## NEURAL CONSTRUCTS OF MAGNETIC SPACE LEAD TO HOMING BEHAVIOR IN PIGEONS

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Many animals can detect and use the Earth's magnetic field (EMF) for orientation and navigation functions. We have recently discovered cells in the vestibular brainstem (MR cells) of pigeons that encode the direction, intensity, and polarity of the EMF (Wu and Dickman, Science, 2012). We have also characterized a magnetic sense neural pathway that includes regions in the brain known to be involved with spatial orientation and navigation tasks, including the vestibular nuclei, dorsal thalamus, hippocampus, and visual association cortex (Wu and Dickman, Current Biology, 2011). Here we present new data regarding multisensory convergence of vestibular and magnetic sense signals in MR cells that create neural constructs to encode geopositional and heading direction information. Our findings suggest that MR cell directional responses are spatially stable and do not change with head position, thus they are encoded in an earth-fixed gravity coordinate system. We also have trained racing pigeons to home to a loft from dozens of miles, while carrying GPS tracking motion, and magnetic sensors. We find that pigeons do not return home via straight line routes when released from novel locations, but instead follow the outbound path even when alternative cues are available. The homing results suggest that pigeons either path integrate the outbound route via vestibular cues, or store a magnetic signature (map) of the route that is followed on the return home. These results may provide key insights into important brain functions and bring us closer to understanind navigation map representations in the brain.

### Orientation & Navigation

Keywords :navigation; magnetoreception; path integration

## THE ROLE OF THE MIDBRAIN SC IN NATURAL ORIENTING BEHAVIORS OF THE ECHOLOCATING BAT

**Melville Wohlgemuth**[1]
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The midbrain superior colliculus (SC) has been implicated in species-specific orienting behaviors, and yet most neurophysiological studies of the mammalian SC have been conducted in restrained animals. To bridge this gap, we took multichannel recordings from the SC of the echolocating bat as it performed natural orienting tasks. We hypothesize that the orienting behaviors of the bat are tied to coordinated activity patterns across pools of SC neurons. To test this hypothesis, we designed a behavioral paradigm in which the bat's head/pinna movements and natural echolocation behaviors could be precisely measured with respect to activity patterns across SC sensory and motor neurons. In the current paradigm, the movement of the target could be experimentally controlled, allowing us to introduce target trajectories with moments of unpredictability to invoke error-correcting adaptive processes within the SC. We find that when the target abruptly shifts direction, there are coordinated changes in both the orienting behaviors of the bat, and the activity of pools of SC neurons. Our data suggest that activity across layers in the bat SC is involved in calculating motor error for acoustic orienting by sonar, and identify ways in which populations of SC neurons contribute to coordinated orienting behaviors.

### Sensorimotor Integration

Keywords :superior colliculus; echolocation; stimulus selection

## CORTICAL MECHANISMS OF SOUND LOCALIZATION IN THE PALLID BAT

**Khaleel Razak**[1]
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The auditory cortex is required for sound localization but how sound locations are represented in the cortex remains unclear. A novel mechanism of 2D spatial representation in the auditory cortex of the pallid bat will be described here. The pallid bat is a 'gleaner' that localizes terrestrial prey by listening to prey-generated noise while reserving active echolocation for obstacle avoidance. A part of the auditory cortex is selective for prey-generated noise (noise selective region, NSR). The NSR is subdivided into two clusters (peaked and EI) based on binaural selectivity. The peaked cluster is an acoustic fovea for midline locations. The EI cluster houses a population code for contralateral azimuth locations that depends on systematic changes in the extent of activated cortex. I will describe how source elevation influences this azimuth code in the EI cluster. This is based on recording 2D spatial receptive fields (SRF) in the NSR. There are significant correlations between frequency tuning and SRF properties in NSR.

Neurons with low best frequency exhibited larger SRFs and lower centroid elevation. With increasing best frequencies, the SRFs became smaller and restricted to upper elevation. These relationships indicate that the tonotopic map and source elevation will predictably restrict the azimuth dependent spread of EI cluster activity. How the pallid bat may use these spatial representations to hunt will be discussed.

**Sensory: Audition**

Keywords :sound localization; auditory cortex; echolocation

## THE DEVELOPMENT AND EVOLUTION OF VERTEBRATE LATERAL LINE ELECTRORECEPTORS

**Clare Baker[1]; Melinda Modrell[1]; Harold Zakon[2]; Jamie Ladbrooke[1]; Adrian Carr[1]; Mike Lyne[1]**
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Electrosensory ampullary organs that detect weak electric fields in water (primarily used for hunting live prey) are found in all major groups of jawed vertebrates, innervated by lateral line neurons projecting to a specific nucleus in the hindbrain. In non-teleosts, they are derived embryonically from lateral line placodes (together with mechanosensory neuromasts) and respond to low-frequency cathodal stimuli. The electrosensory division of the lateral line system was lost independently in several groups, including the lineage leading to teleosts. Ampullary organs that respond to low-frequency anodal stimuli subsequently evolved independently at least twice in different teleost groups, with some lineages also independently evolving both electric organs and tuberous organs that detect high-frequency electric organ discharges. We have used a comparative RNA-Seq approach in a chondrostean (non-teleost) ray-finned fish, the paddlefish Polyodon spathula, to identify many genes expressed in both sense organs, highlighting their overall similarity, as well as a few genes expressed in ampullary organ electroreceptors but not neuromast hair cells (encoding voltage-gated potassium channel subunits, a calcium-buffering protein and a transcription factor). We have also used a comparative RNA-Seq approach in a gymnotiform teleost, Apteronotus albifrons (with both ampullary and tuberous organs), to inform cloning and validation of candidate genes in a siluriform teleost (in a sister group to gymnotiforms), Ictalurus punctatus, which only has ampullary organs. This cross-species approach has identified a transcription factor gene expressed in siluriform ampullary organs but not neuromasts. Using these approaches, we are starting to uncover the developmental and evolutionary basis of electroreception.

### Sensory: Electrosensory

Keywords :; ;

## LOSS OF SWEET TASTE IN BIRDS AND RE-EVOLUTION OF SWEET TASTE IN HUMMINGBIRDS

**Maude Baldwin[1,5]; Yasuka Toda[2]; Tomoya Nakagita[2]; Mary O'connell[3]; Kirk Klasing[4]; Takumi Misaka[2]; Scott Edwards[5]; Stephen Liberles[6]**

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Sensory systems are shaped both by an organism's evolutionary history as well as by selection pressures encountered in current environments. Although the degree to which the vertebrate taste receptor repertoire evolves to reflect feeding ecology is debated, many instances of diet-related taste receptor change have been reported, such as the loss of the sweet receptor subunit (T1R2) and subsequent loss of sweet taste perception in some mammalian carnivores. Birds too appear to be missing T1R2, perhaps due to the carnivory of their theropod dinosaur ancestors, but many groups of birds are nectar-specialists and clearly can detect carbohydrates. To understand the molecular basis of sugar sensing in hummingbirds, we cloned members of the T1R taste receptor gene family from oral tissue of hummingbirds, swifts, and chickens. Receptor expression studies revealed that the ancestral umami receptor (T1R1-T1R3 heterodimer) was re-purposed in hummingbirds, but not in swifts, their closest relatives, to function as a carbohydrate receptor. Behavioral choice tests and high-speed videography in wild and captive hummingbird populations indicated sweet taste preferences that correlated with in vitro functional studies. This change in taste receptor function may have been one of many key adaptations enabling hummingbirds to detect and utilize nectar, facilitating the radiation of hummingbird species. However, many aspects of the consequences of altered receptor function remain to be elucidated.

### Sensory: Olfaction and Taste

Keywords :taste; hummingbirds; evolution

## FROM GAINERS TO LOSERS: EVOLUTIONARY REDUCTION AND REGRESSION OF TYMPANAL HEARING ORGANS IN INSECTS

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Tympanal hearing organs in insects have evolved independently at least 18 times. Auditory organs are model sensory systems in neuroethology studied for their functional anatomy, sensory physiology, and acoustic behaviours in several insect groups like Orthoptera, Lepidoptera, Mantodea, and Diptera. Here, we explore the evolutionary forces on tympanal hearing organs from gaining hearing ability to losing that sensory modality in different insect lineages. Hearing is adapted for mate detection and location, predator avoidance, and host detection, whereby the sensory adaptations may be sex specific. In several insect lineages, secondary regressions and reductions of tympanal organs are documented occurring if the initial selection pressures on the auditory sensitivity or acuity stops. These may be lack of exposure to predators, changes in intraspecific communication, or loss of intraspecific acoustic signalling. Regressive changes lead to a weaker function of the auditory sense, while reduction means the complete loss of tympanal membranes. Sensory regression may occur if a selection factor is no longer present but others may prevail,resulting in the maintenance of a weaker sensory function. In reductive events tympanal hearing is completely lost. We consider the forces acting against the maintenance of sensory organs, like energetic costs of the neural tissue, or neutral drift. We discuss which elements of hearing organs are affected by regression and reduction and to which extend reduction may maximally occur. We argue that evolutionary losses of sensory function provide a rich field to study the multiple factors acting on sensory organs for hearing especially in Orthoptera.

### Evolution

Keywords :auditory organ; ;

## TO EAR OR NOT TO EAR? CONVERGENT LOSS OF LATE-FORMING EARS IN TOADS

**Molly Womack[1]; Jakob Christensen-Dalsgaard[1]; Marissa Metz[1]; Jennifer Stynoski[1]; Kim Hoke[1]**

Anurans have outer and middle ear structures to transmit airborne sound from the environment to their inner ear sensory cells. Yet, many bufonid (true toad) species have independently evolved earlessness, the lack of middle and outer ear structures, despite the importance of acoustic communication in most toad mating systems. Our work aims to determine why middle and outer ear structures are so evolutionarily labile in the Bufonidae family by comparing hearing and morphological data of eared and earless bufonid species within a phylogenetic context. We show that the middle and outer ear structures form very late in the development of toads and take many months past metamorphosis to become fully functional. Adult earless species are typically less sensitive to acoustic stimuli at high frequencies and more sensitive to low frequency vibrations compared to eared toads. The skulls of earless species neither lack other skull bones nor are less ossified than skulls of eared species. We conclude that extratympanic hearing pathways buffer the hearing consequences of tympanic ear loss, and we discuss roles for heterochrony and directional selection in shaping the evolutionary lability of ear structures.

### Evolution

Keywords :earlessness; toad; trait loss

## CIRCADIAN TIMING OF DROSOPHILA EMERGENCE

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Circadian (biological) clocks regulate the timing of behavior and physiology of multicellular organisms. In mammals, a central “master” clock located in the suprachiasmatic nucleus plays a dominant role in setting the phase of autonomous “slave” clocks located in peripheral organs. In insects, by contrast, the peripheral clocks are typically autonomous, and the animal’s various clocks are synchronized through the action of a common daily entraining signal—either light, which can penetrate the translucent exoskeleton, or temperature. An exception is the circadian system that regulates the timing of adult emergence (eclosion). In most insect species, the circadian clock restricts the time of emergence of the adult to a specific window of time within the (subjective) day—usually dawn or dusk, depending on the species. This circadian regulation of the time of emergence depends on the actions of, and interactions between, a central pacemaker located in the insect’s brain, and a peripheral pacemaker, located in the peripheral prothoracic gland (PG), which produces the molting hormone, ecdysone. I will discuss our progress, using Drosophila melanogaster, in understanding the hierarchical relationship between the central brain and the PG clocks, and how the brain clock regulates the rhythmicity of the PG clock. I will also present a single fly assay we have developed to investigate the mechanism by which the biological clock imposes a circadian rhythmicity to the timing of adult emergence.

### Circadian Rhythms

Keywords :insect behavior; neuropeptide; endocrinology

## SENSORY CONFLICT AND MULTIMODAL ENTRAINMENT OF THE DROSOPHILA CIRCADIAN CLOCK

**Ross Harper[1]; Peter Dayan[1]; Ralf Stanewsky[1]; Joerg T Albert[1]**
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Periodic changes in various environmental stimuli can synchronize the Drosophila circadian system. Next to light, temperature changes, social cues and mechanical stimulation have all been shown capable of setting the fly's clock. However, the question of how the brain integrates these different input pathways to set circadian time has remained unanswered. Entrainment to each of these cues will rely on signaling from a diversity of peripheral sensory organs. In turn, the clock (and circadian time) has been shown to affect sensory organ function and sensitivity. The inherent bi-directionality of this interrelation blurs the conventionally clear boundaries between clock output and clock input, and invites more dedicated analyses into how exactly multiple sensory modalities are processed to compute circadian time. One method of exploring sensory integration by the clock is through the construction of sensory conflicts, which serve to decouple input signals and to disentangle signal dependence (e.g. between light and temperature sensing pathways). We show that misaligned light and temperature cycles can (i) lead to dramatic changes in the daily locomotor activities of wild type flies, (ii) associate with drastic reductions in the amplitudes of PERIOD (PER) oscillations in brain clock neurons, and (iii) desynchronize light- and temperature-sensitive subgroups of clock neurons. These results lend further support to the view of the clock as a network of coupled oscillatory subunits; one that normally functions within a limited range of sensory inputs.

### Circadian Rhythms

Keywords :circadian time; multisensory entrainment; drosophila

## THE EFFECT OF DIURNAL RHYTHM ON THE SENSITIVITY LIMIT OF MOUSE VISION

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The presence of several circadian rhythms in the retina has led to the hypothesis that visual sensitivity is under circadian control. However, it has never been fully assessed whether the sensitivity limit of vision depends on the circadian clock. We determined for the first time if the sensitivity limit of mouse ganglion cells (RGCs) and visually guided behavior depends on the diurnal rhythm. Using both melatonin deficient (C57BL/6J) and melatonin producing (CBA/CaJ) mouse strains, we compared the visual sensitivity of mice in their subjective night with those measured in their subjective day. We measured the sensitivity of On and Off ganglion cells in flat-mount preparations of isolated, dark-adapted mice retinas in cell-attached patch clamp configuration. We determined the behavioral sensitivity limit of mice in a dim-spot detection task using a six-armed water maze. Our results show no significant difference in the sensitivity of the ganglion cells between day and night. Consistent with the electrophysiological results, the behaviorally measured absolute threshold (the weakest stimulus giving a reliable response) did not differ between the night and day groups nor between the mouse strains. However, over a range of light intensities above the threshold, the visual sensitivity was higher during the night than during the day. This effect seems to arise from diurnal differences downstream from retina, i.e. differences in cognitive functions.

### Sensory: Vision

Keywords :circadian rhythms; retina; visual sensitivity

## DAILY REWIRING OF ADULT NETWORKS IN DROSOPHILA

**María Fernanda Ceriani**[1]
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Circadian rhythms regulate physiology and behavior through the action of self-sustained transcriptional feedback loops of clock genes operating in discrete groups of neurons. In Drosophila, about 150 neurons in the central brain are implicated in the circadian regulation of rest-activity cycles, but a subset known as the small ventral lateral neurons (sLNvs) are essential; in fact, preservation of molecular oscillations within this cluster is key to command rhythmic behavior in the absence of environmental cues. The sLNvs transmit time-of-day information releasing a neuropeptide known as pigment dispersing factor (PDF) as well as classical neurotransmitters whose role has only recently been explored. In addition to the release of signaling molecules, sLNv axonal terminals undergo extensive remodeling on daily basis, and such plasticity in the number of synapses could provide an alternative means of encoding time-of-day information. A number of years ago we carried out an unbiased screen to map the connectivity of sLNv neurons using GRASP (GFP reconstitution across synaptic partners). Remarkably, GRASP analysis revealed that sLNv terminals contact different target cells along the day, thus extending the impact of core pacemaker neurons to circuits beyond the circadian network. This finding opens the possibility that circadian structural remodeling provides a mechanism by which a neuron can exert sequential control of different target circuits along the day.

### Circadian Rhythms

Keywords :drosophila; structural plasticity; intercellular communication

## ARTHROPOD´S PERIPHERAL VISUAL NEURONS SHAPE BEHAVIORAL RESPONSES TO OBJECT MOTION STIMULI

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Object motion detection provides essential cues for a wide variety of animal behaviors such as mate, prey, or predator detection. In decapod crustaceans and pterygote insects, object motion would be first codified by small field columnar neurons projecting from the second to the third optic neuropil. Studying electrophyisiolocally the codification properties of these columnar neurons has been an elusive issue. Thus, we have started studying the population calcium response of these columnar neurons to different visual cues such as target velocity, contrast and motion direction. The activity observed in these columnar neurons from crabs showed a high correlation with behavioral responses to variations in such visual parameters. Besides, in many different arthropod species (e.g. hoverflies, locusts, crayfishes and crabs) the repetitive presentation of object motion stimuli induces a reduction in the response of tangential neurons from their third optic ganglion that would account for the reduction in the animal response to repetitive visual stimulation. We found that the calcium response of their columnar presynaptic neurons rapidly declines with repetitive motion stimuli presentations. In correspondence with animal behavior and with the activity of the tangential neurons, the response of their presynaptic columnar neurons completely recovers after fifteen minutes and the reduction in response is retinotopic specific. Our results show that stereotyped but still plastic behaviors can already be shaped by the activity of peripheral columnar neurons arising in the arthropod's second optic ganglion.

### Sensory: Vision

Keywords :arthropod; vision; physiology

## A RADIAL MAP OF SELECTIVITY TO MULTI-WHISKER CORRELATION IN THE RAT BARREL CORTEX

**Laurent Bourdieu[1,2]; Luc Estebanez[1,2]; Daniel Shulz[1]; Jean-Francois Leger[2]**

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In rodents, the exploration of the environment results in a variety of correlation patterns of multi-whisker deflections, from multi-whisker asynchronous stick and slips events during texture probing, to highly synchronous barrages of whisker deflections during first contacts with edges and object surfaces. In visual and auditory cortices, the spatio-temporal correlation patterns of sensory inputs are key parameters to explain neuronal firing. In the barrel cortex, specific subpopulations of neurons have been shown recently to be tuned to multiwhisker correlation patterns. Functional maps are a prominent feature of primary sensory cortices and are typically observed for sensory parameters of perceptual relevance. Several single whisker sensory maps are known in the barrel cortex, but so far the cortical mapping of neurons tuned to multiwhisker input statistics is unknown. Here we use two-photon fluorescence microscopy to explore the spatial organization of neurons selectively responding to multi whisker correlations in layer 2/3 of the barrel cortex. We show that temporal correlations in multiwhisker deflections drive efficiently neurons in layer 2/3. We report moreover that layer 2/3 of the barrel cortex contains an additional functional map based on neuronal tuning to complex multiwhisker stimuli: neurons responding to temporal correlations are distributed on rings located at the vertical projections of layer 4 barrel borders. This map may arise from integration at multiple stages of the thalamo-cortical loop through lemniscal and paralemniscal pathways, as well as local cortical processing.

**Sensory: Mechanosensation**

Keywords :barrel cortex; functional maps; spatio-temporal correlations

## PHEROMONES AS MODULATORS OF INSECT BEHAVIOR

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Pheromones are conspecific communication signals usually eliciting stereotyped behavioural or physiological responses. They trigger immediate or delayed innate responses to relevant stimuli, and thus are crucial for regulating social or sexual interactions. However, pheromones have also been suggested to act as "modulators" of cognitive phenomena, facilitating or inhibiting associative learning and memory. We study the modulator effect of pheromones on experience-dependent insect behaviour in order to determine mechanisms that are either conserved across species or species-specific and associable with particular life-styles. To this end, we use a combination of behavioural, pharmacological and physiological (optical imaging) methods in bees, ants and moths.

### Cognition

Keywords :pheromones; insects; cognition

## EARLY PROCESSING OF ELECTROSENSORY IMAGES IN PULSE GYMNOTIFORMES.

**Angel Caputi**[1]
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Weakly electric fish use field distortion of a self-emitted electric discharge to explore their environment and to communicate. The talk deals with how signals sensed by different types of electroreceptors are integrated at the electrosensory lobe where novelties in the spatial pattern of amplitude and time waveform of the carrier are detected. We integrate information from image generation biophysics, circuit anatomy and neuron properties studied in vitro with electrophysiological recordings obtained in vivo either in self-emitting descerebrated preparations or in freely moving animals to model some of the mechanisms explaining the brain stem integrated novelty responses characteristic of pulse Gymnotiformes

### Sensory: Electrosensory

Keywords :neural coding; image; active sense

## SHAPE RECOGNITION BASED ON ARTIFICIAL ELECTRIC SENSE FOR UNDERWATER ROBOTICS

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Fish that can electrocute their prey are known since antiquity and have inspired Volta to design the first battery. However the ability of other fish to perceive their near surrounding by sensing the modification of a weak self generated electric field has been only discovered in the 50's. Named active electrolocation, this original sense is used by many species of fresh water fish. These fish can polarize a specific electric organ located in their tail with respect to the rest of their body. The polarization generates an electric field in their close surrounding that polarizes in turn the nearby objects. The object then reflect back a secondary field that can be measured by transdermal receptors covering the fish skin. By comparing the electric currents, with and without perturbative objects, the fish build an electric image on its skin which is processed by the its brain to infer a three dimensional image of the environment. An important corpus of knowledge exists in biology on these fish. Particularly, recent behavioral experiments achieved in darkness have shown that the elephant fish can localize objects, perceive their electric nature and discriminate their shape. Remarkably, electric sense can work in harsh conditions where other senses fail. This is the reason why it has recently drawn the attention of roboticist with the aim of building a new generation of underwater robots able to navigate in turbid waters which are untill now, out of reach using our current sensor technologies based on vision or sonar. This talk aims at providing recent results in robotics with a special emphasize on the challenging issue of shape recognition. To that end, we will use an electric probe bio-inspired from electric fish “fish-probe”, and will consider elliptic shaped objects. More than being the simplest shape after the sphere, this particular shape is of crucial interest for object recognition, since any object can be characterized at the leading order, by the dipolar tensor of an equivalent ellipsoid. After having stated shape recognition as a mathematical inverse problem, we will develop a two steps approach. First, we will address the issue of object localization with different techniques ranking from the source localization Music (MUltiple SIgnal Classification) algorithm to more bio-inspired approaches based on the extraction of indices from temporal electric images recorded along specific motions of the fish-probe. Combining these different approaches we will propose an original solution providing an accurate localization of any elliptic object. In a second step, with the knowledge of the localization of the object, we will develop a novel identification algorithm capable of estimating the volume and the aspect ratio of an ellipsoidal object. The whole approach will be illustrated through many examples carried out on a finite-element numerical simulator and an experimental setup devoted to the study of electric sense. Based on these first results, we will open further perspectives and issues. Supported by European Unions Horizon 2020 research and innovation programme under grant agreement No 640967. Project subCULTron: submarine cultures perform long-term robotic exploration of unconventional environmental niches. http://www.subcultron.eu

**Sensory: Electrosensory**

Keywords :electric sense; robots; shape recognition

## HONEYBEE INTERNEURONS RESPONSIVE TO THE PULSED VIBRATION PRODUCED BY WAGGLE DANCE

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The forager of honeybee communicates with hive-mates about the spatial information to the profitable flower by waggle dance. The waggle dance consists of waggle phase and return phase. The distance to the flower is suggested to be encoded in a parameter linearly changing with the duration of the waggle phase (von Frisch, 1967). Performing the waggle dance, the dancer produces a unique temporal pattern of pulsed vibration. Bursts of wingbeats occur at the timings when the tail end passes the run axis during the waggle phase, resulting in narrow jet air flow (Michelsen, 2003). The carrier frequency is c.a. 265 Hz and the frequency of pulse is c.a. 15 Hz and these are not modified by profitability of food (Hrncir et al., 2011). These results suggest the distance to the flower is encoded in the number of pulses. We have been interested in how the hivemates decipher the distance information and have identified 188 vibration-sensitive interneurons in the brain. In the present study we categorized our identified interneurons by morphology and response patterns to the vibration to the Johnston's Organ (JO) and investigated the GABA immunoreactivity of three critical classes of dorsal lobe interneurons, DL-Int-1, DL-Int-2 and vibration-sensitive bilateral neuron families. These three neuron classes specifically respond to continuous pulse vibration to the JO and DL-Int-1s have GABA immunoreactivities. The results suggest a specific inhibitory network in the dorsal lobe working for decoding pulse trains. We discuss its role for counting the number of pulses produced in the waggle dance.

### Cognition

Keywords :honeybee; waggle dance; gaba

## GENETIC AND NEURAL MECHANISMS GOVERNING THE SEXUAL DIMORPHISM OF AGONISTIC BEHAVIOR IN DROSOPHILA MELANOGASTER

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Agonistic behavior, or fighting, is an innate behavior exhibited by many animal species. Although both males and females can display agonistic behavior, the contexts in which they fight, and the motor programs characterizing their agonistic behaviors, are often distinct. We are using the vinegar fly Drosophila melanogaster as a model to characterize neurons controlling agonistic behavior in a sex-specific manner. Taking advantage of an automated behavior-classification system, as well as the genetic resources available in the fly, we have characterized a small number of neurons that specifically control male agonistic behavior, but not male courtship behavior. This population of neurons (previously named aSP-g/6 cells) exhibits sexually dimorphic branching patterns. We found that misexpression of the male-specific isoform of a sex-determining gene fruitless (FruM) in the female brain resulted in male-type morphology of the aSP-g/6 neurons. Moreover, activation of the aSP-g/6 neurons in the FruM “masculinized” female brain caused the female flies to fight using a male motor program. These finding indicate that a specific neural population controls sexually dimorphic agonistic behavior in Drosophila, and suggest the existence of sexually dimorphic neural circuits and gene regulatory patterns. We are currently characterizing the genetic pathways that underlie sexual dimorphism of aSP-g/6 neurons (as well as the neural circuits that involve aSP-g/6 neurons) and that contribute to the generation of sexually dimorphic “aggressive arousal”, and the expression of agonistic behavior.

### Genetics, Epigenetics & Behavior

Keywords :social behavior; decision making; aggression

## DO MOTOR NEURONS REGULATE PREMOTOR VOCAL RHYTHMS?

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In the canonical view of motor systems, premotor neurons drive motor neurons, which in turn activate muscles. In contrast, we have discovered evidence that vocal motor neurons in the South African clawed frog, Xenopus laevis, may regulate “upstream” premotor neurons. Earlier work showed that signals originating in the motor nucleus strongly modify firing patterns of neurons in the premotor nucleus. Using electrophysiological recordings and pharmacological perturbations, we are acquiring mounting evidence that these signals require motor neuron spiking, implying that the motor-to-premotor input involves an efference copy of motor neuron output. The majority of motor-to-premotor inputs appear to be inhibitory, indicating a possible mechanism by which motor feedback facilitates premotor synchrony. These findings, along with a small number of other “exceptions” to the top-down view of motor systems—such as Renshaw cell activation in spinal circuits—suggest that bottom-up signaling in vertebrate motor circuits may be more common than generally assumed.

### Motor Systems

Keywords :frog; vocal; cpg

## NEURONAL ACTIVATION IN THE PREOPTIC AREA DURING AGONISTIC BEHAVIOR IN THE WEAKLY ELECTRIC FISH, GYMNOTUS OMARORUM

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Social behavior is controlled by a conserved network of brain areas, the social behavior network (SBN). The activation pattern of SBN neurons varies with the form of sociality each species exhibits, and also among phenotypes. Neurons in the preoptic area (POA), which belongs to the SBN, that contain vasotocin (AVT) modulate social behavior. Gymnotus omarorum is a sexually monomorphic, solitary and highly aggressive species that displays non-sexually biased territorial aggression all year-round. Our aim was to describe the neuronal activation of POA neurons during agonistic encounters in G. omarorum non-breeding males. Firstly, we described the spatial distribution of AVTergic cells along the POA. Secondly, we carried out male-male contests, and the POAs of dominant males were immunolabeled for both c-fos and AVT, using expected dominants that did not fight as controls. We found three populations of AVTergic cells clustered in a large band extending from behind the anterior commissure to the posterior POA, above the optic chiasm. The parvocells (pPOA) are the most rostral and ventral, while magnocells are more dorsal and twice the size of pPOA. The gigantocells are the largest most dorso-caudal cells We found more c-fos positive cells in dominant males with respect to controls. We did not find correlations between AVT/c-fos labeling and the percentage of time in which males displayed locomotor activity. Neuronal activation differences in AVT populations among phenotypes are currently being explored.

### Social Behavior

Keywords :social behavior; vasotocin; neuronal activation

## REPRESENTATION OF CONSPECIFICS BY BAT HIPPOCAMPAL PLACE CELLS

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In animals living in social groups, learning can be facilitated by observing the behavior of conspecifics (observational learning). In particular, it is important for social animals to know the spatial location of conspecifics, both because they need to know the locations of socially-dominant animals, and for purposes of group navigation. However, nothing is known about how the location of other animals is represented in the brain.

Here, we addressed this question by studying bats – highly-social mammals that excel in observational-learning and are also outstanding navigators. We designed an observational-learning task for Egyptian fruit bats (Rousettus aegyptiacus), where animals were trained in pairs: In each trial, one bat ('observer') had to observe and remember the flight-trajectory of the other bat ('demonstrator'). After a short delay, the observer had to imitate the demonstrator and fly along the same flight-trajectory to receive a reward, which required the observer to pay close attention to the demonstrator's behavior. We recorded neurons in hippocampal area CA1 of the observer bat during this task, using a tetrode-microdrive and a miniaturized wireless electrophysiology system that allows recording individual neurons during flight. To control for the known spatial properties of hippocampal place-cells, we did two things: first, the observer hung at a fixed position while observing ('space-clamp'); and second, we used an accelerometer to exclude neural activity due to head-movements. Our preliminary data suggest that some CA1 neurons in the observer's hippocampus represent both the bat's own position (place cells) as well as the position of the conspecific.

### Learning & Memory

Keywords :hippocampal place-cells; observational learning; spatial representation

## SENSORY ADAPTATION TO THE SOCIAL ENVIRONMENT THROUGH SPIKE-TIMING-DEPENDENT PLASTICITY IN MORMYRID ELECTRIC FISH

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The temporal patterning of action potentials can convey information in the nervous system. Several studies have revealed how sensory pathways can decode temporal sequences, but we know little about how this is influenced by long-term plasticity. Here we show that spike-timing-dependent plasticity (STDP) shapes the processing of behaviorally relevant patterns of synaptic input in a network of midbrain sensory neurons. Mormyrid fish communicate by varying the intervals between electric pulses. Midbrain electrosensory neurons exhibit a wide range of interval tuning, which is partly determined by extensive excitatory connections among these neurons. Using a whole-brain in vitro preparation, we asked whether STDP contributes to the topology of this network by repeatedly pairing pre-and postsynaptic spikes at a range of delays. We found increases in synaptic strength when presynaptic spikes consistently led postsynaptic spikes, and decreases when presynaptic spikes consistently followed postsynaptic spikes. To test whether this STDP could influence the interval tuning of individual neurons, we stimulated afferent input to ELp at a range of intervals, but paired postsynaptic spikes with only one interval. This led to a shift in tuning towards the paired interval. Finally, to test whether intrinsic patterns of spiking within this network can influence interval tuning without artificially induced postsynaptic spiking, we repeatedly stimulated afferent input at a single interval. This caused tuning to shift in the direction of the repeated interval. We hypothesize that STDP provides a mechanism to alter network connectivity to optimize the coding of stimuli in response to changes in stimulus statistics.

**Sensory: Electrosensory**

Keywords :synaptic plasticity; sensory processing; temporal coding

## HOMING IN DESERT DUNG BEETLES - AN ACCURATE NAVIGATION SYSTEM WITHOUT LANDMARKS

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Some ant species appear to use a combination of path integration (navigation by integrating the distance and direction walked on the outbound trip, and following the opposite "vector" to return home) and view-based homing (using information gained from landmarks and panoramic snapshots) to return to their nest in a variety of different environments. Flightless desert dung beetles (Pachysoma spp.) have to solve a similar task. When they find a suitable source of dry dung or plant detritus, they build a burrow a few metres away from the food source, and carry the food in straight lines into this newly built nest. We here show that the beetles use path integration to guide their navigation. Similar to ants, they use a skylight compass (polarised light and sun azimuth) and a stride integration odometer to encode direction and distance, respectively. However, unlike ants or other path-integrating insects studied so far, the beetles do not seem to integrate landmark cues or view-based memories in their navigational system. By calculating image difference functions (IDFs) from panoramic photographs along the beetles' homebound path, and recording the search patterns of displaced beetles, we show that neither full-vector nor zero-vector beetles show any deviation from a pure path integration strategy when lost, even though a large amount of navigational information is encoded in panoramic snapshots. We propose that this pure path integration system in a large and easy-to-manipulate animal might serve as a great tool to investigate the physiological and neuronal basis of insect path integration.

**Orientation & Navigation**

Keywords :dung beetles; path integration; landmark navigation

## A NOVEL MOTION-SENSITIVE PATHWAY CONNECTING THE OPTIC LOBES AND THE CENTRAL COMPLEX OF A NOCTURNAL BEE

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Sweat bees of genus Megalopta are nocturnal central-place foragers with an extremely sensitive vision and an efficient internal navigation system. Main site of compass information processing in the insect brain is the central complex (CX). In migratory insects it integrates skylight polarisation and other visual compass cues. Neurones in the bee CX react to polarisation and translational optic flow. Therefore the CX is potentially an internal compass and an odometer in central-place foragers. As large-field motion encoding neurones in insects have so far only been located in the optic lobes, we asked how is this information transmitted to the bee CX? We did intracellular recordings in a virtual reality setting in combination with tracer injections to visualise the recorded cells. Our aims were to 1) verify the existence of optic flow-encoding neurones in bee optic lobes, and 2) identify potential pathways linking the optic lobes and the CX. We found a network of novel motion-sensitive neurones in the central brain of Megalopta. Some of their arborisations overlap with the input regions of the CX optic-flow neurones, providing possible input pathways for these cells. Our data suggest that motion processing neurones are widespread in the central brain of insects and allow designating functions to previously uncharted brain areas. The optic-flow inputs in the bee CX suggest that together with polarisation cues they might form the neural basis for path integration essential for the homing behaviour of central-place foragers.

### Orientation & Navigation

Keywords :central complex; compass; odometry

## THE CIRCUIT BASIS OF ON DIRECTIONAL SELECTIVITY IN THE DROSOPHILA VISUAL SYSTEM

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Visual motion detection is critical to many animal behaviors, and flies are a powerful model system for exploring this fundamental neural computation. The classic models proposed over 50 years ago to explain how directional selectivity can be computed from non-selective signals have provided important predictions about the neuronal implementation, and yet most details of this circuit have remained mysterious. Recent advances in connectomics and neurogenetics have provided the detailed anatomical description of the fly visual system required for progress. Two related cell types--T4 and T5--deliver narrow-field directionally selective signals to visual output neurons; T4 encodes the motion of bright patches while T5 encodes dark motion. We focused on the T4 pathway and developed specific genetic driver lines for the four columnar cell types that contribute the majority of presynaptic inputs to T4. We then examined the response properties of each T4 input neuron type, and the contribution each type makes to T4 function and to visually guided walking behaviors. Unexpectedly, we find that each input channel exhibits distinct encoding of visual input. We identified the location in the circuit where directional selectivity emerges by using 2-photon calcium imaging of T4 dendrites and the terminals of the input neurons. Since classical models of motion detection differ on the signs of the inputs, we determined the sign of the connection between each of the input channels and T4. Several surprising results will be explored with computational models.

### Sensory: Vision

Keywords :visual motion detection; directional selectivity; drosophila

## DISTRIBUTED NEURAL PREDICTION IN AMPHIBIAN PREY CAPTURE

**William Mowrey[1]; Anthony Leonardo[1]**

Animals use rapid ballistic movements to capture prey, but the accuracy of these movements is constrained by sensorimotor delays. Recent work has shown that amphibian tongue projections compensate for phototransduction and head movement delays by extrapolating prey motion [1]. One hypothesis is that this extrapolation occurs in the retina, as activity in amphibian fast-OFF retinal ganglion cells has been shown to predict object motion [2]. A tracking estimate to guide the tongue could be extracted from fast-OFF population activity by a population vector average (PVA); if so, tongue projections will have characteristic size- and speed-dependent errors arising from fast-OFF cell population dynamics [3]. We tested this in toads (Anaxyrus terrestris) and found that tongue projections are biased ahead of center for prey elongated in the direction of motion, consistent with fast-OFF/PVA tracking. In contrast to the fast-OFF/PVA model, however, we find that tongue projection accuracy is similar over a 4-fold range of prey speeds, suggesting that additional predictive computation in the brain corrects for speed-dependence in retinal tracking. To determine the total visuomotor delay that is compensated by neural prediction, we presented toads with prey that unpredictably reversed direction and analyzed the time course of correction. These experiments show that phototransduction and motor delays are concurrent, meaning that prey capture kinematics can be modified "in-flight" by visual input. Together, our work shows that distributed neural prediction compensates visuomotor delays in prey capture, and that these delays are minimized by online adjustment of the tongue projection. [1] 10.1523/JNEUROSCI.3189-15.2015 [2] 10.1038/18678 [3] 10.1523/JNEUROSCI.2257-13.2013

### Sensory: Vision

Keywords :prediction; retina; motion extrapolation

## MULTI-MODAL AND MULTI-DIMENSIONAL SENSORY PERCEPTION IN BATS

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How sensory information from different modalities is weighted and integrated and how different dimensions of a sensory stimulus are perceived are fundamental questions in neuroscience. Bats are ideal animal models to study these questions because of their reliance on two sensory systems (vision and echolocation) which can both provide a high resolution representation of the distal environment. Three projects addressing these questions will be presented: (1) we examined how visual information, regulated by altering ambient light level, influences biosonar sampling in Rousettus aegyptiacus bats (Danilovich et al., 2015). The bats increased echolocation rate and intensity at lower light levels, where visual information was limited. Additionally, the bats adjusted biosonar sampling in a task-dependent manner, increasing echolocation rate prior to landing in lit environments, suggesting they use echolocation to complement vision for accurate distance estimation. (2) we studied the sensory properties that define an acoustic object. We independently manipulated two different sensory properties of an object: its size and reflectivity. We found that the two must coincide to allow perception. We compared two bat species that differ in their reliance on biosonar: Rousettus aegyptiacus and Pipistrellus kuhlii. (3) We studied cross-modal recognition between vision and echolocation. Rousettus bats were able to transfer sensory perception of an object acquired using echolocation to the visual modality, suggesting they can create an echo-based representation that is accessible to other sensory modalities. Additionally, by recording echolocation behavior we could tap into the bats' sensory acquisition and assess the information they collect before making a decision.

**Sensory: Audition**

Keywords :multi-sensory; perception; bats

## VISUAL CORTEX RESPONSES OF CATS AND AGOUTIS: AN ELECTROPHYSIOLOGICAL COMPARISON

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Rodents studied so far show no evidence of a columnar organization in V1, as compared to carnivore and primate cortices. Nevertheless, orientation selective neurons have been found in all of the studied species. This opens up the question whether the connectivity underlying the emergence of such cortical response properties follows a different blueprint in animals with interspersed as compared to those with columnar organization. Furthermore, rodent data is only available for species with nocturnal or crepuscular habits and small brain size, two factors that could contribute to develop a different architectural blueprint. Here, we set out to compare cortical functional architecture between carnivores and rodent of diurnal habits, and comparable visual cortex size to that of small primates and carnivores. For this, we performed multi-site electrophysiological recordings from both anesthetized cats (Felis catus domestica) and agoutis (Dasyprocta aguti) visual cortex. Stimuli consisted in contrast reversing checkerboards and oriented gratings. We were able to characterize and compare the visual response properties to several spatial and temporal frequencies of stimulation, in V1 neurons of both species. Moreover, we were able to detect orientation and direction selective responses in the V1 of agouti. We will discuss the implications of our results for the interpretation of the circuitry architecture and its relevance for the life history of both species.

### Sensory: Vision

Keywords :visual cortex; orientation selectivity; electrophysiology

## MOLECULAR BASIS OF MECHANOSENSATION IN TACTILE-FORAGING DUCKS

**Eve Schneider[1]; Evan Anderson[1]; Marco Mastrotto[1]; Willem Laursen[1]; Patrick Gallagher[1]; Robert Lamotte[1]; Elena Gracheva[1]; Slav Bagriantsev[1]**

Tactile-foraging birds use their extremely mechanosensitive bills to detect and capture food. The neuronal basis of somatosensory specialization of the bill underlying the detection of light touch is unknown. We show that in tactile-foraging waterfowl, including ducks, the majority of trigeminal neurons innervating the bill are light-touch receptors, expressing the mechanosensitive ion channel Piezo2, while few neurons are thermoreceptors or nociceptors. In contrast, in visual or non-specialized birds, and in other non-specialized vertebrates, most trigeminal neurons detect painful stimuli and temperature. This suggests a trade-off between sensory modalities as an evolutionary strategy for optimal foraging. We show that mechanosensory specialization of duck trigeminal neurons occurs in ovo. Four days prior to hatching the majority of duck trigeminal neurons have already differentiated into light-touch receptors possessing large mechano-activated currents. In contrast, in embryonic chicken, a visually foraging bird, <20% of trigeminal neurons are mechanoreceptors, with significantly smaller mechano-activated currents than those present in duck neurons. RNA interference for Piezo2 significantly decreases both number of duck neurons responding to mechanical stimulation as well as the amplitude of remaining responses. We are currently investigating the role of Piezo2 in mechanoresponses from trigeminal neurons innervating the intact bill, using virally-delivered shRNA against Piezo2 ex vivo. Our observation that somatosensory specialization occurs in trigeminal ganglia in ovo supports evidence that these precocial birds must forage soon after hatching. Our data provide a neuronal basis for acute mechanosensitivity of the duck bill, and reveal a molecular mechanism of touch-evoked excitation in neuronal mechanoreceptors.

### Sensory: Mechanosensation

Keywords :touch physiology; duck; piezo2

## USING MULTIPLE SOURCES OF INFORMATION TO VISUALIZE STRUCTURE IN BEHAVIORAL DATA

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Advances in recording methods have recently driven the collection of large databases of animal behavior. However, quantifying the individual behaviors in these large datasets remains challenging, particularly because, with the exception of some simple, stereotyped behaviors, determining exactly what a behavior is and how to quantify it is difficult. To address this we exploit the fact that information about the same behavior may be present in multiple channels (for example, visual, auditory or olfactory). We have developed a computer program that uses these multiple, simultaneously recorded, sources of input to visualize structure in behavioral data. Using video and audio recordings of mouse social behavior we show that this system can provide behavioral insight across time, behavioral outcome, and genotype.

### Social Behavior

Keywords :mouse; social behavior; ultrasonic vocalizations

## CIRCUITRY OF SENSORY REPRESENTATION IN MUSHROOM BODY CALYX OF DROSOPHILA LARVA

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The mushroom bodies of insect brains are higher brain centers essential for associative olfactory learning. The Drosophila larval mushroom body calyx, the sensory input region, is organized in about 34 glomeruli. Stimulation of single OSNs shows limited divergence of odor representations in the transition from OSNs to calyx glomeruli. In contrast to stereotypic projection neuron (PN) innervation, innervation of calyx glomeruli by Kenyon cell (KC) dendrites appears random. This pattern is consistent with a combinatorial mechanism that can discriminate a large number of odors. However, the selectivity of odor representations in KCs must be modulated. We have therefore screened for lines that label non-PN non-KC neurons innervating the calyx. One neuron resembles the adult APL, and we designate it as the larval APL; this is the sole detectable GABAergic input in the larval calyx. The larval APL responds to odors, and blocking synaptic output from KCs by shibire-ts decreases larval APL activity. Therefore, the larval APL mediates a negative feedback loop connecting MB output to calyx input. We are now addressing how the APL and other regulatory neurons including octopaminergic neurons fit within the calyx circuitry.

We have analyzed the polarity of all such neurons identified in our screens and are using GRASP to assess the connections between them. Our data will help reveal the logic that determines and regulates the selectivity of sensory representation in the MBs.

### Sensory: Olfaction and Taste

Keywords :olfaction; octopamine; calcium imaging

## NEUROCHEMICAL UNDERPINNINGS OF MORPHINE ADDICTION IN ANTS

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Conventional definitions of drug addiction are focused on characterizing the neurophysiological and behavioral responses of mammals. Although mammalian models have been invaluable in studying specific and complex aspects of addiction, invertebrate systems have proven advantageous in investigating how drugs of abuse corrupt the most basic motivational and neurochemical systems. It has recently been shown that invertebrates and mammals have remarkable similarities in their behavioral and neurochemical responses to drugs of abuse. However, until now only mammals have demonstrated drug-seeking and self-administration without the concurrent presence of a natural reward, e.g., sucrose. Using a sucrose-fading paradigm followed by a two-dish choice test we establish ants as an invertebrate model of opioid addiction. The ant species Camponotus floridanus actively seeks and self-administers morphine even in the absence of caloric value or additional natural reward. Then, using High Pressure Liquid Chromatography (HPLC) equipped with Electrochemical Detection (ED), the neurochemicals serotonin (5-HT), octopamine (OA), and dopamine (DA) were identified and subsequently quantified, establishing the concurrent neurochemical response to the opioid morphine within the invertebrate brain. With this study we demonstrate dopamine to be governing opioid addiction in the brains of ants. Thus, this study establishes ants as the first non-mammalian model of self-administration that is truly analogous to mammals.

### Social Organization

Keywords :addiction; ants; drugs of abuse

## PERSISTENT ACTIVATION OF NITRIC OXIDE SYNTHASE (NOS) IS INVOLVED IN A NOVEL "MOLECULAR LONG-TERM MEMORY SWITCH" IN THE VERTICAL LOBE OF THE OCTOPUS

**Ana Turchetti-Maia[1]; Tal Shomrat[2]; Benny Hochner[1]**

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The octopus vertical lobe (VL) and its LTP are important for the acquisition of long-term memories outside the VL, as saturating LTP in the VL for a period of longer than 75 min impaired long-term memory acquisition but did not erase older memories (Shomrat et al 2008). We therefore started to investigate the mechanism by which the VL LTP mediates memory acquisition outside of the VL. We first show that LTP induction and maintenance during this critical training time is likely not to involve protein synthesis, as the administration of anisomycin in VL slice preparations, before or after LTP induction, did not block LTP induction nor maintenance. We then investigated whether a persistent activation of NOS is involved in the long-term maintenance during the training period. Indeed, we found that in the relevant times (= 240 min) NOS inhibitors reversed the LTP back to the control amplitude. Usually the blocking effect was reversible and washing out the inhibitors brought the response to a full LTP level. However, we found that as the time gets longer after LTP induction, the proportion of experiments where LTP did not recover increased and in some of these cases tetanization induced a second LTP. These results suggest that a persistent NOS activation serve as a "molecular memory switch" to maintain LTP expression through NO production. We hypothesize that such a cellular long-term plasticity process may regulate, through the VL output, a universal protein synthesis-dependent long-term memory acquisition at other brain areas.

### Learning & Memory

Keywords :neural network; nitric oxide; ltp

## TOWARDS THE CONNECTOME OF OCTOPUS VULGARIS: HOW AN ADVANCED INVERTEBRATE NEURAL-CIRCUIT SUPPORTS BEHAVIORAL AND BIOLOGICAL PLASTICITY

**Graziano Fiorito[1]; Ilaria Zarrella[1,2]; Elena Baldascino[1]; Giuseppe Petrosino[1]; Remo Sanges[1]; Giovanna Ponte[1,2]; Shuichi Shigeno[1,3]**

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Individual and social learning capabilities of Octopus vulgaris are investigated with the aim to decipher their neural correlates and the machinery involved in biological plasticity of this cephalopod mollusk. Here we present recent advances in this direction based on two different approaches. First, innate and learned fear paradigms were used to describe plasticity in gene expression profiles for genes of interest such as stathmin, tyrosine hydroxylase, dopamine transporter, octopressin, cephalotocin and glycin transporter, in response to fear conditioning and social interactions. We found a differential pattern of down- and up-regulation of gene expression in different regions of the octopus central nervous system, which challenges current views about modular-hierarchical organization of the octopus 'brain'. Second, functional neural-modulatory and 'connectome' fingerprints were obtained for the first time in octopuses illustrating examples of recent data in O. vulgaris and O. bimaculoides. Our transcriptome data support the view that octopuses represent a case of complex neural systems achieving paramount 'cognitive' properties paralleling those of higher vertebrates achieved in Trochozoans. Supported by: RITMARE Flagship Project (MIUR-IT); MO.DO. Project (FESR-Campania); Progetto Premiale MolEcOC (MIUR)

### Behavioral Plasticity

Keywords :social learning; transcriptome;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-01**
**Presentation Time: 15:00 to 16:00**

## CHEMOSENSORY PATHWAYS IN SPIDERS AND THEIR KIN

**Wulfila Gronenberg[1]; Briggs Carhart[1]; Dylan Hutchison[1];Iliana Manjon[1]**

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Spiders and their kin are known for their sense of touch and vibration and some for their visual capabilities, but very little is known about their chemical senses (smell and 'taste') except for the presence of chemoreceptors on their tarsi and feelers (pedipalps) and the pectens of scorpions whose afferent neurons supply glomerular neuropil reminiscent of insect and vertebrate primary olfactory centers. Here we describe putative chemosensory glomerular neuropils associated with the leg neuromers of spiders. These glomeruli reside in the leg neuromers and the highest numbers of glomeruli are found in the pedipalpal neuromers, corresponding to their function as feelers. Hunting spiders appear to have more elaborate olfactory neuropils compared to web-building spiders. Overall, it appears that chemosensory information in spiders is first processed locally at the level of each leg neuromer and then integrated centrally. We also describe the olfactory pathway of whip spiders (amblypygids), which have immense putative olfactory neuropils associated with their antenniform legs and which comprise many hundreds of glomeruli. These glomeruli give rise to olfactory input to the mushroom bodies, which are equally massive. The amblypygid mushroom body calyces are themselves composed of two glomerular regions, one reminiscent of insect calycal microglomeruli and the other region composed of larger glomeruli. Our study suggests that spiders may rely more on chemosensation than previously assumed and that amblypygids may represent a great system to study olfactory processing

**Anatomy & Neuroanatomy**

Keywords :olfaction; arachnids; whip spiders

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-02**
**Presentation Time: 16:00 to 17:00**

## SYNAPTIC ORGANIZATION IN THE HONEY BEE MUSHROOM BODY CALYCES DOES NOT PREDICT PERFORMANCE ON A CHALLENGING, ECOLOGICALLY RELEVANT, VISUAL LEARNING TASK

**Byron Van NEST[1]; Glen Marrs[1]; Susan Fahrbach[1]**

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The mushroom bodies (MBs) are an insect brain region associated with sensory integration and learning. The dendrites of the intrinsic MB neurons (the Kenyon cells) are in the calycal neuropil, where they receive input from primary sensory neuropils. The calyces are larger in older forager honey bees than in younger non-foragers. Additionally, the microglomeruli in the MB calyces reorganize with age such that older individuals have fewer but larger microglomeruli than younger individuals. It is suggested that such changes in MB organization support learning of complicated foraging tasks. Prior studies focused on the experiences that promote MB growth and the cellular processes that cause this growth; however, the consequences of MB growth for an individual have never been examined. Experience clearly fine-tunes brain structure in animals, but how does this feed forward onto behavior? We developed a field-based visual-discrimination task that mimics aspects of natural foraging. Foragers learned to associate the hue of an artificial flower with a sucrose reward. Each forager was monitored over 12 visits to the flower patch and scored on the rate at which the association was learned. This task revealed three behavioral cohorts: fast-learners (31%), slow-learners (31%), and non-learners (38%). Learning scores were correlated with mi-croglomerular organization in the MB calyces via whole-brain immunolabeling and confocal microscopy. While our age-based results closely match those of previous studies, we found no differences in the volume of individual microglomeruli or the number of microglomeruli per unit volume of MB calyx between fast-learner and non-learner forager honey bees.

**Anatomy & Neuroanatomy**

Keywords :apis mellifera; microglomerulus; foraging

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-03**
**Presentation Time: 17:00 to 18:00**

## MINIATURE MASTERMINDS – NOVEL INSIGHTS ON HALLER’S RULE AND EFFECTS OF EXTREME BRAIN SCALING ON NEURAL ARCHITECTURE IN NASONIA WASPS

**Jitte Groothuis[1]; Hans M. Smid[1]**

Wageningen University,Wageningen,The Netherlands[1]

Haller’s rule states that all animals have an allometric brain-body relationship; meaning that small animals have relatively larger brains than their counterparts. Extremely small-sized (approx. 0.5 mm) parasitoid wasps of the species Trichogramma evanescens, however, were previously shown to have an isometric brain-body relationship. To investigate if this is a consequence of their extreme small size, or a trait associated with parasitoid wasps, we present data on the brain-body relationship of an isogenic line of Nasonia vitripennis, a parasitoid wasp of fly pupae, which is larger than T. evanescens (approx. 2-3 mm). In this species, the variation in body weight can span an order of magnitude. N. vitripennis shows a diphasic relationship where the brains of the larger wasps scale as expected from Haller’s rule; in the smallest wasps, however, the brain scales in a fashion similar to Trichogramma. To further explore this unexpected finding, we present a volumetric analysis of the brains of small and large wasp populations. We describe how specific neuropils have smaller or larger relative volumes than what would be expected if the brain scaled as one unit. We discuss these differences, while considering the potential ecological relevance of these neuropils. To our knowledge, this is the first time the neuropil distribution in the brain of Nasonia vitripennis has been described in detail.

**Anatomy & Neuroanatomy**

Keywords :haller's rule; nasonia; neuropil reconstructions

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-04**
**Presentation Time: 18:00 to 19:00**

## MATCHED ACOUSTIC RECEPTION SYSTEMS TO UNUSUALLY LOW FREQUENCY CALLS PRODUCED BY A PALEOTROPICAL BUSHCRICKET

**Kaveri Rajaraman[1,2]; Natasha Mhatre[3]; Manjari Jain[2];Matthew Postles[3]; Rohini Balakrishnan[2]; Daniel Robert[3]**

University of Hyderabad,Hyderabad,India[1]; Indian Institute of Science,Bangalore,India[2]; University of Bristol, Bristol,UK[3]

Crickets and bushcrickets (Order: Orthoptera, Suborder: Ensifera) rely heavily on acoustic communication to find their mates. We are interested in the question of the match between sound production and sound reception systems, in order to enable successful communication. Pseudophylline bushcrickets predominantly call at high, often ultrasonic broadband frequencies. We investigated the behavioural and mechanical frequency tuning of one bushcricket species, Onomarchus uninotatus, that produces a narrow bandwidth call at an unusually low carrier frequency of 3.2 kHz. We found that unlike the high-pass filter characteristic of other bushcricket tympana, the anterior tympanal membrane of this species acts as a low-pass filter, precisely attenuating sounds at frequencies above 3.5 kHz, i.e: above that of the male call and below most acoustically competing Orthopterans in the same rainforest. Responses to higher frequencies are partitioned to the posterior tympanal membrane - a novel feature. The use of such low-frequency, long-wavelength sounds poses directional challenges for small animals, but we find that both membranes show some directional sensitivity. Behaviourally, we find that the female shows band pass selectivity around the frequency of the male call, measured using the rate at which she tremulates to the male call. If we assess her directional ability based on phonotaxis, which is a lower likelihood event than tremulation, we find an error rate. We investigate this error rate as well as the choice between tremulation and phonotaxis with respect to parameters of the male call and contextualize them with respect to predator pressure.

**Anatomy & Neuroanatomy**

Keywords :acoustic; auditory; bushcricket

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-05**
**Presentation Time: 15:00 to 16:00**

## DIFFERENCES IN HEAD MORPHOLOGY OF A CAVEFISH AND ITS SURFACE ANCESTOR AS EXPLORED BY MICROCT AND MICROMRI

**Daphne Soares[1]; Marina Yoffe[1]; Cornelius Faber[2]; Alexander Ziegler[3]**

New Jersey Institute of Technology,Newark,USA[1]; Universitätsklinikum Münster,Münster,Germany[2]; Universität Bonn,Bonn,Germany[3]

The evolution of morphological diversity has been of interest to Biologists for decades. Insights of such diversity are heuristic when examined through form-function relationship contexts. Troglobitic animals often have derived nervous systems due to both constructive and regressive traits. Cavefishes are especially suited for comparative studies because a) all cavefish species have adapted to cave environments independently, b) many different groups of fishes have become cavefishes (such as catfish, loaches, tetras, etc.) c) cavefishes have been adapted to caves for a different amount of time and d) many of the surface ancestors are still extant. Furthermore, the environment of study (caves) is a particularly good setting because of the clear sensory pressure it exerts in its inhabitants: the lack of light. The most overt morphological feature of adult cavefishes is the lack of eyes and pigmentation. But other morphological differences arise from cave adaptation? Here we examine the changes in the head of the Mexican tetra Astyanax mexicanus. This fish provides a particularly good window into the adaptive changes in networks and behavior because it is undergoing allopatric speciation and is extant in two readily available forms: a visual river (surface) dwelling form and blind cave dwelling forms. We examined differences in soft and hard tissues that arise from cave adaptation and eye loss.

**Anatomy & Neuroanatomy**

Keywords :micromri; microct; cavefish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-06**
**Presentation Time: 16:00 to 17:00**

## FREEZING IN RESPONSE TO INESCAPABLE LOOMING STIMULI IS SEXUALLY DIMORPHIC

**Marta Moita[1]; Ricardo Zacarias[1]; Maria Vasconcelos[1]**

Champalimaud Foundation,Lisbon,Portugal[1]

The escape behaviour of Drosophila melanogaster can be triggered robustly by an overhead expanding shadow that simulates an object on a collision course (looming). Previous research has focused on the response to a single presentation of a looming stimulus. However, how a fly responds to a repetitive and unavoidable threat remains poorly understood. Therefore, we developed a behavioural assay, which aims at elucidating the mechanisms underlying defence behaviours of fruit flies in such circumstances. Single flies placed in an enclosed walking arena were exposed to multiple presentations of a looming stimulus. We found that flies jump, as previously described, often times repeatedly. However a large fraction of flies responded with sudden immobility, akin to the freezing responses extensively studied in rodents. Freezing could last for the whole duration of exposure to the repeated looming stimuli (i.e. 5 minutes). In addition, we found that the frequency of freezing responses was sexually dimorphic. Females flies were much more likely to freeze (~80%) than male flies (~50%). In both genders, flies that did not freeze increased the amount of time spent walking and their walking velocity. Finally, we hypothesized that flies will by default escape, but once they learn through exploration that there is no escape then they will freeze. Results from a series of experiments in our lab support this hypothesis.

### Behavioral Plasticity

Keywords :drosophila; defence responses; learning

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-07**
**Presentation Time: 17:00 to 18:00**

## HONEY BEES SHOW RESPONSES TO ALARM PHEROMONE THAT ARE FLEXIBLE YET CONSISTENT, AND CAN BE MIMICKED BY TREATING BEES WITH ALLATOSTATINS.

**Elodie Urlacher[1]; Jean-marc Devaud[2]; Alison Mercer[1]**

University of Otago,Dunedin,New Zealand[1]; UNIVERSITÉ TOULOUSE III - Paul Sabatier,Toulouse,France[2]

Guard bees release alarm pheromones when they perceive a threat, promoting the defense of the colony by recruiting and increasing aggressiveness of most nestmates. Alarm pheromone, or its main component isopentyl acetate (IPA), can promote stinging behavior, possibly by modulating the sensitivity of worker bees to noxious stimuli. Other less deadly consequences include an apparent impairment of the bees' ability to associate odors with a food reward, as well as a reduction of foraging activity. IPA can also induce opioid-like analgesia, and the vertebrate opioid receptor agonist, morphine, has been found to decrease both nociception and appetitive learning in bees. However, because of the high doses of opioid agonists that have to be employed, and because opioid-like peptides in insects have yet to be identified, the existence of an endogenous opioid system in insects is still debated. Nevertheless, similarities between opioid systems in mammals and potentially parallel systems in insects have been identified, in particular in relation to allatostatin receptors. Applying physiologically relevant doses of allatostatin neuropeptides adjacent to learning centers of the bee brain modifies appetitive learning in a similar manner to IPA exposure. Interestingly, responses to IPA and to allatostatins show plasticity. For example, learning impairment resulting from IPA exposure is not apparent in young bees reared in presence of queen mandibular pheromone. Whether effects of allatostatin in young worker bees can be modulated by queen mandibular pheromone is examined also in this paper.

### Behavioral Plasticity

Keywords :allatostatins; learning; memory

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-08**
**Presentation Time: 18:00 to 19:00**

## ROLE OF REPRODUCTIVE CONTEXT AND PUP DEVELOPMENT ON THE BEHAVIORAL FLEXIBILITY OF MOTHER RATS

**Natalia Uriarte[1]; Marcela Ferreño[1]; Sabrina Pose[1]; Daniella Agrati[1]; María JOSÉ Zuluaga[1]; Annabel Ferreira[1]; Mariana Pereira[2]**

Facultad de Ciencias,Montevideo,Uruguay[1]; University of Massachusetts,Amherst,USA[2]

During the postpartum period (PP), the rat (Rattus norvegicus) adapts her maternal behavior (MB) to the pups' changing needs. This behavioral plasticity is evident also under challenging conditions, as is the overlapping of litters, when as a result of mating at the postpartum estrus, mothers simultaneously take care of two successive litters in different developmental stages. We further analyzed MB during this reproductive context by comparing the relative incentive value of junior versus senior litters in a preference Y-maze and the MB in the home-cage, of rats exposed to different hormonal priming and pups traits: mothers with overlapping litters (OLM) (raising 2-4 and 22-24 days-old pups simultaneously), multiparous females in early PP (EPM, 2-4 days-old pups) and multiparous females in late PP (LPM, 22-24 days-old pups). Although OLM directed more effort in taking care of newborns –licked and nursed them more than juveniles-, they did not exhibit any preference in the Y-maze. Conversely, EPM strongly preferred the neonates over the juveniles, whereas OLM did not show any preference. Interestingly, OLM and EPM who experienced recent hormonal priming of gestation and parturition, made more effort to obtain the newborns compared to LPM. These results suggest that for OLM, juveniles and newborns have similar incentive values and therefore the low levels of MB toward juveniles represent a maternal adjustment to take care of "less demanding" pups. Thus, plasticity in maternal responses appears to be modulated by female endocrine status as well as by characteristics of the pups, impacting on the neural substrates involved in MB expression. Support: PEDECIBA, FCE-2014-1-104678.

### Behavioral Plasticity

Keywords :maternal behavior; pup stimuli; preference

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-09**
**Presentation Time: 15:00 to 16:00**

## YOU ARE WHAT YOU EAT: CANNIBALISM-MEDIATED NEUROMODULATION OF BEHAVIORAL PHASE TRAITS IN THE DESERT LOCUST

**Yaara Saad[1]; Daniel Knebel[1]; Moshe Guershon[1]; Amir Ayali[1,2]**

Tel Aviv University,Tel Aviv,Israel[1]; Sagol Interdisciplinary School of Neurosciences,Tel Aviv,Israel[2]

Desert locusts are known for their remarkable ability to alternate between two distinct behavioral phases- solitary and gregarious- depending on their population density. Gregarious locusts are attracted to each other and are notorious for aggregating into massive migrating swarms. Conversely, solitary locusts tend to actively avoid conspecifics, and exhibit distinct locomotion patterns. Here, we show for the first time that feeding solitary locusts with brains of gregarious locusts causes a shift in their behavior towards the gregarious phase. The consumption of other locusts' brain tissue is not an artificial manipulation, as ample research has documented the cannibalistic tendency of locusts in their natural environment. Our hypothesis is that cannibalism, in addition to contributing to nutritional protein balance, contributes to a behavioral phase shift, hence serving to maintain and enhance gregarious behavior in locust swarms. Our recent findings suggest that the locust brain contains a phase-specific neuromodulatory agent, which could be transferable between locusts and affect their behavior. Previous research into the neural substrates of locust phase change has revealed several candidates for such an agent, as it was shown that the brains of solitary and gregarious locusts differ in gene expression, neurotransmitter composition, and epigenetic regulation. Pinpointing the specific element which exerts its effect on cannibalizing locusts could have substantial implications for our understanding of the locust phase phenomenon, as well as for our wider understanding of horizontal transfer of behavioral traits between conspecifics.

### Behavioral Plasticity

Keywords :locusts; cannibalism; behavioral neuromodulation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-10**
**Presentation Time: 16:00 to 17:00**

## SPATIAL LEARNING IN KISSING BUGS: APPETITIVE AND AVERSIVE CONDITIONING

**Agustina Cano[1]; Nahuel Roldan[1]; Amorina Magallanes[1]; Romina Barrozo[1]; Sebastian Minoli[1]**

IBBEA, UBA-CONICET,Buenos Aires,Argentina[1]

Innate responses in animals can be modulated by experience. However, not much is known about the modulation of this behavior by non-associative and associative cognitive processes. Here we present evidences of the cognitive capacities of Rhodnius prolixus larvae in an aversive and appetitive context under different associative conditioning paradigms. The first conditioning protocol consisted in training the insects in an experimental arena which had two surfaces, one smooth and the other one wrinkled. When bugs walked in the side that was chosen as punished, they suffered a vibration which made them escape to the other side. Inmediately after this training the preference of insects to rest at one of the two sides of the arena was tested in the absence of punishment. In the second protocol, one of the sides of the same arena was instead rewarded, ie. the insect had access to a feeder containing an appetitive solution. Following the training, the preference of insects was tested as before. Insects don´t show an innate preference for any of the surfaces. However, after aversive conditioning, the insects showed a preference for the side of the arena that had not been punished. Similarly, although preliminary, under the appetitive conditioning protocol, bugs also preferred to rest at the rewarded side of the arena. R. prolixus was able to learn and memorize information of the spatial context under aversive and appetitive associative conditioning protocols. The behavior of these insects is plastic, allowing them to cope with changes in the environment.

### Behavioral Plasticity

Keywords :learning; plasticity; insect

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-11**
**Presentation Time: 17:00 to 18:00**

## HONEY BEE PUNISHMENT AND REWARD PATHWAYS: PRIOR EXPERIENCE ALTERS BIOGENIC AMINE LEVELS AND MODULATES SUCROSE RESPONSIVENESS

**Abby Finkelstein[1]; Colin Brent[2]; Martin Giurfa[3]; Gro Amdam[1,4]**

Arizona State University,Tempe,USA[1]; U.S. Arid Land Agricultural Research Center,Maricopa,USA[2]; CNRS - Université Paul Sabatier,Toulouse,France[3]; Norwegian University of Life Sciences,Aas,Norway[4]

Rewards and punishments guide the behavior of organisms as varied as nematodes, flies, and humans, often via signaling of the same biogenic amine molecules. The plasticity of reward and punishment responsiveness provides a rich substrate for behavioral variation. We are interested in how experience modulates biogenic amine pathways and sucrose responsiveness in Apis mellifera, an organism with demonstrated capacity for behavioral and neurochemical plasticity. Groups of caged honey bees were presented with scented feeders offering punishing (electric shock + sucrose) or rewarding (sucrose) foraging experiences. Control bees were presented with unscented feeders. To test the social transmission of foraging information, bees of the same behavioral phenotype were separated by mesh into two groups: feeder-foraging bees and bees fed via trophallaxis. Two days of treatment were followed by 3 days' rest before bees were pseudo-randomly selected to be flash-frozen or harnessed. Antennal lobes were dissected from frozen samples for HPLC analysis of biogenic amine levels, and harnessed bees were presented with increasing sucrose concentrations to quantify responsiveness. Scented sucrose reduced forager bees' sucrose responsiveness and antennal lobe octopamine levels, relative to unscented control. Electric shock eliminated both changes. Scent-paired electric shock increased antennal lobe serotonin relative to unscented control. In contrast, bees fed via trophallaxis showed unchanged responsiveness. Our work suggests that pairing of nectar scents with concurrent rewards or punishments causes long-term changes in foragers' responsiveness pathways. Bees acting as nectar receivers are not affected the same way. These results set the stage for investigating mechanisms underlying responsiveness plasticity.

### Behavioral Plasticity

Keywords :social insects; biogenic amines; plasticity

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-12**
**Presentation Time: 18:00 to 19:00**

## THE ROLE OF PH AND GABAERGIC SIGNALING IN DETECTION OF PREDATOR CHEMICAL CUES IN A LARVAL CRAB

**Corie L. Charpentier[1]; Jonathan H. Cohen[1]**

University of Delaware,Lewes,DE,United States[1]

Estuarine and coastal zooplankton experience daily fluctuations in pH, influenced by diel and tidal cycles. Increases in seawater acidity negatively impacted detection of predator chemical cues or kairomones in an ichthyoplankton, and previous work suggests that this change is due to reversed function of a gamma aminobutyric acid (GABA) neural signaling pathway. Here, we investigated the role of GABAergic signaling and the effect of pH on detection of kairomones in a crustacean zooplankton. Larvae of the Asian shore crab, Hemigrapsus sanguineus, exhibit descent responses following increases in downwelling light, as part of their predator avoidance behavior. After exposure to kairomones from fish, the lowest light level to induce a descent response, or behavioral threshold, decreases. We conducted photobehavioral assays in an apparatus that mimics the underwater light field to determine the behavioral threshold of larvae exposed to various pH and chemical treatments. Prior to experiments, larvae were acclimated to an ambient (8.1) or low pH (7.8) treatment for 12 h. In addition, we exposed larvae to either kairomones from fish, a GABA receptor inhibitor (gabazine), kairomones and gabazine, or no additional treatment (control) for at least 1 h. The behavioral threshold decreased after kairomone exposure in the ambient pH but not in the low pH treatment. When gabazine was added, the kairomone effect was reversed back to control levels. Our data suggest that decreases in pH that occur naturally over tidal cycles in estuarine/coastal systems and inhibition of GABAergic signals negatively impact this zooplankter's ability to detect predator kairomones.

### Behavioral Plasticity

Keywords :kairomones; gaba; acidification

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-13**
**Presentation Time: 15:00 to 16:00**

## PLASTICITY OF EXTERNAL SETAE DURING CLAW TRANSFORMATION IN THE SNAPPING SHRIMP, ALPHEUS ANGULOSUS

**Chris Korey[1]; Erica akhte[1]; Ariane Pereira[1]; Needhee Patel[1]; Kelsey Vollmer[1]; Melissa Hughes[1]**

College of Charleston,Charleston,United States[1]

The snapping shrimp, Alpheus angulosus, is a small crustacean with bilaterally asymmetric claws that serve distinct behavioral and sensory functions. If the large claw is lost, the organism switches handedness, transforming its small pincer claw into a large snapping claw while simultaneously developing a small claw on the contralateral side. To better understand the mechanisms required to adapt to this radical change in body composition, we examined developmental plasticity by tracing changes in sensory setae distribution on the claws throughout transformation. We observed only two broad types of setae, simple and plumose. Quantitative analysis across molt stages revealed significant alterations in setae composition and numbers that occurred primarily on the edge of the propodus, where the most drastic morphological changes also occur. Our quantitative approach has created a detailed map of how the setae of the large snapping claw emerge and proliferate during the transformation process. In addition to our map of setal plasticity, we will also present our preliminary neuroanatomical work that is beginning to elucidate the putative sensory neuroanatomy underlying the external setae of the small and large claw. The sensory nervous system undergoes a massive proliferation during transformation to support the different functional and behavioral roles of the new large claw. Connecting this proliferation event to external proliferation of setae would suggest that in addition to setal differentiation, new sensory neuron proliferation may also be occurring.

### Behavioral Plasticity

Keywords :snapping shrimp; setae; transformation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-14**
**Presentation Time: 16:00 to 17:00**

## BEHAVIORAL AND ANATOMICAL STUDIES OF DAILY RHYTHMS IN SOLITARIOUS AND GREGARIOUS DESERT LOCUSTS

**Evelyn Rieber[1]; Adrian Wroblewski[2]; Ronny Rosner[3]; Uwe Homberg[2]**

Johannes-Gutenberg University,Mainz,Germany[1]; Philipps-University,Marburg,Germany[2]; Newcastle University,Newcastle,Great Britain[3]

Exogenous environmental factors like daylight change with a period of 24-hours and influence the activity pattern of animals. In response to the 24-hour external periodicity, endogenously oscillating activity patterns with a period of about 24-hours (circadian) have been evolved in animals. Lesion experiments in flies and cockroaches showed that the accessory medulla (aMe), a small neuropil of the optic lobe, houses the internal pacemaker controlling circadian activity rhythms (Helfrich-Förster et al. 1998, Chronobiol Int 15:567). Until now no putative input fibers providing time information to the aMe have been found in the desert locust Schistocerca gregaria. Before searching for those fibers in locusts it is necessary to test under laboratory controlled conditions whether locusts show circadian activity rhythms. S. gregaria shows a prominent phase dimorphism: a gregarious and a solitarious phase. Anatomical and physiological differences between both phases have already been reported. To test for behavioral differences we recorded the locomotor activity patterns in both phases at 12:12 LD regimes and in constant darkness. Gregarious animals were more active during light than dark phases, and during constant darkness the animals showed periodic activity patterns with a period of nearly 24-hours (23±3h). In contrast, solitarious animals were predominantly active during dawn and the period of their activity phase was significantly lower (10±6h). Anatomical studies with antibodies against the neuropeptide orcokinin revealed a prominent fiber tract interconnecting distal parts of the optic lobe with the aMe. This tract might be a possible candidate for providing light information to the circadian system.

### Circadian Rhythms

Keywords :insects; locomotor activity; immunostaining

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-15**
**Presentation Time: 17:00 to 18:00**

## AGGRESSIVE BEHAVIOUR AND CIRCADIAN RHYTHMS: BEHAVIOURAL ANALYSIS IN THE LIZARD GONATODES ALBOGULARIS

**Iván Beltrán Arévalo[1]; Verónica Akle[1]; Adolfo Amezquita[1]**

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Several physiological and behavioural processes of vertebrates such as body temperature and locomotor activity are controlled by internal clocks of approximately 24 hours, commonly referred as circadian rhythms. The role of circadian rhythms on aggressiveness has received special attention in order to understand the physiological and environmental factors underpinning social interactions. In vertebrates, testosterone is positively associated with aggressive and dominant behaviour. Furthermore, as testosterone takes place in the development of sexual traits, it has been correlated with male ecological success. Most studies reporting diurnal variation in aggressive behaviour disregard the ecological implications of the variation in behaviour. Using behavioural, morphological and physiological approaches we evaluated diurnal variation in aggressive behaviour in the yellow-headed gecko Gonatodes albogularis under laboratory conditions. We found that males of this species are significantly more aggressive at midday suggesting the existence of physiological machinery that modulates the intensity of aggressive encounters through the day. Because aggressiveness was significantly correlated with Body Mass Index we suggest that energetic reserves should be more important during aggressive encounters than body size. The relationship between aggressiveness and testicle weight remains unclear for this species. However, our results supports the hypothesis that testosterone concentration in blood is not related to short-day-induced aggressive encounters. Similarly, our results suggest in G. albogularis males, gular patch traits, such as size and coloration, are not related to aggressiveness.

### Circadian Rhythms

Keywords :aggressiveness; lizards; circadian rhythm

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-16**
**Presentation Time: 18:00 to 19:00**

## CENTRAL VS. PERIPHERAL CIRCADIAN CONTROL OF OVIPOSITION IN DROSOPHILA MELANOGASTER.

**Paula Drausal[1]; Guadalupe Cascallares[2]; Sebastian Risau Gusman[2]; Pablo Gleiser[2]; M. Fernanda Ceriani[3]; D. Lorena Franco[1]**

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The circadian system allows synchronization of vital biochemical, cellular and physiological processes to cyclical environmental events in a wide array of organisms. The Drosophila circadian clock is controlled by interlocked transcriptional feedback loops present in neuronal and non-neuronal tissues. In Drosophila, the periodic egg-laying behavior, or oviposition, is one of the several physiological processes regulated in a circadian fashion. However, this rhythmic behavior is poorly studied and many important aspects related with the role of the molecular clock remain to be elucidated. To address the role of the molecular clock in the circadian control of egg-laying behavior we first turn to per and tim null mutants, which lack a functional clock. Interestingly, no rhythms in oviposition could be detected, in contrast to what was observed in wild type controls. Moreover, to study if this circadian behavior is centrally or peripheral regulated, we downregulated the expression of per exclusively in the brain. Preliminary experiments indicate that the central molecular clock is necessary for rhythmic oviposition, since a reduction of per levels exclusively in the brain induces arrythmicity.

### Circadian Rhythms

Keywords :oviposition; circadian rhythms; drosophila melanogaster

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-17**
**Presentation Time: 15:00 to 16:00**

## FREE RUNNING IN THE WILD: CIRCADIAN RHYTHMICITY IN ELECTRIC BEHAVIOR IN TWO SPECIES OF SOUTH AMERICAN WEAKLY ELECTRIC FISH

**Adriana Migliaro[1,2]; Ana Silva[1,2]**

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Gymnotus omarorum and Brachyhypopomus gauderio are nocturnal weakly electric fish from Uruguayan freshwaters that constantly emit the Electric Organ Discharge (EOD), which is an electric behavior modulated by social, perceptual, and motivational influences. Its basal rate (EOD-BR) is under control of a medullary pacemaker. Arousal in both species involves a melatonin-dependent nocturnal increase in EOD-BR, which is species-specific in amplitude and dynamics. We first evaluated the circadian nature of this nocturnal increase in EOD-BR by recording the EOD-BR of isolated animals of both species in controlled light and temperature conditions. Animals under a 12:12 light/dark photoperiod showed very strong daily variations in both EOD-BR and locomotor activity. When placed in constant darkness, EOD-BR maintains a circadian rhythmicity albeit shifted, showing a strong influence of environmental light. To confirm if this rhythm is expressed in nature, with animals exposed to natural environmental influences, we recorded the electric behavior in the wild in individuals of both species during 72hs. We found a consistent rhythm of EOD-BR with a sharp increase close to sunset and a gradual decrease during the night. Interestingly, this rhythm occurred despite the absence of environmental light changes, as animals are in constant darkness underneath aquatic plants in their natural habitat. These data suggest that other environmental cues, as temperature and social interaction, might be crucial for the entrainment of circadian rhythmicity in weakly electric fish.

### Circadian Rhythms

Keywords :electric fish; electric behavior; field study

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-18**
**Presentation Time: 16:00 to 17:00**

## CONTRIBUTION OF THE BMP PATHWAY TO THE OPERATION OF THE CIRCADIAN NETWORK IN ADULT DROSOPHILA

**Sofia Polcowñuk[1]; María Fernanda Ceriani[1]**

Fundación Instituto Leloir,Capital Federal,Argentina[1]

Circadian behavior is controlled by an endogenous clock that enables organisms to prepare for the changes that accompany the day-night cycles, driving various aspects of their physiology and activity. In Drosophila, this clock resides in about 150 neurons; among them, the sLNvs -that release the PDF neuropeptide onto other circadian clusters-, are particularly relevant to set the free-running period. To improve our understanding about the logic of the communication among different circadian clusters a number of years ago we carried out a miss-expression screen in the sLNvs. This approach uncovered a long period phenotype mutant that affected the levels of a positive regulator of the bone morphogenetic protein (BMP) pathway, a highly conserved retrograde signaling pathway that influences synaptic connectivity through transcriptional control. While activation of different members of the signaling cascade triggers a long period phenotype, downregulation of specific ligands (dpp, gbb, actb, scw, daw, myo and mav) in a broad circadian domain generates loss of rhythmicity. Taking advantage of genetic tools available we examined the spatial distribution of the different ligands. Cluster-specific downregulation also triggered loss of rhythmicity under constant conditions (DD). Interestingly, pan-circadian downregulation of actb also affected behavior under entrained conditions, in particular, altering evening anticipation. These results, coupled to a time-of-day-dependent detection of P-MAD –a bonafide readout of pathway activation- in defined circadian clusters opens the provocative possibility that the BMP pathway is recruited for fine tuning clock properties at specific times in the day.

### Circadian Rhythms

Keywords :bmp; behavior; drosophila

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-19**
**Presentation Time: 17:00 to 18:00**

## NON-LOCOMOTION DEPENDENT NOCTURNAL INCREASE IN THE ELECTRIC BEHAVIOR OF THE WEAKLY ELECTRIC FISH, GYMNOTUS OMARORUM

**María Moreno[1]; Adriana Migliaro[1,2]; Ana Silva[1,2]**

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Gymnotus omarorum is a nocturnal weakly electric fish that inhabits Uruguayan freshwaters and constantly emits an electric signal produced by the discharge of a specialized organ (the Electric Organ Discharge, EOD). This emission is part of a refined sensory system serving perceptual and communicative functions. The EOD is an electric behavior modulated by social, perceptual and motivational influences, and its basal rate (EOD-BR) is under the control of a medullary pacemaker. Arousal in this nocturnal species includes a nocturnal increase in EOD-BR together with an increase in locomotor activity subserving exploratory behavior, as observed in isolated animals in lab settings. We recorded the electric behavior in the wild to assess the influence of environmental circadian changes in photoperiod on EOD-BR. Fish were placed in floating nets under the natural vegetation during 72hs. We found a consistent rhythm of a EOD-BR sharp increase close to sunset with a gradual decrease during the night. In order to know if this natural EOD-BR increment was asociated to exploratory behavior we devised a semi-natural approach where EOD-BR was recorded only if animals were inside shelters and hence motionless. EOD-BR in immobile fish shows the same circadian changes observed in natural freely moving fish. Our data suggest that daily variations of EOD-BR represent a true circadian rhythm driven by an endogenous clock.

**Circadian Rhythms**

Keywords :electric organ discharge; eod rate; field study

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-20**
**Presentation Time: 15:00 to 16:00**

## PHEROMONE AUTODETECTION IN A NOCTUID MOTH: GC-EAD RESPONSE OF FEMALE PSEUDALETIA ADULTERA TO ITS OWN SEX PHEROMONE COMPONENTS

**Guillermo Rehermann[1]; Jeremy N. Mcneil[2]; Andrés González[1]**

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Pheromone autodetection, the detection of conspecific sex pheromones by females, has been reported in a small number of moth species, and it has been suggested that this allows a female to modulate the emission of sex pheromones in response to the presence of conspecifics. We demonstrated that in the presence of sexually mature conspecifics, females of the noctuid Pseudaletia adultera become sexually mature at a younger age, and spend more time calling than isolated individuals. In this study, using Gas Chromatograph-Electroantennogram Detector (GC-EAD), we show that female antennae, like those of males, respond to each of the three main sex pheromone components:
(Z)-11-hexadecen-1-ol, (Z)-11-hexadecen-1-yl-acetate and (Z)-11-hexadecenal. However, while the major component of the female sex pheromone, (Z)-11-hexadecen-1-ol elicits the strongest male EAD responses, the minor pheromone components elicited the highest responses in females. These findings support the hypothesis that P. adultera are capable of autodetection. A number of potential benefits of autodetection have been postulated, included the detection of closely related sympatric species that use similar pheromone components. Pseudaletia sequax, a sympatric species, has the same pheromone components as P. adultera although in this case the acetate and the aldehyde components are at higher relative concentrations than the alcohol. The high sensitivity to the minor components of its own pheromone could allow P. adultera females to avoid areas where P. sequax occurs at high densities and thus reduce the possibility of interspecific mating.

### Communication

Keywords :sex pheromones; autodetection; electroantennography

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-21**
**Presentation Time: 16:00 to 17:00**

## INVITATION BY VIBRATION: SOCIAL CATERPILLARS USE VIBROACOUSTIC SIGNALS TO ADVERTISE 'ACCOMMODATIONS' TO POTENTIAL SHELTER MATES

**Chanchal Yadav[1]; Sarah Matheson[1]; Jayne Yack[1]**

Carleton University,Ottawa,Canada[1]

Group-living is widespread among larval insects. While the benefits of such groups are widely recognized, less is known about the proximate mechanisms mediating group formation and maintenance. Our study tests the hypothesis that caterpillars use vibroacoustic signals to attract conspecifics to social groups. Early instar caterpillars of the masked birch caterpillar (Drepana arcuata) (Drepanoidea) live gregariously in silk shelters on birch leaves, but how these caterpillars, the size of a pinhead at hatching, locate one another, is unknown. We provide experimental evidence for the following: 1. Caterpillars actively select shelters occupied by conspecifics; 2. Four distinct vibratory signals (buzz scrape, mandible scrape, mandible drum and anal scrape) are generated during different stages of joining events: anal scraping and buzz scraping signals are used to 'advertise' a quality shelter and feeding site to potential recruits, whereas additional signal components (mandible drumming and scraping) are incorporated as 'beckoning' signals as recruits visit a shelter. 3. In addition to functioning in group formation, these complex signals are believed to play roles in spacing, cohesion, and task division once groups are formed. These results provide the first evidence that caterpillars use vibratory signalling to form social groups. Moreover, the signalling repertoires of these caterpillars change as 'social' early instars develop into 'solitary' late instars. Some of the proposed sensori-motor and genetic mechanisms associated with these developmental changes will be discussed.

### Communication

Keywords :vibroacoustics; social; proximate mechanisms

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-22**
**Presentation Time: 17:00 to 18:00**

## ODOUR ODDITY: FEMALES RECOGNIZE CONSPECIFIC MALES BASED ON OLFACTORY CUES IN AN ANNUAL FISH WITH INTENSE SEXUAL SELECTION

**Federico Reyes[1]; Carlos Passos[1]; Bettina Tassino[1]**

Sección Etología, Facultad de Ciencias, Universidad de la República,Montevideo,Uruguay[1]

Mate choice decisions are usually based on information collected through a sort of sensory modalities. Most fish rely though on visual and olfactory traits to reproduce. Annual fish inhabit temporary ponds that dry out seasonally. Austrolebias reicherti is an endemic species of Uruguay`s eastern wetlands, which is parapatrically distributed with its sister species A. charrua. Reproductive isolation between this species is mainly maintained by the mating preferences of the females. A. reicherti females coming from parapatric areas discriminate for conspecifics males. Herein, we assessed whether A. reicherti females have the capability to recognize conspecific males through different sensory modalities.

Fifteen females were individually assessed for mating preference in standard dual choice experiments consisting in an aquarium divided in three compartments: a large central female compartment and two lateral compartments, one for the conspecific and the other for the heterospecific male. Side allocation was randomized. Different partitions were placed between female and males compartments so to allow -or prevent- the exchange of certain cues. Hence, females were sequentially assessed in three experiments: a) only visual cues, b) only olfactory cues, and c) both visual and olfactory cues. Presentation order effects were controlled. Interestingly A. reicherti females were able to discriminate for conspecifics based only on olfactory cues. Females did not discriminate when visual information was available, though a methodological artefact cannot be ruled out to affirm “blindness” in species recognition in this species. Overall, these results suggest the importance of chemical communication in species recognition and female choice in A. reicherti.

### Communication

Keywords :species recognition; chemical communication; sexual selection

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-23**
**Presentation Time: 18:00 to 19:00**

## SIGNALS OF ELECTRIC FISH ENCODE DIFFERENT TRAITS UNDER DIFFERENT FOOD REGIMES

**Philip Stoddard[1]; Sat Gavassa[1]**

Florida International University,Miami,33199[1]

We know a lot about how electric fish signals are generated and regulated, but very little about what socially relevant information is encoded or extracted during communication. Females of the Uruguayan gymnotiform electric fish Brachyhypopomus gauderio prefer to mate with males of greater body length, and body length determines the outcome of territorial contests among breeding males. Accordingly males engage each other based on electric signal amplitude when no other information about body size is available. We find that changes in food availability shift the meaning of male signal amplitude. When food is scarce, signal amplitude encodes body length, with larger signals indicating larger body size. However, when food is abundant, signal amplitude no longer encodes body length, but instead encodes body condition, with larger signals indicating higher body condition but not greater body length. B. gauderio is a short-lived species, never surviving longer than one year in the wild. When food is abundant, males are capital signalers, investing energy in signals when fat reserves are high, and cutting back on signal amplitude when fat reserves are low. However, when food is scarce their survival is threatened, and males allocate all their energy to signaling in one last burst of reproductive effort (terminal investment). At that time, males increase their signal amplitudes to the maxima allowed by electric organs of a given length, and thus signal amplitude accurately predicts body length. In this way, food scarcity shifts the meaning of male signal amplitude from body condition to body length. Supported by NSF IOS-1457173

**Communication**

Keywords :gymnotiform; communication; signal reliability

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-24**
**Presentation Time: 15:00 to 16:00**

## EXPERIENCE WITH SOCIAL SIGNALS MODIFIES PERIPHERAL AUDITORY PROCESSING IN GREEN TREEFROGS (HYLA CINEREA)

**Walter Wilczynski[1]; Megan D. Gall[2]**

Georgia State University,Atlanta,USA[1]; Vassar College,Poughkeepsie,USA[2]

Individuals breeding in communal assemblies such as frog choruses hear multiple vocalizing males for an extended time. We tested whether experience hearing chorus sounds modifies peripheral auditory response properties in green treefrogs. Individuals were exposed for ten nights to chorus sounds constructed from individual treefrog calls, or a control stimulus of random tones. Frequency sensitivity was assessed before and after the ten days of acoustic stimulation using evoked potentials. We also assessed forward masking of a 90dB target stimulus by tones at amplitudes from 60 to 90 dB and interstimulus intervals from 2.5 to 50 ms before and after the acoustic exposure. Hearing the chorus stimulus, but not the tone control, significantly lowered peripheral auditory thresholds overall, and enhanced suprathreshold responses to low frequencies. When the masker and target stimulus were presented at the same amplitude the response to the target stimulus decreased with decreasing interstimulus intervals both before and after hearing chorus sounds or control. However, animals exposed to the ten nights of chorus sounds, but not to the control tone stimulus, showed reduced forward masking. Our results add to a growing body of work indicating that the auditory periphery is much more plastic than often assumed. Experience with social signals can modify the ear's response properties to increase its sensitivity to conspecific acoustic communication signals, and enhance its ability to detect them against the background noise of a breeding chorus.

**Communication**

Keywords :amphibian, acoustic communication, peripheral auditory system, masking, plasticity; ;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-25**
**Presentation Time: 16:00 to 17:00**

## NEURAL MECHANISMS IN ACOUSTIC COMMUNICATION AND EMOTION: THE BASOLATERAL AMYGDALA OF BATS AND MICE

**Sharad Shanbhag[1]; Marie Gadziola[1]; Emily Hazlett[1]; Jasmine Grimsley[1]; Jeffrey Wenstrup[1]**

Northeast Ohio Medical University,Rootstown,USA[1]

Based on its central roles in establishing associations between sensory cues and biologically important events and in orchestrating emotional responses, the amygdala likely serves an important function in acoustic communication. Here we summarize recent studies that focus on responses to vocal communication sounds in the basolateral amygdala (BLA) in two species of bat [mustached bats (Pteronotus parnellii), big brown bats (Eptesicus fuscus)] and mice (Mus musculus, CBA/CaJ). Across these species, a substantial number of neurons display a high degree of selectivity for particular vocalization syllables or syllable sequences. An exception to this finding is a population of neurons in the big brown bat. Here, the degree of responsiveness to vocalizations was related to background discharge rate. Neurons with low background discharge (<=1 Hz) comprise about half of BLA neurons in bats, mice, and also rats. In the big brown bat, these display highly selective responses to vocalizations. Neurons with high background discharge are, in these bats, highly responsive to vocal stimuli. We speculate that background discharge may be a key to understanding vocalization responses in other species. A second major result is that, in both bats and mice, temporal patterns of neural activity provide information about the identity and emotional valence of acoustic stimuli. Overall, these species comparisons suggest common functional principles by which BLA neurons analyze social vocalizations. Supported by NIH grant R01-DC00937.

### Communication

Keywords :vocal communication; amygdala; emotion

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-26**
**Presentation Time: 17:00 to 18:00**

## COURT AND SPARK IN THE WILD: COMMUNICATION AT THE LIMITS OF SENSATION

**Joerg Henninger[1]; Frank Kirschbaum[2]; Jan Grewe[1]; Rüdiger Krahe[3]; Jan Benda[1]**

Eberhard Karls Universität,Tübingen,Germany[1]; Humboldt-Universität zu Berlin,Berlin,Germany[2]; McGill University,Montreal,Canada[3]

The active electrosensory system of Neotropical weakly electric fish is used for electrolocation of objects and for communication. Electrocommunication signals like chirps are brief frequency modulations of the periodic electric organ discharges (EOD) of Apteronotus species. These signals have been studied in detail in the lab, but their meaning is still debated. We developed a submerged multi-electrode array and tracked communication behavior of A. rostratus in their Neotropical habitats in Panama with high spatio-temporal resolution. This big-data approach allowed us to clearly link signals to behavior. Highly stereotyped patterns of small chirps leading up to a long chirp emitted exclusively by the female synchronized spawning in courting dyads. The sub-second precision of male echo responses in these interactions and their importance for reproduction is contrasted by a surprisingly weak activation of the electrosensory system because of frequency mismatch arising from sexual dimorphism in EOD frequency. On the other hand, electrocommunication in same-sex aggressive encounters matches frequency tuning of receptor neurons well but occurs at distances of up to 1.7?m where electric signals decayed down to the microvolt range. Our field data thus point to an unexpected violation of the efficient coding hypothesis and to computational challenges faced and solved by sensory systems at the limits of sensation. Our results on natural stimulus statistics demonstrate that a much larger stimulus space has to be probed in further physiological studies on the communication aspects of the electrosensory system.

### Communication

Keywords :electric fish; communication; optimal coding

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-27**
**Presentation Time: 15:00 to 16:00**

## EFFECTS OF PHYSICAL LOAD ON DECISION-MAKING AND ACTIVITY OF SEROTONERGIC NEURONS IN THE SNAIL LYMNAEA STAGNALIS

**Varvara Dyakonova[1]; Tatiana Korshunova[1]; Dmitry Vorontsov[1]; Taisia Dyakonova[1]**

Institute of Developmental Biology, RAS,Moscow,Russia[1]

The benefits of physical exercise for brain functions have been demonstrated in humans and rodents. One of the most firmly established effects is serotonin-mediated improvement of depression symptoms, including the facilitation of decision-making. Here we show that preceding intense locomotion can facilitate the decision-making in a vital situation in the mollusc Lymnaea stagnalis. Snails, normally living in water, were put into a square asymmetrically lightened arena on a flat dry surface which aimed to simulate a rare, although not impossible for a snail, risky event of getting out of water. In the test arena, snails demonstrated two clearly distinct phases in behavior: 1) slow rotation, repeated changes of movement direction and 2) intense cyclic locomotion in chosen direction. We interpret this behavior as the transition from uncertainty to decision making. Snails which were previously forced to use intense locomotion (2 hours in 1 mm layer of water, n=48) demonstrated faster onset of movement, made less turns in the first phase and earlier reached the border of arena, than the control (2 hours in 9 cm layer of water, n=65). Intense locomotion produced also strong excitatory effect on the serotonergic pedal cells. The effects remained highly significant even after complete isolation of neurons. In other words, a single isolated serotonergic neuron appears to keep the memory of a recent behavioural state connected with physical exercise. Our data suggest that the effects of motor activity on serotonergic system and the decision-making might be the evolutionary conserved phenomena. RFBR grants 14-04-00875, 14-04-00537

### Decision Making

Keywords :serotonin; mollusk; neuromodulation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-28**
**Presentation Time: 16:00 to 17:00**

### NOVELTY-INDUCED HYPOFAGIA IN PIGEONS (COLUMBA LIVIA): DESCRIPTION OF BEHAVIORAL RESPONSES, THE EFFECTS OF RE-EXPOSURE AND SEX DIFFERENCES.

**Mauro Federico Ramirez[1]; Marina Bacha Nascimento[1]; Fernando Falkenburger Melleu[1]; José Marino-neto[1,2]**

Department of Physiological Sciences, CCB, UFSC,Florianópolis,Brazil[1]; Institute of Biomedical Engineering, EEL-CTC, UFSC,Florianópolis,Brazil[2]

Novelty-induced hypophagia has been studied in mammals to examine stress-induced anxiety-related behaviors. However, there are few studies in birds. In this work, we have submitted 12 pigeons (Columba livia, 6 males and 6 females) to a 4-hour fasting, and then to an unknown environment (UE) containing a known palatable food for 3 times (7-days apart, for 30 min), measuring the latency to the first ingestive event, as well as duration and frequency of feeding, exploratory/locomotor, vigilance and maintenance behaviors. We compared these data for the effects of 3 repetitions and for sex differences. Significant decreases in the latency for eating in the second and third exposure were observed. Temporal analysis revealed that different strategies are used by males and females to deal with a novelty and to reach satiety. An inverse relationship between exploratory behaviors and food intake was observed in all sessions, so that even in the first session, the animals first eat to satiety and then start exploring the environment. In conclusion, our data indicate that these birds use active and rapid decision-making strategies of prandial behavior in unfamiliar environments. Once taken the decision to start eating, these behaviors prevail over exploratory behavior even in unfamiliar surroundings, and environmental exploration only return at the end of satiation process. These strategies may allow these animals to deal effectively with changing environments such as urban environments.

**Decision Making**

Keywords :novelty-induced hypofagia; pigeons; prandial behaviors

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-29**
**Presentation Time: 17:00 to 18:00**

## APPETITIVE FLORAL ODOURS PREVENT AGGRESSION IN HONEYBEES

**Nouvian Morgane[1,2]; Lucie Hotier[1]; Charles Claudianos[2,3]; Martin Giurfa[1]; Judith Reinhard[2]**

Paul Sabatier University / CNRS,Toulouse,France[1]; University of Queensland,Brisbane,Australia[2]; Monash University,Melbourne,Australia[3]

Honeybees defend their colonies aggressively against intruders, and release a potent alarm pheromone to recruit nestmates into defensive tasks. The effect of floral odours on this behaviour has never been studied, despite the relevance of these olfactory cues for the biology of bees. Here we use a novel assay to investigate social and olfactory cues that drive defensive behaviour in bees. We show that social interactions are necessary to reveal the recruiting function of the alarm pheromone and that specific floral odours – linalool and 2-phenylethanol – have the surprising capacity to block recruitment by the alarm pheromone. This effect is not due to an olfactory masking of the pheromone by the floral odours, but correlates with their appetitive value. In addition to their potential applications, these findings provide new insights about how honeybees make the decision to engage into defence and how conflicting information affects this process.

### Decision Making

Keywords :alarm pheromone; defensive behaviour; contextual cues

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-30**
**Presentation Time: 18:00 to 19:00**

## OBJECT DETECTION IN ELECTROSENSORY LEARNING: THE ACTION-PERCEPTION LOOP IN GNATHONEMUS PETERSII

**Federico Pedraja[1]; Volker Hofmann[1]; Damaris Klocke[1]; Jacob Engelamann[1]**

Universität Bielefeld,Bielefeld,Germany[1]

Action and perception form an interactive process during which the corollaries of the ongoing behavior alter the sensory signals that in turn can be used to modify the motor response. In this context learning may be defined as the adaptive adjustment of sensorimotor patterns to efficiently disambiguate or maximize the information necessary for successfully solving a specific task. We here use weakly electric Mormyrid fish to address how sensorimotor interactions change with learning and how these changes shape the sensory input. Gnathonemus petersii (N=3) were trained in a "go vs no-go" paradigm in which they needed to swim towards a metal cube and pass a decision line to receive a reward. We analyzed the electromotor behavior for three phases of the psychometric function ("beginning", "acquisition" and "plateau"). During and after learning the number of turns towards the object was elevated, indicating an increased precision in the localization of the target. This was accompanied by systematic changes in the motor repertoire and sampling behavior. While the EOD-discharge pattern became more regular, the sampling density (EOD.cm-1) increased in the vicinity of the target. Together these data show a consistent adaption of the electromotor behavior with leaning. Presently we are investigating which sensory corollaries emerge from these changes and, more specifically, which aspects of the electrosensory flow are enhanced by them. Combining the quantitative behavioral analysis with the computational reconstruction of the sensory input will enable us to identify sensory features required for decision making, that are actively enhance by the electromotor adaptations.

### Decision Making

Keywords :electroreception; action-perception loop; learning

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-31**
**Presentation Time: 16:00 to 17:00**

## PREDATORS INHIBIT BRAIN CELL PROLIFERATION IN NATURAL POPULATIONS OF ELECTRIC FISH, BRACHYHYPOPOMUS OCCIDENTALIS

**Kent Dunlap[1]; Alex Tran[2]; Michael Ragazzi[1]; Rudiger Krahe[2]; Vicki Salazar[3]**

Trinity College,Hartford,USA[1]; McGill University,Montreal,Canada[2];Cape Breton University,Sydney,Canada[3]

In the laboratory, predatory stimuli tend to inhibit brain cell proliferation often via elevating plasma glucocorticoids. However, it is unknown how natural predators affect cell proliferation or whether glucocorticoids mediate the neurogenic response to natural predators. We examined brain cell proliferation in six populations of the electric fish, Brachyhypopomus occidentalis, exposed to three forms of predator stimuli: a) natural variation in the density of predatory catfish, b) tail injury, presumably from predation attempts, and c) the acute stress of capture. Populations with higher predation pressure had lower density of proliferating (PCNA+) cells, and fish with injured tails had lower proliferating cell density than those with intact tails. When we controlled for genetic and environmental divergence among populations by comparing populations within a drainage, high predator populations still had lower rates of brain cell proliferation. However, plasma cortisol did not vary at the population-level according to predation pressure or at the individual level according to tail injury. Capture stress significantly increased cortisol, but only marginally decreased cell proliferation. Thus, it appears that the presence of natural predators inhibits brain cell proliferation, but not via mechanisms that depend on changes in basal cortisol levels. This study is the first demonstration of predator-induced alteration of brain cell proliferation in a free-living vertebrate.

### Ecology

Keywords :predators; neurogenesis; electric fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-32**
**Presentation Time: 15:00 to 16:00**

## THE TRANSCRIPTIONAL BASIS OF DIVERGENT ELECTRIC ORGAN DISCHARGES IN PARAMORMYROPS ELECTRIC FISH

**Mauricio Losilla[1]; Jason Gallant[1]**

Michigan State University,East Lansing,United States[1]

Interspecific differences in electric organ discharges (EODs) are strongly related to patterns of species divergence in African mormyrid electric fish. An ideal genus for understanding this relationship is that of Paramormyrops, an instance of a so-called "species-flock" that has diverged rapidly over a relatively restricted geographic area.

EOD variation among Paramormyrops embodies three of the most important and widespread aspects of EOD waveform variation among mormyrids: duration, waveform complexity and polarity. In this study, we have sequenced and assembled whole transcriptomes from the electric organs (EOs) of 11 wild-captured Paramormyrops individuals: five P. kingsleyae (three biphasic and two triphasic EODs), four P. magnostipes (two Type I and two Type II polarity), and two P. SN3 (very short EODs). Comparison between groups of individuals allows five independent pairwise comparisons with biological replication to rigorously examine patterns of differential gene expression associated with the evolution of divergent EOD waveform patterns in Paramormyrops. We hypothesize that (1) differential gene expression of cytoskeletal genes are associated with changes in waveform complexity and polarity and (2) that differential expression of ion-channel encoding genes (particularly Na+ and K+ channels) are related to differences in EOD duration. Identification of differentially expressed genes related to specific EOD differences will greatly facilitate the ability to determine the genomic basis of EO evolution. This work is supported by National Science Foundation Grant (NSF) 1455405.

### Evolution

Keywords :differential gene expression; transcriptome assembly; mormyridae

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-33**
**Presentation Time: 16:00 to 17:00**

## THE GENOMIC BASIS OF SIGNAL COMPLEXITY IN PARAMORMYROPS ELECTRIC FISH

**William Pitchers[1]**

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The mormyrid electric fish genus Paramormyrops is a rapidly diverged species flock endemic to West-Central Africa. The rapid speciation of Paramormyrops spp. is thought to have been facilitated by evolution of electric organ discharges (EODs). EODs signals vary widely among mormyrids, but appear to be species-specific, and have been shown to function in species recognition and mate choice. A key aspect of signal variation is in waveform complexity: Paramormyrops and other mormyrid EOD waveforms are typically bi- or triphasic. The differences in complexity are predicted by cellular morphological differences in the electric organ. The recent discovery of polymorphism for waveform complexity in the species Paramormyrops kingsleyae, together with an assembled P. kingsleyae genome, enabled us to use population genomics to identify genetic loci that are associated with this trait. We sequenced whole genomes from 63 individuals, at 8x coverage, from 6 populations of P. kingsleyae. Populations represented were either (1) wholly bi-phasic or (2) wholly tri-phasic, or (3) occurring along a “hybrid zone” where both P. kingsleyae signal morphs co-occur. By calculating genome-wide pairwise divergence statistics between pairs of populations across the assembled genome, we were able to identify regions of the genome associated with the switch between biphasic and triphasic EOD waveforms. Given role of EOD waveform diversity in the evolution of prezygotic isolation , such regions may be candidate “speciation genes” involved with the rapid radiation of Paramormyrops. This work was supported by the NSF (#1455405).

**Evolution**

Keywords :electric fish; adaptive radiation; genomics

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-34**
**Presentation Time: 17:00 to 18:00**

## EVOLUTION OF BILATERAL TOPOGRAPHY IN THE MAMMALIAN NEOCORTEX.

**Rodrigo Suárez[1]; Annalisa Paolino[1]; Peter Kozulin[1]; Laura Morcom[1]; Laura Fenlon[1]; Nyoman Kurniawan[1]; Linda Richards[1]**

The University of Queensland,Brisbane,Australia[1]

Left-right integration of the cerebral cortices is essential for sensorimotor, associative and higher cognitive functions. In placental mammals, this is achieved via a precise map of interhemispheric cortical connections conveyed through the corpus callosum, the largest axonal tract in the human brain. Features of neocortical connectivity between hemispheres in placentals include point-to-point connections between homotopic regions, hyperconnected regions, as well as a topographic segregation of axons along the tract that recapitulate neuronal birthdate and somal position between and within layers. However, although monotremes and marsupials have a well-developed neocortex they lack a corpus callosum, therefore it is unclear whether the placental map of bilateral connectivity originated before or after callosal evolution. Here we show that an ancient map of bilateral cortical connections arose in early mammals, at least 80 million years before the origin of the corpus callosum. By combining diffusion tensor imaging, axon tracing and electroporation of fluorescent constructs in monotremes and marsupials, we found that the organisation of interhemispheric axons along the tract recapitulates position and birth-date of neurons. Moreover, bilateral circuits include homotopic connections between corresponding cortical areas and hyperconnected hubs in the cingulate and insular cortices. Our findings demonstrate the wide conservation of a mammalian bilateral connectivity map despite lineage-specific differences in axonal routes. This suggests that the origin of the corpus callosum involved exaptation of pre-existing mechanisms of axon guidance, targeting and circuit maturation required to form such precise bilateral map. Moreover, they suggest that general rules of neocortical wiring and plasticity might be conserved across all extant mammals.

### Evolution

Keywords :corpus callosum; topographic maps; marsupials

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-35**
**Presentation Time: 18:00 to 19:00**

## GENETIC DRIFT AND NATURAL SELECTION AS DRIVING FORCES IN THE EVOLUTION OF ELECTRIC SIGNALS IN WEAKLY ELECTRIC FISH

**Rüdiger Krahe[1]; Sophie Picq[1,2]; Alex Tran[1,2]**

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The diversity of communication signals is usually assumed to have been shaped by selective forces. The null hypothesis of divergence through genetic drift is often not considered.

The Panamanian weakly electric fish, Brachyhypopomus occidentalis, offers an excellent opportunity to study the role of various factors in shaping the divergence of their electric signals. Multiple independent drainage systems provide a natural evolutionary laboratory for the study of genetic and signal divergence. Evaluating the genetic divergence of B. occidentalis, we found that their evolutionary history is mainly driven by drift, through vicariance and isolation of drainages. We then quantified geographic variation in the waveform of their electric signals to test whether signal variation could be explained by stochastic divergence. Our results are consistent with a major role of genetic drift. Significant differences at smaller spatial scale, i.e., within drainage, suggested, however, that electric signals can also evolve faster than expected under drift alone. A prime candidate for an additional factor in waveform evolution is predation by electroreceptive catfish. Within-drainage comparisons showed that fish from populations with stronger electroreceptive predation produce signals that are harder to detect by electroreceptive predators. Our data provide the first evidence from natural populations for a role of predation in shaping electric signal properties, but support genetic drift as the dominant factor in the evolution of electric signal waveform at a larger geographic scale.

**Evolution**

Keywords :geographic variation; communication signals; predation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-36**
**Presentation Time: 15:00 to 16:00**

## TRAINING INTENSITY DURING SEQUENTIAL CONTEXTUAL FEAR CONDITIONING MODIFIES THE RATE OF SYSTEMS CONSOLIDATION AND MEMORY QUALITY: IMPLICATIONS FOR CONSOLIDATION OF MULTIPLE MEMORY TRACES

**Lizeth Pedraza CORREA[1]; Rodrigo Sierra ORDOÑEZ[1]; Ana Crestani[1]; Jorge Quillfeldt[1]; Lucas De Oliveira Alvares[1]**

Systems memory consolidation has been considered a time-dependent memory reorganization where memories initially require the hippocampus for retrieval. However over time, this structure is no longer involved in the expression of remote memories. Systems consolidation has been studied by exposing animals to one task and testing memory performance and hippocampal or cortical dependency in different periods after acquisition. Compared to real life situations in which memories are formed based on multiple past experiences, this one task approach could be insufficient to characterize the mnemonic process occurring during systems consolidation of multiple memory traces. The objective of the present study was to investigate hippocampal dependency and memory precision during sequential contextual fear conditioning using different training intensities in Wistar rats. We found that two sequential learnings with high training intensity accelerate the decay of hippocampal dependency and promotes memory generalization of the first learning, however the second learning maintains both hippocampal dependency and precision. Interestingly, the Anterior Cingulate Cortex is recruited for retrieval of the first and second learning, 15 days but not 10 days after training, supporting the acceleration rate of systems consolidation. The increased rate of systems consolidation in high intensity protocol was prevented by periodical memory reactivation. Our results suggest that training intensity during sequential learning could modify the rate of systems consolidation and the organization of multiple memory traces in the brain.

**Learning & Memory**

Keywords :systems memory consolidation; hippocampal dependency; sequential contextual fear conditioning

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-37**
**Presentation Time: 16:00 to 17:00**

## ACUTE STRESS IN NEOHELICE GRANULATA IMPAIRS MEMORY RETRIEVAL BUT NO MEMORY RE-ACTIVATION.

**Heidi González[1]; Francisco Maza[1]; Alejandro Delorenzi[1]**

Laboratorio de Neurobiología de la memoria, DFBMC, FCEN, Universidad de Buenos Aires. IFIBYNE-CONICET.,Ciudad Autónoma de Buenos Aires,Argentina[1]

Stress alters adaptive behaviours including memory processes. Canonical views describe that stressful events can enhance memory consolidation but impair memory recall. However, our previous results showed that memory reactivation can occur even if memories are behaviorally unexpressed. The goal of this work is to find evidence to support that even in the absence of expression caused by an stressful event, memories can be reactivated. We focus on how an environmentally relevant stressor, in this case immobilization, could alter retrieval in Neohelice granulata. Our preliminary results show that crabs have impaired performance in a reminder session after being inmovilized for 45 min but this stress did not disrupt memory reactivation because retention was disclosed 24 hr after. To test the success of immovilization as a stressful condition we will evaluate whether it produces a detectable increment of glucose in hemolymph. To show whether stressed animals can reactivate memory independently of its expression we will study HSP70 expression, which have been shown to increase in the crab´s protocerebrum after memory reactivation. Our hypothesis proposed that stress would only affect the memory expression but not its reactivation and labilization, and, in this particular case of stress by immobilization, suggests that the retention impairment is directly related to the stress state of the crab.

**Learning & Memory**

Keywords :stress; memory; retrieval

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-38**
**Presentation Time: 17:00 to 18:00**

## THE ROLE OF DOPAMINE AND OCTOPAMINE IN ASSOCIATIVE LEARNING OF THE PARASITIC WASP NASONIA VITRIPENNIS: EFFECTS OF ANTAGONISTS

**Hans Smid**[1]

Wageningen University,Wageningen,The Netherlands[1]

Reinforcement in associative learning in insects is thought to be mediated by dopaminergic neurons in the case of punishment and by octopaminergic neurons in the case of reward. Recent studies in flies, however, showed that dopaminergic neurons were involved in mediating the reward as well, and only acquisition of short lasting memory required octopaminergic signaling. This raises the question whether flies are different from bees and crickets is this aspect, or that differences in methodology underlie this variation. We investigated the role of dopaminergic and octopaminergic signaling in an appetitive conditioning paradigm in the parasitic wasp Nasonia vitripennis. Parasitic wasps lay their eggs in host insects and the developing wasp larvae eventually kill the host. In our study, the encounter of a host and subsequent parasitization was used as a reward in an olfactory conditioning paradigm. N. vitripennis is known to form long term memory after a single conditioning trial. We used the octopamine receptor antagonist mianserin and the dopamine receptor antagonist fluphenazine to study the role of the two signaling pathways. The antagonists were fed to the wasps directly before conditioning, and memory retention was measured at various times after conditioning up to 5 days. Our results show that both antagonists inhibit the formation of memory in N. vitripennis, suggesting that dopamine is involved in reward processing in parasitic wasps.

### Learning & Memory

Keywords :dopamine; octopamine; memory

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-39**
**Presentation Time: 18:00 to 19:00**

## AVERSIVE AND APPETITIVE MEMORIES COMPETE DURING RETRIEVAL IN THE CRAB NEOHELICE.

**Martin Klappenbach[1,2]; Ayelén Nally[1,2]; Fernando Locatelli[1,2]**

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In contrast to experimentally controlled situations, animals in nature might be exposed to contradictory information. Situations or places might predict simultaneous desired and undesired consequences. However, at some point the situation has to be categorized as appetitive or aversive, in order to decide if repeat or avoid it in the future. How contradictory information is integrated and how it affects learning and memory has not been yet extensively studied. In the present work we took advantage of the well described aversive and appetitive learning paradigms in the crab Neohelice to explore learning after simultaneous appetitive and aversive experiences associated to the same context. First, we found that two parallel memory traces are formed after simultaneous appetitive and aversive training. Second, we found that the probability to express none, one or both learned behaviors depend on the balance between the relative strength of the aversive and appetitive unconditioned stimuli, thus revealing a mutual interference under certain conditions. Finally, we found that the mentioned interference does not occur during learning or memory formation, rather during memory retrieval. These results suggest that both memories can be retrieved upon presentation of the conditioned stimulus, but the access of memory to behavior might be modulated based on specific demands at the moment of retrieval.

### Learning & Memory

Keywords :learning; invertebrates; memory

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-40**
**Presentation Time: 15:00 to 16:00**

## EXPERIENCE DURING ADULT BRAIN MATURATION IS REQUIRED FOR THE DEVELOPMENT OF COMPLEX COGNITIVE CAPACITIES IN HONEY BEES

**Amélie Cabirol[1,2]; Andrew Barron[2]; Jean-Marc Devaud[1]**

Research Center on Animal Cognition, Center for Integrative Biology, Toulouse university, CNRS,Toulouse,France[1]; Macquarie university, Department of biological sciences,North Ryde,Australia[2]

During the first week of adulthood, expansion of the mushroom bodies (MBs), a multi-sensory integration center, can be observed in the honey bee brain. This reflects a maturation process which is partly shaped by experience and partly the result of a developmental program maintained under sensory deprivation. Here, we studied the consequences of deprived conditions on MB maturation and performance in a MB dependent learning task. The olfactory conditioning of the proboscis extension reflex allowed the identification of learning tasks that depend on functional MB, such as reversal learning.

Using this ambiguous learning task, we compared the performances of 10-day-old bees reared under normal conditions (in-hive bees), deprived conditions (experience-independent plasticity) and partially deprived conditions in which we tried to reproduce the olfactory environment of the hive. Images of synapsin-immunolabeled brains have been acquired and are still analyzed to assess the volume of different MB subparts and synaptic boutons density. Contrary to in-hive bees, bees reared under deprived or partially deprived conditions were not able to solve the learning task. Our results suggest that experience-independent plasticity is not sufficient for the formation of MB-dependent cognitive capacities. As olfactory exposure to the in-hive environment did not restore these capacities, further studies are needed to identify the components of in-hive experience that enable the development of such cognitive capacities.

**Learning & Memory**

Keywords :environmental deprivation; cognitive capacities; brain maturation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-41**
**Presentation Time: 16:00 to 17:00**

## SPATIAL NAVIGATION IN AMPHIBIANS: IMPORTANCE OF THE MEDIAL PALLIUM

**María Inés Sotelo[1]; María Florencia Daneri[1]; Verner Peter Bingman[2]; Rubén Néstor Muzio[1]**

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Although of crucial importance in vertebrate evolution, amphibians are rarely considered in studies of comparative cognition. Previously, we demonstrated in a goal location task that toads can use both boundary geometry and visual features to navigate, but they preferentially use geometry. Briefly, using water as reward, we first trained two groups of the toad Rhinella arenarum in a Geometry-Only task and Geometry–Feature task. In the former task, experimental toads, partially dehydrated, were trained to find water in a rectangular arena with no predictive information available other than the arena's boundary geometry. In the latter task, the toads were trained in the same rectangular arena, but with a colored panel placed on one of the walls. We then analyzed the neural activity associated with performance of the two tasks by mapping c-Fos/IEG immunostaining. Results showed that the Medial Pallium, presumptive homologue of the mammalian hippocampus, displayed increased activity in animals that were trained in both tasks when compared to a control group with no prior training. The findings resemble those found in other vertebrate groups suggesting a conserved role of hippocampal homologues in boundary geometry-guided, spatial cognition. We also found that the Dorsal Pallium and Lateral Pallium were differentially activated only when visual features could be used for locating the goal (Geometry–Feature group), suggesting a role of these forebrain regions in feature-guided behavior.

**Learning & Memory**

Keywords :amphibia; cognition; hippocampal formation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-42**
**Presentation Time: 17:00 to 18:00**

## BRAIN PLASTICITY AND COMPLEX LEARNING TASKS IN THE HONEY BEE: RECRUITMENT OF SPECIFIC NEURAL CIRCUITS ALLOWS AMBIGUITY RESOLUTION.

**Jean-Marc Devaud[1]; Constance Boitard[1]; Thomas Papouin[1]; Guillaume Isabel[1]; Martin Giurfa[1]**

Paul Sabatier University / CNRS,Toulouse,France[1]

Learning allows individuals to make reliable predictions about connected events in their environment, and is thus a crucial factor for behavioural plasticity. While the honey bee is a model species for understanding learning and memory processes, most studies dedicated to their neural bases have focused on elemental learning tasks, i.e. tasks based on simple and unambiguous links between specific stimuli (e.g. a stimulus A is associated with a reinforcement while stimulus B is not: A+ vs. B-). By contrast, ambiguity and non-linearity characterise more complex learning tasks, thus making discriminations difficult. During foraging, honey bees are likely to experience complex learning situations, particularly due to the time-limited availability of food provided by flowers and the complexity of their aromas. Yet, the underlying learning processes have been poorly investigated under controlled laboratory conditions. In mammals, different brain structures are associated with learning forms exhibiting different levels of ambiguity. We asked whether the same principle applied to an insect brain, by combining the olfactory appetitive conditioning of the proboscis extension response with pharmacological approaches. By doing so, we unraveled the crucial role of a paired brain structure, the mushroom bodies (MBs), in a variety of ambiguous learning tasks. In several cases, we could pinpoint the necessity for active inhibitory connections within the MBs, for ambiguities to be solved. Overall, these results reveal an unsuspected level of brain plasticity allowing the functional recruitment of different neural circuits, depending on the learning situation encountered by the animal in its environment.

### Learning & Memory

Keywords :insect; olfaction; ;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-43**
**Presentation Time: 18:00 to 19:00**

## OCTOPAMINE AND DOPAMINE MODULATE APPETITIVE VISUAL LEARNING IN AFRICANIZED HONEYBEES

**Theo Mota[1]; Nayara Salles Neves[1]; Jean Viana Rodrigues[1]**

Universidade Federal de Minas Gerais (UFMG),Belo Horizonte,Brazil[1]

Honeybees are excellent models for studying visual learning and memory, because of their sophisticated visual system and amazing cognitive capacities. Visual learning in free-flying bees has been traditionally studied using operant conditioning. This well stablished protocol, however, can hardly be combined with invasive protocols for studying the neural basis of visual learning. Different efforts have been made to develop protocols for studying visual learning in harnessed honeybees, though poor learning performances were reached in most of these studies. We performed differential visual conditioning of the proboscis extension reflex (PER) using harnessed Africanized honeybees and found that a small percentage of animals (~30%) was able to acquire consistent conditioned responses. We then performed orientation tests in Y-maze presenting the same visual stimuli bees were trained before in classical conditioning of PER. In this new operant context, we found a much higher percentage of animals (~80%) displaying correct discriminative choices. This learning transfer from a classical to an operant context was combined with selective pharmacological injections to test the effect of dopamine and octopamine in appetitive visual learning. Bees injected with octopamine antagonist were not capable of learning any association between visual stimuli and sucrose. Blocking of dopaminergic receptors significantly decreased the level of conditioned responses during classical conditioning, as well as the percentage of correct choices in Y-maze orientation tests. Our results suggest that both octopamine and dopamine modulate appetitive visual learning by Africanized honeybees.

### Learning & Memory

Keywords :visual learning; biogenic amines; honeybees

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-44**
**Presentation Time: 15:00 to 16:00**

## STUDY OF ADF/COFILIN AS A REGULATOR OF ACTIN CYTOSKELETON DYNAMICS IN FEAR MEMORY LABILIZATION AND RECONSOLIDATION

**Candela Medina[1,2]; Verónica de la Fuente[1,2]; Arturo Romano[1,2]**

IFIBYNE - CONICET,Buenos Aires,Argentina[1]; DFBMC - FCEyN,Buenos Aires,Argentina[2]

Consolidation is the process by which new information is encoded in neural circuits. However, once a memory is consolidated it does not remain stable forever. In particular, it can change over experience. When a reminder of the learning event is presented to an animal that has learnt something new, the memory and thus the neural circuits that encode that memory, become labile and need a process of reconsolidation to be re-stabilized. Several studies support the fact that consolidation entails neuronal morphologic changes, like modifications of spine density and morphology. Nevertheless, no data is available regarding changes in neuronal morphology related to labilization and reconsolidation of memory. Besides, actin cytoskeleton plays a key role in cellular morphogenesis and is, therefore, important in the processes that underlie modification of spine morphology.

Actin dynamics between its monomeric form and its filamentous polymer is finely regulated by many factors, including ADF/cofilin, a protein with depolymerizing activity.

ADF/cofilin has recently emerged as a central determinant for many memory processes, including acquisition and extinction. Yet, its role on regulating actin cytoskeleton during memory labilization and reconsolidation is still unknown. In our work, we approached this issue by first studying actin dynamics after a reminder that elicits these processes, using a fear conditioning paradigm in mice.

**Learning & Memory**

Keywords :memory; cytoskeleton; reconsolidation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-45**
**Presentation Time: 16:00 to 17:00**

## HONEY BEE LEARNING AND MEMORY IMPAIRMENTS CAUSED BY SELENIUM INGESTION MAY BE MEDIATED BY MECHANISMS IN THE GUT

**Christina Burden[1]; Gro Amdam[1,2]; Brian Smith[1]**

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Honey bees (Apis mellifera) are exposed to many toxic compounds through collecting nectar and pollen from flowers growing in contaminated areas. One such toxin is selenium. Though selenium is an essential nutrient, it becomes a lethal toxin at high concentrations.

Selenium can accumulate to toxic levels in areas contaminated with runoff from heavily used agricultural areas, industrial waste, or mining waste. Our work has shown that even sublethal levels of selenium impair honey bee health and behavior. A single dose of selenium as low as 1.8 ng impairs performance of forager honey bees during olfactory conditioning and long-term memory recall. The amount of selenium the bees were exposed to in our studies was much lower than what bees are exposed to when feeding on the nectar of plants grown in selenium-contaminated soil. This impairment may reduce a forager's ability to efficiently gather resources for the colony. To identify potential mechanisms mediating these learning and memory impairments, we used x-ray fluorescence microscopy to map the distribution of selenium in bees 24 h following an acute dose and following 7 days of chronic exposure. We found the selenium was exclusively located in areas corresponding to the gut lumen, indicating a peripheral mechanism is likely mediating the selenium-induced learning and memory impairments.

**Learning & Memory**

Keywords :learning & memory; selenium toxicity; proboscis extension response

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-46**
**Presentation Time: 17:00 to 18:00**

## EARLY CORTICAL ACTIVITY IS REQUIRED FOR THE FORMATION AND EXPRESSION OF REMOTE FEAR MEMORIES: INTERACTIONS WITH MEMORY RECONSOLIDATION

**Rodrigo Sierra Oordoñez[1]; Lizeth Pedraza[1]; Fabiana Santana[1]; Flavia Booz[1]; Ana Paula Crestani[1]; Lucas de Olivera Alvares[1]; Jorge Quillfeldt[1]**

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System consolidation is a process of reorganizing the brain circuits underlying long-term memory maintenance. In the classical view, contextual fear memories are encoded and transiently dependent of the hippocampus to retrieval (recent memories), and then they are gradually transformed to long-term storage depending of neocortical structures (remote memories). Is cortical activity necessary during memory formation for the expression of remote memories? To address these questions, we used a contextual fear conditioning (CFC) paradigm in Wistar rats and temporal inhibition (muscimol; 1µg/µl) of the Anterior Cingulate Cortex (ACC) during acquisition and reactivation of recent memory. Our result showed that animals with ACC inhibition before training express less freezing during reactivation session (on day 3) than control group, however during remote memory test (on day 40) no significant differences were found. When reactivation was omitted, animals with ACC inhibition before training express less freezing than control group on day 40. Nimodipine administration prevents the facilitatory effect of reactivation on remote memory expression in animals with ACC inhibition. Double inhibition of the ACC (before training and reactivation) prevents remote memory formation. Taken together, we found that the inhibition of CCA before training in CFC impairs remote memory expression; however this effect was prevented by a single memory reactivation. The effect of memory reactivation is dependent of reconsolidation mechanism. The promoting effect of memory reactivation is associated to reengagement of ACC during this session. Our data suggest that early activity of cortical networks is a crucial neurobiological process for remote memory formation.

**Learning & Memory**

Keywords :systems consolidation; reconsolidation; contextual fear conditioning

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-47**
**Presentation Time: 18:00 to 19:00**

## TRANSLATIONAL CONTROL OF LEARNING AND STRUCTURAL PLASTICITY DURING THE SENSITIVE PERIOD FOR IMPRINTING IN CHICKENS

**Gervasio Batista[1]; Jennifer Jhonson[2]; Elena Dominguez[1]; Mauro Costa-Matiolli[2]; Jose Peña[1]**

Albert Einstein College of Medicine,New York,United States[1]; Baylor College of Medicine,Houston,United States[2]

The molecular pathways linking experience with structural and behavioral changes during early critical periods remain elusive. We addressed this question investigating the role of two translational control pathways, mTORC1 and eIF2a, in structural plasticity and learning during the sensitive period for imprinting in chickens. Imprinting is the acquisition of a preference for certain stimuli, characterized by vigorous following behavior. In laboratory settings, we can quantify this behavior and precisely control sensory experience. This allows us to link experience with structural changes and molecular mechanisms in specific imprinting-relevant areas of the brain. Using western blotting and pharmacology we found that mTORC1 is activated and required for imprinting in both sensory modalities. In contrast, eIF2a signaling is only required for auditory imprinting. To further investigate the mechanisms underlying imprinting, we used Diolistic labeling and assessed changes in dendritic spines after training. We found that training leads to an mTORC1-dependent increase in mature (mushroom type) spines in both auditory and visual imprinting areas. Consistent with behavioral data, eIF2a was only required for structural plasticity in the auditory pathway. Finally, we aimed to extend de critical period through direct activation of mTORC1 and eIF2a signaling. Indeed, while targeting mTORC1 extended the critical period in both sensory modalities, eIF2a activation selectively enhanced auditory imprinting. Together our results show that translational control bridges experience with structural and behavioral changes during the sensitive period for imprinting through modality-specific molecular cascades.

**Learning & Memory**

Keywords :imprinting; translational control; critical period

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-48**
**Presentation Time: 15:00 to 16:00**

## ENHANCING DISCOVERY-BASED TRAINING IN THE NEURAL SYSTEMS & BEHAVIOR COURSE

**Rayna M Harris[1]; André A Fenton[2]; Hans A Hofmann[1]**

Thu University of Texas,Austin,USA[1]; New York University,New York,USA[2]

The Neural Systems & Behavior course at the Marine Biological Laboratory is the premier discovery-driven training opportunity for neuroethologists and systems neuroscientists. These fields have increasingly benefited from integrating data across spatial and temporal scales as well as levels of organization to understand the neural basis of behavior. We have enhanced and expanded the course by integrating molecular and genomic approaches with behavioral, electrophysiological, and evolutionary analyses to study complex problems in neuroscience. For instance, we have developed an interdisciplinary research program aimed at understanding the behavioral, electrophysiological, and molecular mechanisms of learning and memory. We employ a hippocampal-dependent learning paradigm to assess how well laboratory mice can learn and remember to associate spatial cues with a stimulus. We then use ex vivo slice physiology to quantify the levels of synaptic plasticity that are indicative of a memory trace. Finally, we isolate discrete hippocampal regions and single neurons to identify changes in gene expression related to variability in behavior and synaptic plasticity. We find that active place avoidance training causes widespread input-specific changes in hippocampal synaptic network function that accompanies memory persistence. Ongoing research aims to identify transcriptome-wide changes in neural activity that are indicative of memory persistence and synaptic plasticity. Understanding how the brain stores memory is still poorly understood, but our integrative approach sheds new light on the neuromolecular mechanisms at play. This integrative approach can be applied to many unsolved questions about neural function and animal behavior.

### Learning & Memory

Keywords :intgrative approach; spatial cues;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-49**
**Presentation Time: 16:00 to 17:00**

## DIFFERENTIALLY EXPRESSED GLUTAMATE AND DOPAMINE RECEPTORS IN TWO SISTER SPECIES OF WILD BIRDS WITH WIDELY DIVERGENT COGNITIVE ABILITIES.

**Jean-Nicolas Audet[1]; Lima Kayello[1]; Simon Ducatez[1]; Erich Jarvis[2]; Lauren O'Connell[3]; Louis Lefebvre[1]**

McGill University,Montreal,Canada[1]; Duke University and Howard Hughes Medical Institute,Durham,USA[2]; Harvard University,Cambridge,USA[3]

Research on humans and model species of lab animals suggests that glutamate and dopamine receptors have key roles in cognition. In wild birds and primates, innovation rate has been proposed as an estimate of cognition in the field, while problem-solving tasks are valid experimental measures of innovativeness in captivity. We captured wild Loxigilla barbadensis and Tiaris bicolor, two sympatric sister species that have a similar social structure, but show extreme divergence in opportunism and innovation in Barbados. We assessed their problem-solving abilities using two different tasks and quantified the expression of dopamine (D1 through D5) and glutamate receptors (NMDA, AMPA, Kainate and metabotropic) using in situ hybridization and RNA-Seq data. In problem-solving tasks, we found that L. barbadensis outperformed T. bicolor in an all-or-none manner. At the RNA level, the two techniques concordantly revealed that four NMDA (NR1, NR2A, NR2B and NR2C), three metabotropic (GRM2, GRM3 and GRM4), one kainate (GRIK4) and two dopamine receptors (DRD5 and DRD3), were differentially expressed between L. barbadensis and T. bicolor. This work is a first step towards identifying the molecular differences that characterize wild species that have evolved divergent cognitive strategies.

### Cognition

Keywords :problem-solving; neutotransmitter receptors; cognition

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-50**
**Presentation Time: 17:00 to 18:00**

## QUANTITY DISCRIMINATION BY ZEBRAFISH (DANIO RERIO)

**Davide Potrich[1]; Valeria Anna Sovrano[1]; Gionata Stancher[1,2]; Giorgio Vallortigara[1]**

University of Trento,Rovereto,Italy[1]; Fondazione Museo Civico di Rovereto,Rovereto,Italy[2]

Discrimination of quantity (magnitude) was investigated in zebrafish (Danio rerio). Male zebrafish chose to approach the location previously occupied by the larger in number between 2 groups of female conspecifics (no longer visible at test) in sets of 1 versus 2 items, and 2 versus 3 items, but failed at 3 versus 4 items; similarly, when tested with larger numbers, zebrafish succeeded with 2 versus 4, 4 versus 6, and 4 versus 8 items, but failed with 6 versus 8 items. The results suggest that zebrafish rely on an approximate number system to discriminate memorized sets of conspecifics of different magnitudes, the degree of precision in recall being mainly dependent on the ratio between the sets to be discriminated.

**Cognition**

Keywords :numerical cognition; number; zebrafish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-51**
**Presentation Time: 18:00 to 19:00**

## MULTISENSING AND CROSS-MODAL OBJECT RECOGNITION IN A FISH

**Sarah Schumacher[1]; Theresa Burt de Perera[2]; Johanna Thenert[1]; Gerhard Von der Emde[1]**

Universität Bonn,Bonn,Germany[1]; University of Oxford,Oxford,United Kingdom[2]

Most animals use multiple senses to obtain information about objects in their environment. Being able to recognise objects cross-modally increases the flexibility of a multisensory system. So far cross-modal object recognition has only been shown in mammals, suggesting that this high-level cognitive ability may be absent in animals lacking a cerebral cortex.

We used an object discrimination paradigm based on operant conditioning to test whether the weakly electric fish Gnathonemus petersii, is capable of performing spontaneous cross-modal object recognition. When trained to discriminate between two objects with vision and the active electric sense in combination, electrolocation dominated over vision, leading to an inability/decreased ability to fulfil the task in mono-modal visual tests at 1cm distance. Fish trained with only vision or only the active electric sense available were subsequently able to solve the task using only the untrained sense, demonstrating spontaneous cross-modal object recognition. When tested visually, the performance of the fish trained only with their active electric sense depended on the distance of the objects. Like in the fish trained with both senses the electrosensory input dominated over vision at short distances but with deceasing reliability of the electric sense at longer distances, the visual performance increased, showing that the most reliable sensory input determined the behavioural output. In conclusion, we show for the first time that a non-mammalian vertebrate is capable of performing spontaneous cross-modal object recognition and that the sensory inputs are weighted dynamically depending on their reliability during object discrimination.

### Cognition

Keywords :cross-modal object recognition; dynamic weighting of sensory inputs; multisensory integration

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-52**
**Presentation Time: 16:00 to 17:00**

## ELECTRICAL ACTIVITY-DEPENDENT REGULATION OF MUSCLE GENE EXPRESSION IN THE ELECTRIC ORGAN AFTER CHRONIC STIMULATION IN LIVE STERNOPYGUS MACRURUS

**Graciela Unguez[1]**

New Mexico State University,Las Cruces,Unites States[1]

Skeletal muscle responds to changes in electrical activity by modifying its phenotypic properties. An extreme case of activity-dependent muscle plasticity occurs in electric fish whereby some differentiated skeletal muscle fibers convert into the non-contractile, current-producing cells (electrocytes) of the electric organ (EO). In the gymnotiform S.

macrurus, mature EO down-regulates some, but not all muscle genes, and neural activity is required to maintain this phenotype of electrocytes as removal of neural input results in the re-expression of sarcomeric proteins. The activity-dependent molecular mechanisms regulating the expression of select muscle-specific genes in the EO are not known. To test the hypothesis that the pattern of neural activity regulates muscle genes in EO, we will investigate the effect of different activation patterns and on muscle gene expression levels. We have developed a system to chronically stimulate EO and muscle in live fish.

After removal of endogenous neural input by spinal transection, electrodes were implanted subcutaneously in EO and stimulation sustained for at least 4 days. Preliminary data suggest no tissue damage beyond electrode placement. These results are novel in that we have created the first device for chronic stimulation of myogenic tissues in live fish.

We will begin characterizing changes in molecular pathways known to regulate muscle phenotype after chronic stimulation for up to 2 weeks with EO and muscle-like stimulation patterns.

### Motor Systems

Keywords :aquatic chronic stimulation; muscle-to-electrocyte transformation; nerve-dependent gene regulation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-53**
**Presentation Time: 17:00 to 18:00**

## DISTRIBUTED ENCODING OF VOCAL TIMING REVEALED BY BRAIN COOLING AND INTRACELLULAR RECORDINGS IN SINGING BIRDS

**Kosuke Hamaguchi[1]; Masashi Tanaka[2]; Richard Mooney[2]**

Kyoto University,Kyoto,Japan[1]; Duke University,Durham,USA[2]

How do forebrain and brainstem circuits interact to produce temporally precise and reproducible behaviors? Birdsong is an elaborate, temporally precise and stereotyped vocal behavior controlled by a network for forebrain and brainstem nuclei. An influential idea is that song premotor neurons in a forebrain nucleus (HVC) form a synaptic chain that dictates song timing in a top down manner. Here we combine physiological, dynamical and computational methods to show that song timing is not generated by a mechanism localized to HVC but instead is the product of a distributed and recurrent synaptic network spanning the forebrain and brainstem, of which HVC is a component.

**Motor Systems**

Keywords :synfire chain; birdsong;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-54**
**Presentation Time: 18:00 to 19:00**

## A MODEL OF CAENORHABDITIS ELEGANS LOCOMOTION NETWORK PRODUCES COHERENT UNDULATORY MOTOR OUTPUT WHEN EXCITATORY MOTONEURONS ARE OSCILLATORS

**Gal Haspel[1]; Haroon Anwar[1]; Jordan Storms[1]; Antonio Jurko[1]; Casey Diekman[1]**

New Jersey Institute of Technology,Newark,United States[1]

Neuronal oscillators underlie rhythmic behavior and particularly locomotion, in all animals in which the neural mechanism has been determined. Caenorhabditis elegans is the only animal for which an organism-level connectome exist; yet we still do not know how its nervous system generates locomotory behavior. The original electron micrographic dataset is however incomplete, leaving 21 of 75 motoneurons of the locomotor network with partial or no connectivity data. We recently described how the existing connectivity dataset can be extrapolated into a complete neuromuscular network by identifying rules of connectivity. Here we use an extrapolated network that spans the full length of an animal and includes all the motoneurons of different classes, all muscle cells, and all synaptic connections, both chemical and electrical. The output of the network is the activity pattern of the muscle cells that can be directly interpreted as body curvature. We have developed an ordinary differential equations model of the locomotion circuit and populated the model with two kinds of nodes: passive (for non-oscillatory motoneurons and muscle cells) and oscillating (for autonomously oscillating motoneurons). In the most extreme cases, the motoneurons were either all passive or all oscillating. We systematically screened all 128 combinations of the seven motoneuron classes being oscillatory. For each combination we optimized synaptic parameters for the network simulation to try and produce a propagating dorsoventral alternation of muscular activity in forward or backward directions. Several combinations in which some excitatory motoneurons are oscillators have produced undulatory-like motor programs in both forward and backward directions.

**Motor Systems**

Keywords :c. elegans; computational model; locomotion

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-55**
**Presentation Time: 15:00 to 16:00**

## MODULATION OF COCKROACH’S POSTURAL MOTOR ACTIVITY DURING QUIESCENT AND VENOM-INDUCED LETHARGIC STATES

**Frederic Libersat[1]; Stav Emanuel[1]**

Ben Gurion University,Beer Sheva,Israel[1]

Cockroach escape behavior (Periplaneta americana) is characterized by its rapid response to stimuli and it is crucial for the survival of the animal. Yet, such escape behavior may not occur when the animal is either in quiescent state or after being stung by the jewel wasp (Ampulex compressa). In contrast to quiescence, the venom-induced lethargic state is not naturally induced. The jewel wasp alters the behavior of cockroaches by inflicting a sting into the cockroach's brain inside a neuropile called the central complex (CX), a ‘higher center’ known to regulate motor behaviors. In this work, we show that, in both states, a single tactile stimulus known to trigger escape fails to initiate a response in the cockroach and multiple stimuli are required. Electromyogram (EMG) from the cockroach's third leg coxa segment reveals that the slow motor neuron (Ds) tonic activity, known to be involved in posture, is reduced in quiescent and stung animals as compared to awake. Moreover, in the stung cockroach the regular tonic firing of the slow motor neuron present in both awake and quiescent cockroaches is lost in stung cockroaches. To test whether these modulations on the cockroach behavior originates in CX, we injected procaine (a reversible action potential blocker) in the CX. This focal injection resulted in a decrease in Ds firing rate which recovers after the effect of procaine wears off. Our results indicate that neuronal modulation occurring during the quiescence and venom-induced lethargic states may share a common mechanism.

### Motor Systems

Keywords :jewel wasp; cockroach; sleep

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-56**
**Presentation Time: 16:00 to 17:00**

## OCTOPUS ARMS KEEP THE OCTOPUS HEAD HORIZONTAL TO SIMPLIFY CONTROL OF THE FLEXIBLE ARMS DURING LOCOMOTION

**Guy Levy[1]; Benny Hochner[1]**

The Hebrew University of Jerusalem,Jerusalem,Israel[1]

We report here that during various forms of locomotion octopuses keep their head constantly horizontal. Keeping the head in a fixed reference to the external world simplifies the complexity involved in controlling the soft and very flexible arms, as it reduces the interactions with the world from 3D to virtually 2D. Moreover, we show that this constrain is also important for arm coordination because as in all cephalopods, octopus arms are connected directly to the head and therefore the arms that interact with the surroundings are responsible for keeping the head horizontal. This suggests that keeping the horizontal head posture, in turn, constrains and simplifies the control of the interactions of the flexible arms with the substrate during locomotion. Kinematic analysis of octopus crawling, walking, and climbing suggest that all these locomotion maneuvers are controlled by a 'probabilistic' strategy of moment-to-moment recruitment of the acting arms. This is in sharp contrast to the more familiar CPG mechanisms, which are likely good strategies for locomotion with skeletal appendages that have only few DOFs. These findings further support the theory (see Hochner 2013) that embodied organization of behavior has led to the evolvement of unique control mechanisms in concert with the evolution of the 'strange' morphology of this soft bodied animal. Acknowledgement: Supported by EP7 STIFF-FLOP project

### Motor Systems

Keywords :octopus; central-pattern-generator; locomotion

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-57**
**Presentation Time: 17:00 to 18:00**

## ADAPTIVE CONTROL OF CATERPILLAR PROLEG GRIP-RELEASE

**Ritwika Mukherjee[1]; Samuel Vaughan[1]; Barry Trimmer[1]**

Tufts University,Medford,USA[1]

Transfer of forces during adaptive locomotion in animals depends on body morphology, properties of tissues and neural activation of muscles. When external forces change (e.g., the direction of gravity with shifts in animal orientation), movement adaptation could be passive through mechanical self-compensation or active by sensory feedback control of muscle tension. Because of their deformable bodies, soft animals are particularly affected by external forces. To explore the mechanism of active adaptive control we recorded EMGs from the Principle Planta Retractor Muscle (PPRM) of the soft-bodied caterpillar Manduca sexta while it crawled upright and upside-down. PPRM is the primary muscle controlling grip-release and its activity is critical for locomotion. Because PPRM is innervated by a single neuron, EMGs can be resolved into electrical spikes representing neuron activity. During upright crawling the firing frequency increases approximately 0.6 seconds before grip-release but during upside-down crawling this activity begins significantly earlier possibly pre-tensioning the muscle. This suggests that under different loading conditions Manduca alters the timing of its motor commands relative to its stance/swing cycle. However, the frequency changes are too small to produce significant differences in muscle force. Kinematic measurements show that the planta surface area increases immediately before the start of swing. This passive mechanical action prepares the planta for subsequent retraction controlled by PPRM activity. Thus an interplay of passive mechanics and active neural activity is required to control proleg grip-release.

### Motor Systems

Keywords :manduca sexta; soft-bodied locomotion; adaptive control

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-58**
**Presentation Time: 18:00 to 19:00**

## LOCOMOTION AND COORDINATION: MECHANISMS UNDERLYING HOMEOSTATIC PLASTICITY FOLLOWING INJURY TO THE CNS

**Joshua Puhl[1]; Morgan Newhoff[1]; Mara Rue[1]; Karen Mesce[1]**

University of Minnesota, Twin Cities,St. Paul,USA[1]

We have shown previously that the medicinal leech displays a remarkable ability to recover its crawling after neural projections from the brain have been removed. Such descending information was shown to be vital for the initiation and coordination of the body segments during crawling. To understand how coordinated crawling becomes reinstated, we examined the neuroanatomical, electrophysiological and cell-molecular features of the anterior-most ganglion and remaining nerve cord in crawl-recovered animals. We have determined that recovery does not involve the reconnection of axons from anterior neuronal projections or is recovery due to major morphological alterations in key crawl-related motoneurons. In contrast, the terminal arbors of identified stretch receptors in the CNS, which can provide proprioceptive feedback during locomotion, were found to differ from those in control animals; these terminals encompassed a greater ganglionic volume. When nerve cords from crawl-recovered animals were isolated in vitro and fictive crawling recorded across multiple segments, they responded to dopamine with uncoordinated crawl-like bursting (similar to brainless controls), indicating the need for proprioceptive input.

For reasons not yet understood, however, some isolated nerve cords obtained from animals with less than 2-3 months of recovery did, indeed, display crawl-burst intersegmental coordination. Currently, we are investigating whether subsets of animals take different mechanistic paths to achieve a solution in their acquisition of locomotor recovery.

### Motor Systems

Keywords :leech; spinal cord injury; descending control

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-59**
**Presentation Time: 15:00 to 16:00**

## CLIMBING IN COMPLEX ENVIRONMENTS: GAIT ADAPTATION BY A SOFT-BODIED INVERTEBRATE

**Barry Trimmer[1]; Cinzia Metallo[1]**

Tufts University,Medford,United States[1]

Most animals can successfully travel across cluttered uneven terrain and cope with enormous changes in surface friction and stiffness. We know relatively little about how they achieve this adaptability or how animals evaluate their situation to achieve such robustness. Even less is known about how highly deformable animals, such as caterpillars, are able to move in complex environments. By monitoring the kinematics of Manduca sexta caterpillars crawling on different substrates and in different orientations we have established that the likelihood of different stepping patterns changes on stiff and soft substrates. These changes in the sequence of transitions between swing and stance for prolegs in different body segments are distinct gaits. This is the first evidence that Manduca can detect differences in the material properties of a substrate and adjust its behavior. We have also found that crawling motor programs can be changed in response to substrate orientation. Electromyographic recordings from the large dorsal internal muscles (DIM) are correlated with the crawl duration and the swing phase of particular prolegs. During horizontal crawling, the activity of one motor neuron innervating DIM is correlated with the swing phase of the proleg belonging to the next posterior segment. During vertical crawling, the activity of the same motor neuron is correlated with the swing phase of the proleg in the next anterior segment. This shift is consistent with the Environmental Skeleton strategy for maintaining a soft body during scansorial locomotion.

### Motor Systems

Keywords :kinematics; electromyography; locomotion

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-60**
**Presentation Time: 16:00 to 17:00**

## THE ROLE OF ESTRADIOL UNDERLYING NON-BREEDING TERRITORIAL AGGRESSION IN A TELEOST FISH: A COMPLEMENTARY APPROACH FROM THE FIELD AND THE LAB

**Lucía Zubizarreta[1,2]; Laura Quintana[2]; Renata G Moreira[3]; Renato M Honji[3]; Ana Silva[2,4]**

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The neuroendocrine control of non-breeding aggression is under ongoing research, with evidence that it may be sustained by estradiol (E2) neurosynthesis. Both males and females of the electric fish Gymnotus omarorum display non-breeding territorial aggression (NBTA), which is independent of gonadal hormones in males. We studied the role of E2 in NBTA in the field by correlating plasmatic E2 to interindividual distance (ID, territory size-proxy), and in laboratory settings by analyzing the influence of E2 upon aggressive contests among females. We sampled 8 field sites in the non-breeding season and found no sexual dimorphism in ID nor circulating E2 (Females: 90.6±36; males: 86.8±36.3 pg/ml). ID was positively correlated to body size ($R2=0.25$, $p=0.02$, $n=20$), but did not correlate to E2 levels. Dominant and subordinate females did not significantly differ in their circulating E2 levels (1 hour post resolution), nor were they different from pre contest levels. Nevertheless, blocking aromatase in both contenders (fadrozole 20 µg/gbw, 1 hour pre-contest) did not change circulating E2 levels but significantly decreased the probability of engaging in fights (4/7 dyads vs 9/9 control dyads, X2, $p=0.02$). In summary, circulating levels of E2 do not correlate to the occurrence of aggression, although normal aromatase activity is crucial. These results suggest an important role of estrogens, most probably brain derived, in non breeding aggression.

### Neuroendocrinology

Keywords :electric fish; territorial aggression; estrogen

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-61**
**Presentation Time: 17:00 to 18:00**

## FROM THE MOUTH TO THE BRAIN AND BEYOND: AN L-TRYPTOPHAN-ENRICHED DIET MODULATES AGONISTIC BEHAVIOR AND NEUROENDOCRINE ACTIVITY IN A SOUTH AMERICAN CICHLID FISH

**Matias Pandolfi[1,2]; Leonel Morandini[1]; Martín Roberto Ramallo[1]; Gustavo Manuel Somoza[2]**

DBBE, FCEN, UBA and IBBEA, CONICET-UBA,CABA,Argentina[1]; IIB-INTECH (CONICET- UNSAM) ,Chascomús, Argentina[2]

L-Tryptophan (TRP) supplementation has been broadly implemented to investigate the role of serotonin (5-HT) in varied physiological and behavioral processes. The heart of the matter lies in the fact that TRP is the precursor 5-HT biosynthesis. Therefore, variation in food TRP concentration is expected to change 5-HT levels in the brain. The aim of this work was to evaluate the effects of two diets with different TRP concentrations on stress and sexual steroid hormones, serotonergic activity, and agonistic behavior in the South American cichlid fish Cichlasoma dimerus. In an initial study, isolated specimens (males and females) were fed during 4 weeks with either of the diets. Animals fed with enriched-TRP (+TRP) exhibited higher forebrain serotonergic activity and reduced cortisol plasma levels, while sexual steroid plasma levels did not differ from those present with less TRP. In a second experiment, males were isolated for 2 weeks, receiving either of the aforementioned diets. Afterwards, pairs of males were placed in fighting arenas and agonistic interactions were recorded for one hour. Results showed that the total number of aggressive displays was lower and the latency to the first attack was longer when both males had been fed with +TRP. Winner males always exhibited lower cortisol and higher 11-ketotestosterone plasma levels. In conclusion, dietary TRP supplementation succeeded in modulating behavioral and neuroendocrine parameters, probably through changes in brain 5-HT activity.

### Neuroendocrinology

Keywords :dietary l-tryptophan; agonistic behavior; cichlid fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-62**
**Presentation Time: 18:00 to 19:00**

## VASOTOCIN EXPRESSION IN THE PREOPTIC AREA OF FROGS BATRACHYLA UNDER NOISE EXPOSURE

**Matías Muñoz[1]; Maricel Quispe[1]; Cristián Sanchez[1]; Mario Penna[1]**

Program of Physiology and Biophysics, Faculty of Medicine, University of Chile,Santiago,Chile[1]

In non-mammalian vertebrates, the nonapeptide arginine vasotocin (AVT) is involved in the modulation of a wide diversity of social behaviors. In anurans, reproductive interactions rely strongly on acoustic signals. Within calling assemblages, male frogs typically vocalize in response to the calls of other nearby conspecifics, and the administration of systemic AVT has been shown to produce rapid modifications in the calling activity of males. The vocal output of male frogs is also associated to the expression of AVT in the brain, active males having lower expression levels relative to quieter individuals. During the breeding season, frogs of the genus Batrachyla from the South American temperate forest have been shown to increase their vocal activity when exposed to conspecific calls and to natural rain and creek noises. We measured the number and area of coverage of AVT-immunoreactive neurons in the preoptic area (POA) and recorded the vocal activity of males of Batrachyla antartandica exposed in the field to either conspecific chorus or natural rain noise during 30 min. During stimulation, all the males exposed to conspecific chorus and rain noise increased their vocal activity. AVT expression in the POA showed a wide range of variation among individuals but no clear relationships with the kind of exposure or the level of vocal activity elicited. These results likely imply the relevance of other factors on brain and vocal activation of breeding male frogs, such as testosterone or melatonin, prompting comparisons with measurements carried out in laboratory controlled conditions. FONDECYT grant 1140014.

### Neuroendocrinology

Keywords :anura; arginine vasotocin; vocal activity

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-63**
**Presentation Time: 15:00 to 16:00**

## EXPRESSION: ONE OF THE POSSIBLE FATES OF REACTIVATED LONG-TERM MEMORIES

**Alejandro Delorenzi[1]; Fransisco Javier Maza[1]; Victor Molina[3]; Jimmy Stehberg[2]; Pablo Nicolas Fernández Larrosa[1]; Alejandro Ojea[1]**

Universidad de Buenos Aires,CABA,Argentina[1]; Universidad Andrés Bello,Santiago,Chile[2]; Universidad Nacional de Córdoba,Cordoba,Argentina[3]

The idea that memories are variable after the consolidation process has led to new perspectives about the memory processes. In this framework, our numerous studies (reviewed in Delorenzi et al, J Physiol Paris. 2014) in the crab Neohelice (Chasmagnathus) granulata and humans allow us to propose that during both memory consolidation and reconsolidation, neuromodulators can determine the probability of the memory trace to guide behavior, without affecting the potential of persistent memories to be activated and become labile. Our hypothesis is based on the findings that positive modulation of memory expression during reconsolidation occurs even if memories are behaviorally unexpressed. Based on experimental data, here we presented a different way of thinking about persistent but unexpressed long-term memories following either weak trainings or some experimental amnesia. The hypothesis includes the view that memory expression during retrievals sessions can be dissociated from memory reactivation. Furthermore, the strategy presented here allowed us to show in human declarative memory that the periods in which long-term memory can be activated and become labile during reconsolidation exceeds the periods in which that memory is expressed, providing direct evidence that the expression of memory is not needed for reconsolidation. Specific controls based on the constraints of reminders to trigger reconsolidation allow us to distinguish between obliterated and unexpressed but activated long-term memories after amnesic treatments, weak trainings and forgetting. In the hypothesis discussed, memory expressibility--the outcome of experience-dependent changes in the potential to behave--is considered as a flexible and modulable attribute of long-term memories.

### Neuromodulation

Keywords :consolidation; reconsolidation; neuromodulators

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-64**
**Presentation Time: 16:00 to 17:00**

## SOCIAL EFFECTS OF VASOTOCIN ON THE AGONISTIC ELECTRIC DISPLAYS OF TWO SPECIES OF WEAKLY ELECTRIC FISH

**Rossana Perrone[2]; Ana Silva[1,2]**

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Electric fish express their social status through the modulation of the emission of their electric signals in both amplitude and rate. In dyadic interactions within the non-breeding territorial aggression of Gymnotus omarorum, subordinates show electric submission by decreasing their EOD rate and by producing transient signals as interruptions (cessation of the EOD) and chirps (high frequency signals with decreased amplitude). In dyadic interactions within the reproductive-related aggression of Brachyhypopomus gauderio, submission is rarely shown electrically, except for a few sporadic interruptions. We pharmacologically manipulated the Arginine-vasotocin (AVT) system to explore its role in the social interaction of dyads of both species, focusing on electric submission signals. AVT (1µg/gbw) administered to dominant males of B. gauderio did not affect their level of aggression, but significantly increased the interruption rate in subordinates, as well as the proportion of dyads that produced interruptions. AVT administered to dominants of G. omarorum did not affect their level of aggression, but produced an increase in the submission signals of subordinates: EOD rate submission was more pronounced, and the rate of interruptions and chirps increased. An AVT-V1 receptor antagonist (2µg/gbw) administered to dominants of G. omarorum, not only induced a decrease in their attacks towards subordinates, but also an increase in the latency to transient signals of submission in subordinates. These results suggest that AVT acts upon the dyad as a whole unit, modulating agonistic electric communication among contenders, and represent and interesting example of social interaction effects of pharmacological manipulations of social behavior.

### Neuromodulation

Keywords :agonistic behavior; neuromodulation; electric fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-65**
**Presentation Time: 17:00 to 18:00**

## STRESS AND REPRODUCTION IN EPHEMERAL ENVIRONMENTS: TOLERANCE OR POSITIVE REGULATION?

**Bettina Tassino[1]; Carlos Passos[1]; Cecilia Jalabert[1,2]; Sol De Giacomi[1]; Laura Quintana[2]; Ana Silva[1,2]**

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It is traditionally accepted that animals suppress energy-consuming functions, reproduction in particular, to cope with stress. However, in certain contexts in which animals have limited opportunities for reproduction, reproductive functions might be tolerant or even favored by high levels of glucocorticoid hormones (GC) in detriment of survival. Annual fishes inhabit ephemeral ponds that dry during the summer and present the shortest lifecycle in vertebrates. These species, with a single breeding season followed by programmed death, must resist both environmental and social stress, and promote energy investment in reproduction over survival. This makes them an ideal and novel model system to study the role of GC in reproduction. This study aimed to evaluate the effect of exogenous administration of cortisol on reproductive performance in Austrolebias. Subjects were assigned randomly to receive either cortisol or vehicle in the maintenance aquarium. After 10 days, males were photographed to measure operculum coloration, and changes in body condition and in gonad and hepatosomatic indexes were evaluated in both sexes.

Treatment efficiency was confirmed by quantifying cortisol plasmatic levels by EIA, the first report of steroid hormones measurements in annual fishes. Higher cortisol levels induced intensification of coloration and decline of body condition in males, an increase in the hepatosomatic index in females, and no changes in the gonadosomatic index in either sex. These results suggest reproductive performance in annual fishes is not only GC-tolerant but also somehow promoted by higher levels of GC.

### Neuroendocrinology

Keywords :annual fishes; glucorticoids; cortisol

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-66**
**Presentation Time: 18:00 to 19:00**

## HABITAT3D: RECREATING THE VISUAL HISTORY OF INDIVIDUAL INSECTS

**Michael Mangan[1]; Benjamin Risse[1]; Wolfgang Stuerzl[2]; Barbara Webb[1]**

University of Edinburgh,Edinburgh,United Kingdom[1]; German Aerospace Centre,Munich,Germany[2]

Desert ants are expert navigators capable of returning to their inconspicuous nest entrances from large distances using visual cues alone. Many hypotheses have been proposed to account for these abilities but a means by which to validate models against real ant data, and given identical natural stimulus is needed. Here we describe a novel software tool "Habitat3D" for converting multiple laser scans into a useful photo-realistic mesh of the ant habitat. We firstly show how Habitat3D was used to convert 56 high precision laser scans into a single model of the 800m2 area surrounding the ant nest including the undulating ground surface and ~1,700 individual plants. The resultant habitat model is subsequently used, in combination with real ant paths extracted using the associated "HabiTracks" software, to recreate individual ant's visual experience while travelling through their environment. This detailed reconstruction allows hypotheses cues and algorithms of visual navigation to be probed in a hitherto unprecedented detail: Which facet eye configuration performs best for navigational purposes, what are the relevant visual cues during navigation, which navigational models are most efficient within these habitats? Thus our ultimate goal is to bridge the gap between "real-world field experiments" and "synthetic modelling approaches".

### Novel Tools and Methods

Keywords :desert ant navigation; habitat mapping; compound eye modelling

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-67**
**Presentation Time: 15:00 to 16:00**

## DEVELOPMENT OF SIMULTANEOUS TRACKING SYSTEM FOR MULTIPLE HONEYBEES IN HIVE WITH RFID-TAG AND IMAGE PROCESSING

**Shinya Takahashi[1]; Koji Hashimoto[1]; Sakashi Maeda[1]; Naoyuki Tsuruta[1]; Hiroyuki Ai[1]**

Analyzing communications performed by honeybee workers in their hive is one of the most important issues to reveal a mechanism of honeybee’s language, but these analyses have been usually conducted by observing the hive directly or the long-time video data and extracting honeybee’s species specific behaviors or walking trajectories manually. First of all, we constructed an automatic recording system for long-term tracking of honeybee behaviors with Radio Frequency Identification (RFID) sensors and high-resolution movie recorder using multiple small-size board computers. The size of our target colony is about 400 honeybees including a queen. The tiny RFID-tags are attached into the backs of young adult honeybees after their emergence and two RFID antennae are arranged about 20 centimeters apart to determine the time whether each honeybee was entering or leaving the hive. Three camera modules for the movie-recording device are installed toward both side of a honeycomb frame of the hive and the movies are recorded from 6:30 am to 7:30 pm everyday. Using this system, we could record 4 weeks data until escaping of honeybee colony from the hive and could analyze the relationship between waggle dance related behaviors and their foraging. Secondly, for a systematic and theoretical analysis of honeybee's communication, we developed an automatic tracking algorithm for multiple honeybees using image processing. In preliminary experiments we confirmed this algorithm can track the tagged honeybees in the movie automatically.

### Novel Tools and Methods

Keywords :honeybee; animal behavior; animal tracking

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-68**
**Presentation Time: 16:00 to 17:00**

## IN VITRO BIOASSAY OF LOCOMOTOR ACTIVITY WITH SUB-LETHAL DOSES OF GLYPHOSATE ON HONEYBEE LARVAE

**Diego Vázquez[1,2]; Walter Farina[1,2]**

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The honeybee (Apis mellifera) is the most relevant pollinator in agricultural settings and is therefore exposed to many agrochemicals, among which the herbicide Glyphosate (GLY) is one of the most important worldwide. To detect putative adverse effects of this herbicide on behaviour, we develop a novel in vitro bioassay to analyse locomotive activity in preimaginal individuals. Honeybee larvae were reared in vitro after hatching to control nutritional status and amount of GLY administered by contaminated food (treatments: 0, 2.5 and 5 a.e. mg/L of GLY). We assessed individually 30 fifth instar larvae with complete food intake (110 µl). Larvae were placed in Petri dishes and kept in an incubator (34 ºC and 95% RH). We recorded the position of individual larvae along a period of 20 hours. About 80% of control larvae were active after one hour and never ceased its activity later. At the end of the test all the larvae had moved, although a reduced locomotive activity was detected for larvae exposed to GLY. This was observed for variables such as the proportion of activation, inactivation and displacement. This is the first experimental approach to evaluate honeybee larval activity through an in vitro bioassay, which seems to be suitable for detecting behavioral changes caused by pesticides.

### Novel Tools and Methods

Keywords :honeybee; glyphosate; larval activity

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-69**
**Presentation Time: 17:00 to 18:00**

## A NEW AMBULATORY ELECTROENCEPHALOGRAPHY SYSTEM FOR FREE MOVING HORSES. AN EXAMPLE OF APPLICATION: EVALUATING ATTENTION

**Martine Hausberger[1]; Martial Oger[2]; Celine Rochais[1]; Claire Petoello[1]; Melissa Sebilleau[1]; Severine Henry[1]; Hugo Cousillas[1]**

Université de Rennes 1 – CNRS,Rennes,France[1]; Université de Rennes 1 – CNRS,Rennes,France[2]

Electroencephalography (EEG) has been extensively studied in humans in particular to assess cerebral dysfunctions. EEG is especially useful to characterize different levels of awareness from sleep to wakefulness. Electroencephalography also presents a large interest for studies of animal brain processes. Applications range from fundamental researches on attention or awareness to applied issues such as the impact of anesthesia. Most EEG recordings in animals have been done up to now invasively using deep implanted electrodes (i.e. after surgery) or by using electrodes glued on the animal's head. In any case, the cables linking the electrodes to the recorder are further constraints that also explain that most of these studies have been performed in facilities such as animal hospitals. In the present study, we developed a novel EEG helmet adapted to the horse's head that allows an easy and fast (less than 5 minutes) positioning of the electrodes and that can be used in the home environment on a free moving animal. Awake unrestrained horses' brain activity was recorded on two different days while they were in a quiet state in their home stalls. The waves recorded were clearly characteristic of awake animals. Their relative proportion showed a high inter- and intra-individual stability for a given state but differed according to whether the horses were attentive or not to an environmental stimulus (inversion between Alpha and Gamma waves). This technique therefore proves a useful tool for further "field" studies on horse's behavior and arousal level and opens entire new possibilities of investigation.

### Novel Tools and Methods

Keywords :electroencephalography; horses; attention

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-70**
**Presentation Time: 18:00 to 19:00**

## HABITRACKS: VISUAL TRACKING OF INSECTS IN THEIR NATURAL HABITAT

**Benjamin Risse[1]; Michael Mangan[1]; Luca del Pero[1]; Barbara Webb[1]**

University of Edinburgh,Edinburgh,UK[1]

To understand the means by which walking insects pilot their complex environments, an accurate account of their natural foraging behaviour is required, providing both inspiration and validation for hypotheses. Classic studies relied upon manual methods which are often imprecise and labour intensive. Modern consumer cameras provide sufficient information to track animals continuously as they move through their natural habitats, but dedicated software for outdoor conditions is lacking. Here we present “HabiTracks”, a novel tool capable of semi-autonomously tracking the position and pose of individual desert ants (Cataglyphis velox) from video recordings of their paths through their visually complex world. “HabiTracks” identifies the ant position in individual frames by removing background motion caused by camera movement as the experimenter follows the animal, leaving only animal motion plus noise. The positions are then refined using a global-optimisation scheme, in conjunction with minimal user input, to reliably determine the overall trajectory of the animal across the entire video. Since no additional cues are involved, this approach is robust against occlusions, background clutter and shadows, and is applicable to tracking other animal species. In summary we demonstrate that the combination of inexpensive hardware with our open-source software provides a means of high-throughput, high-precision tracking in natural environments.

### Novel Tools and Methods

Keywords :visual tracking; ants; behaviour

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-71**
**Presentation Time: 15:00 to 16:00**

## INSECT NAVIGATION: FROM RETINOTOPY TO ROTATION INVARIANT VIEWS

**Thomas Stone[1]; Antoine Wystrach[1]; Michael Mangan[1]; Barbara Webb[1]**

Desert ants are solitary foragers, navigating over large distances without the use of chemical trails. Instead, individuals are guided primarily by visual cues: an ability of interest to biologists and roboticists alike. Recent models seeking to describe ant behaviour make of use the retinotopic visual familiarity between the animal's current view and their visual memory. Crucially, this visual familiarity peaks when the animal is facing the same direction as when the memory was stored but drops drastically as the animal rotates. Models have exploited this property to successfully recreate both route following and visual homing behaviours observed in ants. However, several behavioural studies suggest that ants are also capable of measuring visual familiarity independent of their current orientation. Here we demonstrate how encoding images in the frequency domain can give rise to a rotational-invariant representation of the scenery perceived at a given location. This can be obtained using simple feature detectors of a kind present in insects' third optic lobe, and provide a first explanation to some observed behaviours.

### Orientation & Navigation

Keywords :insect navigation; visual homing; rotation invariance

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-72**
**Presentation Time: 16:00 to 17:00**

## DIRECTIONALITY OF SONAR CALLS EMITTED BY MACROPHYLLUM MACROPHYLLUM IN OPEN AND CLUTTERED HABITATS

**Mads Olsen[1]; Lasse Jakobsen[1]; Annemarie Surlykke[1]**

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Echolocating bats dynamically adjust acoustic features of their calls to the situation and behavioral context. Recent results show that they adjust not only temporal and spectral characteristics, but also directionality of the sonar beam, which is an important part of understanding the detection potential of echolocation. The nose-emitting neo-tropical bat Macrophyllum macrophyllum is the only trawling phyllostomid bat. The intensity of its calls is correlated to the degree of clutter and has been shown to be overall more intense than all other members of the phyllostomid family. The unique hunting strategy and acoustical behavior have led to several studies on M. macrophyllum, but none have so far investigated the sound beam patterns. We recorded M. macrophyllum in its natural habitat over open water and in a flight room at Barro Colorado Island, Panama. The recordings show slightly higher horizontal directionality over open water (half-amplitude angle (HAA) of 21°) than in the flight room (HAA of 26°). M. macrophyllum thus has a less directional sound beam than previously studied phyllostomid bats (Carollia perspicillata HAA of 16°, Trachops cirrhosus HAA of 18°). Myotis daubentonii, a vespertilionid mouth emitting bat with similar size and hunting niche as M. macrophyllum has a beam width around 20° half amplitude angle in the open. This indicates that echolocation sound beam patterns might be niche specific despite differences in emission strategy and phylogenetic background.

### Orientation & Navigation

Keywords :echolocation; directionality; bats

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-73**
**Presentation Time: 17:00 to 18:00**

## MALE BUMBLEBEES LEARN WHERE TO DRINK BUT NOT HOW TO GET BACK HOME

**Theo Robert[1]; Elisa Frasnelli[1]; Thomas S. Collett[2]; Natalie Hempel de Ibarra[1]**

University of Exeter,Exeter,UK[1]; University of Sussex,Brighton,UK[2]

Wasp and bee foragers learn the locations of their nest and feeding sites during elaborate learning flights, that the insects perform when they first leave these goals. So far learning flights have been only studied in female insects. Male bumblebees (Bombus terrestris) leave their nest and disperse to find a mate. We have never seen them perform learning flights when leaving the nest (Hempel de Ibarra et al., 2009). Here we show that male bumblebees do perform learning flights after feeding on artificial feeders, presumably to acquire information about the flowers on which they feed. We have recorded and analysed the trajectories of departure flights in bumblebee males at the nest and the feeder. Each of the two goals, nest or feeder, was surrounded by the same set of landmarks, a flat purple ring and three black cylinders. When leaving their nest, males flew directly away without looking back at the nest. In contrast after feeding, they performed elaborate flights around the feeder turning back to view the goal. Comparing these flights with those of workers departing from the feeder, we found striking similarities in durations, viewing directions and other features that characterise insect learning flights. We conclude that learning flights occur in both sexes at goals that are important to them.

**Orientation & Navigation**

Keywords :bees; learning; navigation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-74**
**Presentation Time: 18:00 to 19:00**

## VIRTUAL NAVIGATION IN CATAGLYPHIS DESERT ANTS – PATH INTEGRATION ON AN AIR SUSPENDED SPHERICAL TREADMILL

**Verena Wahl[1]; Hansjürgen Dahmen[2]; Sarah Pfeffer[1]; Matthias Wittlinger[1]**

University of Ulm,Ulm,Germany[1]; University of Tübingen,Tübingen,Germany[2]

The desert ant Cataglyphis, a well-established model organism, has a built-in navigation system, a path integrator that requires and integrates information about the angles steered and the distance travelled. The ants continuously compute their current position along their trajectory relative to their starting position and return to their nest in a straight line. We studied Cataglyphis ants' homing behavior on a newly designed, robust and portable air-suspended spherical treadmill setup under laboratory and realistic field conditions in the Tunisian desert. The sphere's motion is registered by improved optical mouse sensors that are arranged at a 90° angle at the equator of the sphere. The sphere's motion around the vertical axis is blocked, whereas the ant is tethered on top of the sphere in a way that it can freely rotate around its vertical axis. In this way the ant is basically provided with an intrinsic closed-loop feedback of the compass input. The high temporal resolution of the system provides a detailed insight into the natural walking and orientation behavior of the ants e.g. very quick and short stops, little re-orientation loops, or very fast and minute orientation changes. In our study we can for the first time provide the evidence of the complex behavior of path integration in two species of Cataglyphis ants in a virtual environment like the spherical treadmill system.

### Orientation & Navigation

Keywords :cataglyphis; navigation; spherical treadmill

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-75**
**Presentation Time: 15:00 to 16:00**

## ACTIVE VISION STRATEGIES OF BUMBLEBEES DURING LEARNING FLIGHTS

**Charlotte Doussot[1]; Olivier Bertrand[1,2]; Martin Egelhaaf[1,2]**

University of Bielefeld,Bielefeld,Germany[1]; Cluster of Excellence Cognitive Interaction Technology (CITEC),Bielefeld,Germany[2]

Finding back the nest is one of the most important tasks of a bumblebee to ensure the survival of the hive. When leaving the nest for the first time, foragers perform learning flights to gather visual information about the surroundings of the nest entrance.

Bumblebees are using a saccadic flight and gaze strategy to restrain the rotational components of their motion to a brief time interval called saccade. During intersaccadic intervals head rotations were previously concluded to be either negligible, which facilitate the extraction of distance cues relative to the bee (Boeddeker et al. 2015) or to be small, but actively controlled by the bee to allow for gaining distance information relative to the nest (Riabinina et al. 2014). Our current analysis has been designed to reconcile these conflicting interpretations. In the experiments a bee hive was connected to a flight arena via a vertical entrance, and departure flights of bumblebees were recorded with two high resolution cameras. This arrangement facilitates reconstruction of the head orientation and quantification of measurement noise. The reconstruction of these parameters during the learning flights allows us to determine potential points in space that may be fixated during the intersaccades. Analyzing the location of these points in the arena and their retinal displacement during intersaccadic intervals provides information about their potential significance for spatial vision and thus about the gaze strategy used by the bee during their learning flights.

**Orientation & Navigation**

Keywords :active vision; learning flights; saccades

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-76**
**Presentation Time: 16:00 to 17:00**

## LIGHT-DEPENDENT MAGNETIC COMPASS ORIENTATION IN ZEBRA FINCHES

**Atticus Pinzon-Rodriguez[1]; Rachel Muheim[1]**

Lund University,Lund,Sweden[1]

It is well known that birds can detect the Earth's magnetic field for orientation and navigation. Nevertheless, a conclusive explanation about the nature of the receptor involved is still largely under development. Birds use a light-dependent, radical-pair-based magnetic compass for orientation. Cryptochromes have been suggested as the most likely putative magnetoreceptor, in the retina of birds. To investigate how the behavioural responses of birds under different light spectra match cryptochromes as the primary magnetoreceptor, we examined the spectral properties of the magnetic compass in zebra finches. We trained zebra finches to relocate a reward in a spatial orientation task using magnetic cues as only source of information. The birds were trained and tested under different wavelength spectra at different irradiances in the presence and absence of an RF-field. As shown in migratory birds, zebra finches were well oriented under green light, but showed different orientation responses under other wavelengths of light. The birds were disoriented when tested under green light in the presence of an RF-field, supporting previous findings that the magnetic compass used in spatial orientation tasks is identical to the magnetic compass used by migratory birds for orientation. Challenging the orientation capabilities of birds in a maze and using diverse combinations of full spectrum or monochromatic light, with horizontally deflected magnetic fields, it is possible to test the hypotheses on the functional properties and biophysical processes underlying magnetic compass orientation.

**Orientation & Navigation**

Keywords :magnetoreception; orientation; light-dependent compass

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-77**
**Presentation Time: 17:00 to 18:00**

## MULTI-MODAL NAVIGATION IN ANTS: WHAT SENSORI-MOTOR BEHAVIOURS FACILITATE CUE INTEGRATION?

**Cornelia Buehlmann[1]; Paul Graham[1]**

University of Sussex,Brighton,Sussex[1]

During navigation, ants need to process input from different modalities. For example, ants perform path integration, are guided by visual scenes and use their sense of smell, however, we know little about the details of cue integration. We have investigated the paths from ants guided by path integration for what it can tell us about cue integration. Along their homing route ants slowed down before reaching their goal, and also, during the subsequent search paths the walking speed was lower. Thus path integration produces slower walking at the times when other cues are perhaps more important and walking speed could be an indirect mechanism for weighing cues. In further experiments we manipulated the ants' visual surrounding along their homing route and analysed the tolerance for such visual changes. We found that the further along their homing route ants were the more disturbed they were by visual changes, with visual changes making ants more likely to stop and scan the surroundings. By studying the sensori-motor behaviour in such fine detail we hope to gain insights how navigational modalities interact.

### Orientation & Navigation

Keywords :visual navigation; path integration; ants

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-78**
**Presentation Time: 18:00 to 19:00**

## EXPERIENCE-DEPENDENT LANDMARK LEARNING IN DESERT ANTS (CATAGLYPHIS FORTIS)

**Pauline Fleischmann[1]; Marcelo Christian[1]; Valentin Müller[1]; Robin Grob[1]; Wolfgang Rössler[1]; Rüdiger Wehner[2]**

University of Wuerzburg,Wuerzburg,Germany[1]; University of Zürich,Zürich,Switzerland[2]

Desert ants (Cataglyphis fortis) are famous model organisms for navigation. They live in North African saltpans, which offer an almost complete landmark free environment. As typical central place foragers, they need to return to their inconspicuous nest entrance after foraging persistently in the hostile surrounding of their nest. This behavior becomes even more impressive when taking into account that the ants live underground for most time of their life. This age-dependent polyethism requires a rapid and fast transition from indoor to outdoor worker. During the transition phase, the ants perform a distinct behavior, namely the so-called orientation walks. During these explorative trips near the nest, the ants must learn the surrounding features and calibrate their compass system. Our displacement experiments show that the Tunisian C. fortis desert ants learn an artificial landmark panorama rapidly. Within a few days and after only three to seven appearances outside the nest they reliably learn the position of their home and concentrate their searches sharply around the fictive nest position. This study was supported by the German Research Foundation (DFG), Collaborative Research Center SFB 1047 (“Insect Timing”), Project B6.

### Orientation & Navigation

Keywords :landmark learning; desert ant; navigation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-79**
**Presentation Time: 15:00 to 16:00**

## HOW TO FIND HOME BACKWARDS? STEPPING COORDINATION AND NAVIGATION DURING REARWARD HOMING IN DESERT ANT CATAGLYPHIS FORTIS

**Sarah Pfeffer[1]; Matthias Wittlinger[1]**

Cataglyphis desert ants, which are remarkable navigators, accomplish long and meandering foraging trips, where they are mainly guided back to their nest by path integration. Here for the first time we present an example of voluntary and persistent backward walking in Cataglyphis ants that allows us to study rearward locomotion and navigation within a natural context. An ant that finds a food item that is too large to be carried in normal forward-faced orientation will drag the prey backwards towards the nest. This behavior was examined in several experimental paradigms, including high speed-videography, channel experiments and open field studies. The study of inter-leg coordination during backward locomotion reveals a remarkable flexibility. Although ants are known to be robust tripod walkers during forward locomotion, in backward walks no periodically recurrent stepping pattern was found. The leg coordination is not rigidly fixed, however, the single legs seem to act as separate units. Despite the numerous challenges emerging for the navigational system during backward walking (e.g. inverted environment, irregular and reversed motor-sensory feedback) we show that ants come off quite well in our experiments. Angular and distance gauging was comparable to the forward walking control groups.

**Orientation & Navigation**

Keywords :cataglyphis desert ants; locomotion; navigation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-80**
**Presentation Time: 16:00 to 17:00**

## TOWARDS BAT HIPPOCAMPAL RECORDINGS IN LARGE-SCALE ENVIRONMENTS

**Tamir Eliav[1]; Liora Las[1]; Nachum Ulanovsky[1]**

Weizmann Institute of Science,Rehovot,Israel[1]

For the last forty years, hippocampal research has typically focused on spatial representations in small laboratory environments. Nothing is known about hippocampal neural codes on large spatial scales – in environments spanning hundreds of meters or kilometers – the scales of natural navigation by rodents and other mammals. Here we aim for the first time to develop a unique recording setup, including a large-scale ethologically relevant environment, which will allow us to address this fundamental question. We are using the Egyptian fruit bat as our animal model, because (i) bats are excellent navigators over large natural scales, and (ii) bats were shown to have rodent-like hippocampal spatial representations in small laboratory environments, during crawling and flight behaviors. So far, we took the following steps: First, we developed an on-board wireless neural-logging system, which allows recording single-units over unlimited distances. Second, we built a 200-m long tunnel where bats can fly freely. Third, to track the bat's position we utilized an RF localization device that measures distances to an antenna-array – yielding a spatial accuracy of ~10-cm, much better than GPS. Preliminary experiments showed that bats fly volitionally back-and-forth along the tunnel – up to 100 laps per session (20-km total flight distance). We hypothesize two possibilities for hippocampal coding of large-scale environments: (i) enlargement of place-fields to dozens of meters, versus (ii) hundreds of small place-fields for each place-cell. Here we will present the first neural recordings that directly test these hypotheses.

**Orientation & Navigation**

Keywords :bat; large scale; hippocampus

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-81**
**Presentation Time: 17:00 to 18:00**

## INTEGRATION OF OPTIC FLOW AND COMPASS CUES IN THE BOGONG MOTH LATERAL ACCESSORY LOBES

**Andrea Adden[1]; Eric Warrant[1]; Stanley Heinze[1]**

Lund University,Lund,Sweden[1]

The Australian Bogong moth (Agrotis infusa) is known for its ability to navigate under low-light conditions: During their spring migration, these nocturnal moths fly over 1000 km to reach their aestivation sites in the Australian alps, before returning to their breeding grounds in autumn. Behavioural experiments on tethered flying moths have shown that ventral optic flow is necessary for the moths to fly and orient in a target direction. On a cellular level, this suggests that compass and optic flow information are integrated before feeding into motor commands. Candidate brain regions to perform this task are the lateral accessory lobes (LAL): They are known to receive input from compass neurons of the central complex, and have been shown to provide output via proposed premotor neurons to thoracic motor centres. We placed Bogong moths into an LED arena and recorded intracellularly from LAL-neurons while presenting rotational and translational optic flow, as well as polarised-light stimuli. We identified and characterised neurons that respond to optic flow, and neurons that respond to the E-vector orientation of polarised light. Furthermore, we identified motion-sensitive neurons that connect the lobula plate with the LAL, providing a direct pathway between known motion processing centres and the proposed steering network for navigation. Taken together, our results are consistent with the hypothesis that the LAL is the main integration centre of the sensory cues needed for navigation in the migratory Bogong moth.

**Orientation & Navigation**

Keywords :nocturnal migration; central complex; polarised light

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-82**
**Presentation Time: 18:00 to 19:00**

## RESPONSES OF LOCUST MOTION–SENSITIVE NEURONS DURING FLIGHT STEERING

**Cody Manchester[1]; John Gray[1]**

University of Saskatchewan,Saskatoon,Canada[1]

Flying animals display a variety of adaptive behaviours to avoid predators and collisions with conspecifics during flight. The locust descending contralateral motion detector (DCMD) is a well characterized wide field looming sensitive neuron and is an ideal model system for examining sensory coding and integration. While DCMD responses have been described for a wide range of object motion, few studies have recorded responses during flight. This is a critical step to understand how this pathway may control and modulate a well-described behaviour. We recorded, for the first time, DCMD responses to object motion concurrent with initiation of attempted flight steering. We found: 1) that the duration of the DCMD response to a head on collision is shorter and that the peak firing rate is lower in flying locusts compared to a non-flying control, 2) objects approaching 45° from the locust's midline evoked later DCMD peak firing regardless of flight status. We also observed that recently described looming-evoked DCMD bursting occurred in flying and non-flying conditions and that modulation of the burst rate during approach varied with collision trajectory. The results suggest that while underlying coding strategies (i.e. bursting) are maintained across the status of the animal, flight evokes a fine tuned response that may utilize time coding for brief behaviours. Further analysis will relate DCMD firing properties to activity of flight steering muscles.

### Sensorimotor Integration

Keywords :locust; flight; vision

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-83**
**Presentation Time: 15:00 to 16:00**

## SENSORY-MOTOR INTEGRATION IN THE ELEPHANT NOSE FISH – CENTRAL ANATOMY AND SECOND ORDER PATHWAYS OF THE TRIGEMINAL SYSTEM

**Monique Amey-özel[1]; Stefanie Anders[2]; Kirsty Grant[3]; Gerhard Von Der Emde[1]**

Friedrich-Wilhelms-University,Bonn,Germany[1]; Friedrich-Wilhelms-University,Bonn,Germany[2]; UNIC-CNRS,Gif-sur-Yvette,France[3]

The Elephant nose fish, Gnathonemus petersii, uses an active electrosensory system to explore its environment with specialized electroreceptor organs in the skin. These mormyromasts are densely distributed on the Schnauzenorgan, a highly moveable, trunk-like protrusion of the lower jaw. Recent studies have shown that the Schnauzenorgan is adapted for active electrolocation and novelty detection and is used for prey detection and object inspection. The high mobility of the Schnauzenorgan enables the fish to move it like a finger towards and around objects. This requires accurate timing of motoneuron responses to electrosensory input and exceptional coordination of large and small muscles. In this study we investigated the innervation of the Schnauzenorgan muscles and skin by the V cranial nerve. To examine the first and second order motor control centers of the Schnauzenorgan linking perception to action, we combined electrophysiological and neurotracer methods using Biocytin and DiI. Injections into the trigeminal nerve in the Schnauzenorgan revealed strong retrograde labeling of a distinct group of cells only in the main corpus of the V motor nucleus. We further found dense networks of afferent terminals in all descending sensory nuclei of the V nerve, suggesting a high representation in this system. Further investigations on the afferent and efferent projections of the V motor nucleus showed a network of second order pathways connecting different somatic and visceral brain centers. With regard to nuclei involved in electrosensory processing, we found projections to the V motor nucleus from toral and mesencephalic nuclei and the valvula cerebelli.

### Sensorimotor Integration

Keywords :schnauzenorgan; haptic sense; weakly electric fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-84**
**Presentation Time: 16:00 to 17:00**

## DYNAMICS OF THE ELECTRO-MOTOR-SENSORY LOOP IN PULSE GYMNOTIFORMES.

**Pedro Aguilera[1]; Alejo Rodríguez-Cattáneo[1]; Carolina Pereira[1]; Angel Caputi[1]**

IIBCE,Montevideo,Montevideo[1]

We investigated the dynamics of the electromotor-electrosensory loop of Gymnotus omarorum, combining behavior with extracellular recording of primary afferents and neurons of the lateral map of the electrosensory lobe. We used descerebrated, freely discharging, preparations, and freely exploring animals for recording electrosensory lobe neurons and field potentials. Our results show a time window of exquisite sensitivity, coincident with the descending slope between the main head-positive and negative electric-organ discharge (EOD). Changes in interfering stimulus phase within a microsecond range cause intense and transient pacemaker interval reductions (TIR). We found an additional time window, where stimuli cause TIRs starting 5-7 ms before the head positive peak of the EOD (i.e. 2 ms before the pacemaker firing), which last until the beginning of this peak. Stimuli applied within the first window induce changes in the firing latency of a latency coder electroreceptor type firing about 4 ms after the EOD, while those applied at the second block the responses of this electroreceptor subtype to the EOD due to refractoriness. In the rest of the EOD cycle, signals similar to the largest ones recorded in natural conditions were unable to cause TIR. Latency encoder receptors responsiveness causes a bifurcation in the phase portrait of the electromotor electrosensory system under regular jamming. When interfering signals have higher rate than the pacemaker, coincidences cause accelerations and synchronization. In the opposite case, EOD precedence of the interfering stimulus causes acceleration with the consequent reduction of interference in the following cycles. Supported by ANII, PEDECIBA, UDELAR-CAP.

### Sensorimotor Integration

Keywords :electric fish electrosensory integration; electromotor-electrosensory loop;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-85**
**Presentation Time: 17:00 to 18:00**

## CENTRAL-COMPLEX CELLS IN FREELY HUNTING PRAYING MANTISES ENCODE PREY MOTION AND POSITION

**Anne Wosnitza[1]; Joshua P. Martin[1]; Alan J. Pollack[1]; David J. Bertsch[1]; Roy E. Ritzmann[1]**

Case Western Reserve University,Cleveland,44106[1]

Complex tasks like hunting a moving prey through an unpredictable environment require high levels of motor sensory integration. The animal needs to detect and track suitable prey objects, measure their distance and orientation relative to its own position, and finally produce the correct motor output to approach and capture it. In the insect brain the central complex (CX) is one target area where these complex integrations are likely to take place. In the study presented here, we did multi-unit recordings in the different sub-areas of the CX of freely hunting praying mantises (Tenodera sinensis) in an arena. Simulated prey was presented on an LCD screen positioned below the clear floor of the arena and oscillated back and forth at different angles and distances. Comparable to findings in the CX of cockroaches, we identified populations of cells that showed predictive properties of the animals own movements (Martin et al., 2015, Curr Biol. 25:2795-803). Importantly, we also determined populations of cells whose activity patterns were strongly linked to the appearance, movement, and relative position of the virtual prey item. These results suggest a crucial importance of the central complex to prey-capture behavior in predatory insects like the praying mantis and hence further emphasize its role in behaviorally- and ecologically-relevant contexts.

### Sensorimotor Integration

Keywords :central complex; praying mantis; electrophysiology

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-86**
**Presentation Time: 18:00 to 19:00**

## ANESTHESIA AND BRAIN SENSORY PROCESSING: IMPACT ON NEURONAL RESPONSES IN A FEMALE SONGBIRD

**Hugo Cousillas[1]; Genta Karino[2]; Isabelle George[1]; Lauriane Loizon[1]; Geert De GROOF[3]; Martine Hausberger[1]**

Université de Rennes 1 – CNRS,Rennes,France[1]; Tokyo University of Agriculture and Technology, Tokyo, Japan[2]; University of Antwerp,Antwerp,Belgium[3]

Whether anesthesia impacts brain sensory processing is a highly debated and important issue. There is a general agreement that anesthesia tends to diminish neuronal activity, but its potential impact on neuronal “tuning” is still an open question. In the present study, based on electrophysiological recordings of neuronal activity in a large sample of female starlings’ auditory neurons while broadcasting species specific song elements, we could show that 1) there could be atypical increased responses to non-biological sounds under anesthesia, and in any case different neuronal preferences between the anesthetized and awake state, 2) the neuronal preferences were not influenced by the animal’s internal state (i.e. breeding status) contrarily to those of awake birds which show a high seasonal plasticity. These results demonstrate a clear impact of anesthesia on sensory and cognitive processes, by affecting neuronal preferences. They open new lines of thought on the interest of understanding the precise modalities of actions of these drugs on such profound modifications, but also on dissociating sensory basic processing from behaviorally relevant items, that require an increased vigilance.

### Sensory: Audition

Keywords :anesthesia; auditory processing; european starlings

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-87**
**Presentation Time: 15:00 to 16:00**

## HEARING DIVERSITY IN MOTHS REVEALED BY NON-INVASIVE ELECTROPHYSIOLOGY AND DISTORTION-PRODUCTS OTOACOUSTIC EMISSIONS


**Ariadna Cobo-cuan[1]; Yohami Fernández[1]; Frank Macías-escrivá[1]; Manfred Kössl[2]; Emanuel C. Mora[1]**

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Moth ears are adapted to detect bat echolocation signals and may also mediate communication with potential mates. Characterization of moth hearing has been focused on different levels of auditory processing with independent approaches, thus limiting comparisons across studies. In this work, ear tuning in the noctuids Empyreuma pugione and Ascalapha odorata was simultaneously evaluated by neurophysiological recordings and by measuring distortion-products otoacoustic emissions (DPOAE). We investigated how the mechanical nonlinear tympanum response is reflected on neural processing. A novel electrophysiological method is proposed to record the moth auditory nerve response without body dissection, and its results are compared with those of the traditional recording method which require thoracic dissection. For both conditions (non-dissected and dissected) we evaluated the response by acoustically stimulating with a matrix of frequency-level combinations (14-96 kHz and 30-70 dB SPL). Neural audiograms matched to DPOAE audiograms suggesting a unique filtering mechanism. The results revealed a significant change in mechanical properties of the tympanum determined by body dissection: best hearing frequency decreases in both DPOAE and electrophysiological audiograms. By recording DPOAE in non-dissected individuals of other 32 moth species, we identified best hearing to high frequencies (>30 kHz) matching the spectral range of echolocation calls from Cuban insectivorous bats. Our experiments expose the physiological susceptibility of moth hearing and reveal a great diversity of frequency selectivity by using a non-invasive approach.


**Sensory: Audition**


Keywords :hearing; moth; dpoae

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-88**
**Presentation Time: 16:00 to 17:00**

## DIFFERENTIAL AUDITORY ADAPTATION IN KATYDIDS (BUSHCRICKETS) EARS: LOW-FREQUENCY RESONANCE VS. ACOUSTIC FOVEA

**Manuela Nowotny[1]; Jan Scherberich[1]; Jennifer Hummel[1]**

Goethe University Frankfurt,Frankfurt am Main,Germany[1]

To attract mating partners, katydids produce conspecific sounds with their forewings. These sound signals differ in frequency and timing between katydid species. In this project, we tested if differences in the used frequency band of the conspecific sounds are associated with variations in the physiology of the hearing organs. Thus, we studied audition in two tropical katydids and investigated the anatomical, mechanical and physiological characteristics of the respective hearing organ. In Mecopoda elongata (broadband singer, 2-90 kHz) only males produce sound to induce phonotaxis in females. The hearing organ, crista acustica, is about 1 mm long with about 45 sensory cells that are tonotopically tuned to frequencies. We found an exponential distribution of frequencies, but a higher sensitivity to low frequency components (<7 kHz) of the presented broadband song due to mechanical resonances of anatomical structures involved in the hearing process, such as tympana. However, adaptation of the crista acustica itself to the mating song frequencies was found in a second katydid species. In Ancylecha fenestrata (narrowband singer, 8-12 kHz), we found in males a crista acustica of doubled length and sensory cell number. A pronounced part of about 60% of the crista acustica is part of an anatomically based acoustic fovea that covers the frequency range of the narrowband signal. Our results demonstrate that differences in conspecific songs are indeed associated with unexpected variations in the sound receiving structures.

**Sensory: Audition**

Keywords :hearing katydids adaptation; ;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-89**
**Presentation Time: 17:00 to 18:00**

## PROBING THE BEHAVIORAL AND PHYSIOLOGICAL MECHANISMS UNDERLYING VOCALIZATION DISCRIMINATION IN THE COMMON MARMOSET (CALLITHRIX JACCHUS)

**Michael Osmanski[1]; Xiaoqin Wang[1]**

Johns Hopkins University,Baltimore,United States[1]

Animal acoustic communication systems provide fertile ground for studying the perceptual grouping of complex, biologically relevant stimuli. The common marmoset is a small, arboreal New World primate with a rich vocal repertoire. However, we know little about vocal perception in these animals, including the acoustic features that define particular call types. Further, almost nothing is known about the neural underpinnings of vocal perception in marmosets. We trained marmosets to discriminate complex sounds, including both natural and artificial vocalizations, and analyzed response latencies derived from this task using multidimensional scaling (MDS) procedures. MDS arranges these latencies into a multidimensional space that reflects their underlying perceptual organization. Marmosets perceptually grouped certain stimuli together, reflecting previously defined call types for this species. We also examined changes in neural activity across auditory cortex, including putative core and lateral belt auditory fields, while marmosets engaged in a vocalization discrimination task or passively listened to the same stimuli. Results showed significant changes in stimulus-evoked firing rates during active behavior compared to passive listening, including suppression of onset responses along with increases in sustained activity during task engagement. These experiments lay the groundwork for future studies examining the acoustic parameters critical for marmosets' discrimination of different classes of vocal signals and the perceptual and neurophysiological mechanisms involved in the processing of species-specific vocalizations. [Supported by NIH grants DC003180 to XQW and DC013150 to MSO]

**Sensory: Audition**

Keywords :primate; vocalization; perception

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-90**
**Presentation Time: 18:00 to 19:00**

## GENETIC ANALYSIS OF ION PUMPS IN THE GENERATION OF MECHANORECEPTOR LYMPH

**Daniel Eberl[1]; Betul Zora[1]; Elena Sivan-Loukianova[1]; Madhuparna Roy[1]**

University of Iowa,Iowa City,USA[1]

Chordotonal mechanoreception in insect hearing relies on ciliated sensory neurons that express TRPN and TRPV ion channels. Under high frequency auditory stimulation, these channels may only open for short times, minimizing receptor current. This is counteracted by an elevated electrochemical gradient across the ciliary membrane, achieved by a specialized receptor lymph in the scolopale space enclosed by the scolopale cell. The receptor lymph is thought to be rich in K+ and if it resembles the endolymph of mammalian cochlea, it may also be electro-positive. To test the roles of ion pumps and transporters in generating the receptor lymph in the Drosophila Johnston's organ, we expressed RNAi constructs that target a panel of ion pump and transporter genes specifically in the scolopale cells, using the nompA-Gal4 driver. We found that subunits of the Na/K-ATPase and the V-ATPase, primary ion pumps, are essential in the scolopale cell for hearing. Furthermore, we found evidence that some secondary transport mechanisms, such as in the cation chloride co-transporter family, which rely on the gradients generated by the primary transport mechanisms, also play a role in this cell. Our results establish a model for receptor lymph generation and help to understand the fundamental mechanisms of mechanotransduction.

**Sensory: Audition**

Keywords :ion pumps; mechanoreceptors; drosophila

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-91**
**Presentation Time: 15:00 to 16:00**

## REPRESENTATION OF AUDITORY SPACE IN THE OWL'S FOREBRAIN

**Michael Beckert[1]; Jose Pena[1]**

Albert Einstein College of Medicine,New York,United States[1]

While there is a map of auditory space in the midbrain of the barn owl, such a representation is absent in the forebrain of owls and all other species studied. Because the auditory forebrain is essential for high-order functions, it is important to understand why representations in the midbrain and forebrain differ. It has been proposed that mammals utilize a non-topographic rate code for sound localization. The relationship of tunings between nearby cells determines how the population may be readout to command behavior. Importantly, only in the map is the tuning of neighboring cells predictable by their anatomical position. To address this issue, we compared response properties of neighboring neurons recorded with tetrodes in the owl's midbrain and two forebrain structures, Field L – homologue to primary auditory cortex – and the auditory archistriatum (AAr), which has been involved in memory guided sound-localizing behavior. We found that in contrast with the midbrain, the azimuthal tuning of neighboring neurons in Field L was largely heterogeneous. Interestingly, all neurons in AAr displayed a stereotyped and homogeneous spatial tuning for contralateral space, reminiscent of the proposed rate code. We then examined the correlations of response variability and spike timing of neighboring neurons to glean insight into how this spatial tuning may emerge. AAr neurons had low correlated noise which suggests they do not share inputs despite having similar spatial tuning and may maximize information coding. Taken together, we observe a substrate for a rate code in the owl's forebrain, which can be generalized to other species who utilize similar coding strategies.

**Sensory: Audition**

Keywords :sound localization; correlations; heterogeneity

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-92**
**Presentation Time: 16:00 to 17:00**

## THE CORMORANT EAR – AN ADAPTATION TO UNDERWATER HEARING?

**Ole Larsen[1]; Magnus Wahlberg[1]; Jakob Christensen-Dalsgaard[1]**

University of Southern Denmark,Odense M,Denmark[1]

Diving birds may spend 2-20 minutes under water during a single foraging dive and reach depths of 1-200 meters. Surprisingly little is known about avian underwater hearing. We do not know how sensitive their underwater hearing is or even if they respond to underwater sound. Consequently, we do not know if anthropogenic sound affects their hearing during dives. To help filling this gap we measured the audiograms of cormorants and studied the ear anatomy. Wild-caught fledglings were anesthetized and their auditory brainstem response (ABR) to clicks and tone bursts was measured, first in an anechoic box in air and then in a large water-filled tank with their head and neck submerged 10 cm below the surface. The overall shape of air audiograms was similar to that reported for birds of the same size in air. The bandwidth and slopes of the audiograms were similar in air and water. However, in air the highest sensitivity was found at 1-2 kHz, while it was displaced towards lower frequencies under water. These results suggest that cormorants have rather poor in-air hearing compared to similar-sized birds. Their underwater hearing sensitivity, however, is higher than what would have been expected for purely air-adapted ears. A possible reason for the poor in-air sensitivity is the special ear anatomy with the central eardrum shaped as a rigid piston, which is reminiscent of the turtle ear.

**Sensory: Audition**

Keywords :abr; audiogram; anthropogenic sounds

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-93**
**Presentation Time: 17:00 to 18:00**

## PROPERTIES OF PRIMARY AUDITORY CELLS IN MALE MOSQUITOES MEASURED USING POSITIVE FEEDBACK STIMULATION

**Dmitry Vorontsov[1]; Dmitry Lapshin[2]**

Koltzov Institute of Developmental Biology Russian Academy of Sciences,Moscow,Russia[1]; Institute for Information Transmission Problems of the Russian Academy of Sciences (Kharkevich Institute),Moscow,Russia[2]

Perception of sound plays an exceptional role in the life of mosquitoes. Male mosquitoes swarm in quantities, waiting for a female to enter a swarm. As soon as the female is detected by a sound of her flight, males rush to intercept her, still guided by the sound. With strong competition from other males the mosquito auditory system must be in the very focus of natural selection. Although it is long known that the paired organ of auditory sense in mosquitoes, the Johnston organ, contains many thousands of sensory cells, methodical limitations did not allow to investigate its functional organisation. We used the method of positive feedback stimulation: responses of sensory cells recorded from their axons in the antennal nerve were amplified and passed to the stimulating loudspeaker. When the amplitude and the phase of stimulating signal were properly adjusted the whole feedback loop fell into auto-excitation with frequency of oscillations being close to the characteristic frequency of a given sensory cell. We found that 1) individual sensory cells have various frequency tunings; 2) auditory sensory cells pass to the brain amplified analogue signals rather than spikes; 3) every angular sector of the JO contains cells tuned to different frequencies. Our positive feedback stimulation, as a new approach to test individual sensory cell properties, proved to be effective and can be used in future studies of primary sensory cell tuning in different animal species.

### Sensory: Audition

Keywords :mosquito; primary sensory neurons; positive feedback

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-94**
**Presentation Time: 18:00 to 19:00**

## SHARED CODING STRATEGIES FOR SPATIAL HEARING IN BIRDS AND MAMMALS

**Fanny Cazettes[1]; Brian Fischer[2]; Jose L Pena[1]**

Albert Einstein College of Medicine,Bronx,USA[1]; Seattle University,Seattle,USA[2]

The neural code behind sound localizing behavior is among the most controversial topics in neuroscience. The emergence of a map of auditory space in the brain of the barn owl has led to major contributions to understanding coding principles in sound localization. Yet, because such map of space has not been found in the mammalian brain, it has been assumed that the neural code for spatial hearing in mammals and owls is different. Here we ask if besides differences on how sensory information is represented, the code supporting sound localizing behavior exhibits fundamental differences across species. We addressed this question in neurons commanding the owl's orienting behavior, located downstream the map of space. Remarkably, we found that the spatial tuning of these neurons, which receive convergent input from the owl's midbrain map, is reminiscent of the tuning properties of auditory neurons proposed for sound localization in mammals. Furthermore, we found that the activity of the owl's premotor neurons is consistent with the rate-code theory of sound localization proposed for mammals. Therefore, this study demonstrates premotor responses consistent with equivalent coding schemes commanding sound localizing behavior in birds and mammals.

**Sensory: Audition**

Keywords :barn owl; sound localization; neural coding

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-95**
**Presentation Time: 15:00 to 16:00**

## ECHOLOCATION ABILITIES OF RATS

**Orit Dashevsky[1]; Yossi Yovel[1]**

Tel Aviv university,Tel Aviv,Israel[1]

Echolocation allows its users to actively sense the surroundings by emitting sounds and analyzing the returning echoes. Echolocation is known to be used by bats, toothed whales and two groups of birds with different echolocators using different signals according to their surroundings. Rats are able of emitting and hearing ultrasonic sounds. A few old studies described echolocation abilities in rats. However, these studies did not sufficiently quantify the performance facilitated by this sense, and they could not reveal which signals are used by the rats. Here, we revisited this topic characterizing rats' abilities and limits of perceiving their surroundings through active bio-sonar, and revealing the sound signals they use. Rats were able to detect an obstacle blocking an arm in a multi-arm maze at a distance of up to 40 cm in complete darkness. White noise disrupted this ability. We recorded the rats in the maze using ultrasonic microphones, and the most common sound that we found were clicks generated by the rats' teeth. These clicks were brief in time (about 0.1 ms) covering a wide range of frequencies (0-80 kHz). They are thus ideal candidates for serving as bio-sonar signals. We conclude that rats can perform basic orientation tasks in complete darkness based on acoustic cues. Such an ability could be relevant for functioning in dark borrows as rats often do.

**Sensory: Audition**

Keywords :rats; echolocation; orientation in darkness

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-96**
**Presentation Time: 16:00 to 17:00**

## WHAT IS THE NEURAL BASIS OF EVOLUTIONARY CHANGE IN SENSORY PERCEPTION? A CASE STUDY IN WEAKLY ELECTRIC FISH.

**Alejandro Velez[1]; Tsunehiko Kohashi[1,2]; Bruce Carlson[1]**

Washington University in St. Louis,St. Louis,United States[1]; Nagoya University,Nagoya,Japan[2]

Evolutionary change in sensory systems can lead to new perceptual abilities, which can have significant effects on the evolution of animal communication systems. The anatomical and physiological basis of evolutionary change in sensory processing at cellular and circuit levels, however, is poorly understood. Weakly electric fish of the family Mormyridae communicate using electric pulses. A novel perceptual ability to detect subtle variations in signal waveform evolved independently in two mormyrid lineages, and this is associated with parallel changes in the gross anatomy of the central electrosensory system. The ancestral state of the midbrain exterolateral nucleus (EL) is small and undifferentiated. In both lineages, however, the EL is enlarged and divided into separate anterior (ELa) and posterior (ELp) regions. We used neuronal tract tracing, immunohistochemistry, in vivo evoked potential recordings, and in vitro intracellular recordings to understand the underlying physiological and anatomical mechanisms of evolutionary change in sensory processing. We show that the ancestral EL contains the basic building blocks for the ELa/ELp circuitry and that similar evolutionary changes in the electrosensory circuit occurred in parallel in both lineages. The evolution of ELa/ELp and the associated ability to detect signal waveform variation resulted from (i) a lengthening of axons to form delay lines, which allows for fine temporal analysis of signal waveforms, and (ii) an overall increase in cell numbers to process a wider range of timing information. These results are the first to show how parallel changes in a neural circuit mediate parallel evolutionary changes in sensory perception.

**Sensory: Electrosensory**

Keywords :mormyridae; evolution; communication

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-97**
**Presentation Time: 17:00 to 18:00**

## THE ROLE OF NEURAL CORRELATIONS IN INFORMATION CODING

**Michael Metzen[1]; Volker Hofmann[1]; Maurice Chacron[1]**

McGill University,Montreal,Canada[1]

Invariant neural representations of a given stimulus feature even in distracting environments have been observed across sensory modalities and systems. The mechanisms mediating their emergence and subsequent refinement remain poorly understood. Here we reveal the neural circuit across successive stages of processing mediating the emergence and refinement of a phase-invariant neural representation of natural electrosensory objects in the weakly-electric-fish, Apteronotus leptorhynchus. These fish generate an electric organ discharge (EOD) surrounding their body. When two conspecifics come into contact, each fish experiences a sinusoidal amplitude modulation (beat) with a frequency equal to the difference between both EOD-frequencies. Furthermore, these fish generate communication signals or chirps whose identity is characterized by the duration, the transient increase in EOD-frequency and the phase of the beat they occur at. While duration and frequency increase are both narrowly distributed around a mean value, chirps occur at all phases of the beat with uniform probability, leading to an identity preserving transformation of the stimulus. We show that correlated neural activity allows for the emergence of a phase invariant representation of chirps that is further refined across successive stages of processing. Finally, stimulus waveforms associated with a given chirp identity all gave rise to similar behavioral responses. Our results reveal a generic neural circuit performing an elegant computation mediating the emergence and refinement of a phase invariant neural representation of natural stimuli that most likely constitutes a neural correlate of perception.

**Sensory: Electrosensory**

Keywords :phase invariance; correlations; neural coding

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-98**
**Presentation Time: 18:00 to 19:00**

### SPATIAL LEARNING IN WEAKLY ELECTRIC FISH (GNATHONEMUS PETERSII)

**Peter Moller[1]; Peter Serrano[1]; Veronica Sebastion[1]; Christopher Braun[1]; Dorina Jaubelli[1]; Stephen Braren[1]**

Hunter College CUNY,New York,USA[1]

Weakly electric fish, Gnathonemus petersii, were trained to navigate a maze on three consecutive days. Latency to complete the maze and electric organ discharges (EODs) were recorded. Following maze completion, the telencephalon was dissected and prepared for Western blot analysis to assess the density of protein kinase M-zeta (PKM?) a molecular marker involved in memory consolidation. We compared the fish's normal maze performance (a) with fish whose EOD emission was surgically eliminated (b), whose EOD activity, while staying in the goal, was disturbed by a live feed of EODs from two conspecifics kept in a separated tank outside the maze (c), and with "maze-enriched" fish that had prior spatial task experience (e). – Results: (a) Fish showed significant improvement in learning the maze as reflected in a decrease in latency, learning-related emission of characteristic EOD patterns ("scallops"), and an increase in PKM? in the synaptic-membrane fraction of the lateral pallium. (b) Surgically rendered "silent" fish showed major learning deficits.
(c) Disturbing a target fish with conspecific EODs in the goal reduced scallop emission in goal and maze, which was correlated with a lengthening of performance latency. (d) Fish with prior exposure to a "maze-enriched" environment performed as if they had been trained in the unfamiliar test maze, and thus performed superior than naïve fish released without such prior "enrichment". Supported by NIH RR-003037 (Hunter College), DOD W81XWH-08-1-0243 (PS) and PSC-CUNY (PM and PS).

**Sensory: Electrosensory**

Keywords :mormyrid fish; spatial learning; electric organ discharge

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-99**
**Presentation Time: 15:00 to 16:00**

## WEAK SIGNAL AMPLIFICATION AND DETECTION BY HIGHER-ORDER SENSORY NEURONS

**Sarah Nicola Jung[1]; Andre Longtin[2]; Leonard Maler[2]**

Universität Bielefeld,Bielefeld,Germany[1]; University of Ottawa,Ottawa,Canada[2]

The performance level different sensory systems attain varies a lot depending on an animal's habitat and behavioural repertoire. Animals are specialized in extracting specific information relevant for their survival and this sometimes requires extracting very weak signals. How the nervous system reaches such high sensitivity levels is an outstanding question in neuroscience. Weakly electric fish are an excellent model system to address this question because detailed background knowledge is available regarding their behavioural performance and its underlying neuronal substrates. Apteronotus use its electrosense to detect prey objects whose signals can be less than 1µV at the detection distance. We studied the responses of cells in the early sensory processing areas, namely the electroreceptor afferents (EAs) and pyramidal cells (PCs). In agreement with previous work we found that EAs cannot encode very weak signals with a spike count code. However, PCs can encode prey mimic signals by their firing rate, revealing signal amplification between EAs and PCs, and also suggesting differences in the neural code they use for weak stimuli. Anatomical studies have shown that PCs project to the midbrain torus semicircularis (TS) where information from different ELL maps is combined. By using a leaky integrate-and-fire (LIF) model we predict that the target neurons of PCs in the TS are able to detect very weak signals. In particular, TS neurons could do so by assuming biologically plausible convergence rates as well as very simple decoding strategies such as temporal integration, threshold crossing and combining the inputs of different types of PCs.

**Sensory: Electrosensory**

Keywords :sensory processing; weakly electric fish; weak signal detection

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-100**
**Presentation Time: 16:00 to 17:00**

## REPRESENTATION OF ELECTROLOCATION RELATED STIMULI IN THE THALAMUS ANALOG OF WEAKLY ELECTRIC FISH

**Avner Wallach[1]; Leonard Maler[1]**

University of Ottawa,Ottawa,Canada[1]

The teleost fish Apteronotus leptorhynchus uses its ability to sense weak electric fields to perceive its proximal surroundings (electrolocation) and communicate with conspecifics (electocommunication). Past studies of the neural basis of electrolocation focused on exploring hindbrain and midbrain representation of moving objects. Such representations were found to be sparse and very feature specific. Midbrain electrolocation cells, for instance, form topographic maps and are tuned to the object's identity and direction of motion. How this information is used by higher levels of the brain hierarchy in spatial learning and navigation is, however, still unknown. Here we characterize, for the first time in any fish, neural representation in the diencephalic preglomerular complex (PG), the teleost sensory information gateway equivalent to the amniote thalamus. PG receives sensory input from midbrain regions and projects to the lateral pallium (DL), a region resembling both hippocampus and cortex and known to be essential for spatial learning and navigation. While some PG cells have sparse representation of moving objects, the majority of these neurons show little directional, topographic or feature specificity. Remarkably and unlike midbrain neurons, these cells do not respond to constant motion but to changes in motion (initiation and termination) at any site along the body and for any direction. These cells exhibit thalamic-like bursting patterns that display rapid, long lasting adaptation dynamics. Taken together, these findings suggest that PG activity is correlated with the distance between large objects in the environment, thus providing key information required by the DL network to perform spatial learning.

**Sensory: Electrosensory**

Keywords :electrolocation; thalamus; fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-101**
**Presentation Time: 17:00 to 18:00**

## SYNCHRONOUS SPIKES ARE NECESSARY BUT NOT SUFFICIENT FOR A SYNCHRONY CODE

**Jan Benda[1,3]; Benjamin Lindner[2,4]; Alexandra Kruscha[2,4];Jan Grewe[1,3]**

University of Tuebingen,Tuebingen,Germany[1]; Humboldt University,Berlin,Germany[2]; Bernstein Center Computational Neuroscience, Munich,Munich,Germany[3]; Bernstein Center Computational Neuroscience, Berlin, Berlin,Germany[4]

Synchronous activity in neural populations is thought to signal the occurrence of specific events or to bind information from different sensory modalities to a unified percept. Synchronous activity in P-units of the weakly electric fish Apteronotus leptorhynchus best encodes high-frequency communication signals of small amplitude, while low-frequency navigation and prey-related signals are best represented in their asynchronous activity (Middleton et al., J. Neurophysiol., 2009). This splitting of information channels is reproduced in simulations of leaky integrate-and-fire model neurons and explained theoretically, supporting the generality of the result (Sharafi et al., J. Comput. Neurosci., 2013). This way a basic synchrony code is formed where synchronous spikes preferentially encode higher stimulus frequencies. Is the reverse also always true? Does synchronous activity imply a synchrony code? We here show recordings from ampullary electroreceptor afferents in comparison to P-units. Ampullary cells have a much more regular baseline activity (less intrinsic noise) than P-units and are less heterogeneous in their firing properties. Still, in response to band-limited white noise stimuli synchronous spikes can be differentiated from asynchronous activity. The proportion of synchronous events is comparable to the ones in P-units. Nevertheless, both synchronous and asynchronous activity in ampullary cells carries the same information. There is no synchrony code in ampullary cells. Our results suggest, that it is the right level of intrinsic noise in P-units that allows to establish a synchrony code. The mere presence of synchronous spikes does not imply a synchrony code.

**Sensory: Electrosensory**

Keywords :weakly electric fish; coding; synchrony

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-102**
**Presentation Time: 18:00 to 19:00**

## ANDROGENIC MODULATION OF CHIRP-LIKE SIGNALS IN THE PULSE-TYPE GYMNOTIFORM: STEATOGENYS ELEGANS.

**Christopher Braun[1]; Caitlin Field[1]**

Weakly electric fish have active control over their electromotor output, modulating the timing of their electric organ discharge (EOD) in social contexts. The pulse gymnotiform Steatogenys elegans exhibits a modulation that is similar to the chirp described in other gymnotiforms, a dramatic momentary increase in frequency, lasting from 10s of milliseconds to seconds, accompanied by a reduction in EOD amplitude. Although chirps have been documented in several species, this signal has not been described within the Steatogenini [Hypopygus + Steatogenys]. In Steatogenys, individuals chirp spontaneously, and chirps may be easily elicited in conspecific playback experiments. The proclivity and intensity of the chirp are modulated by androgens. Dihydrotestosterone increased chirp magnitude at all doses tested and increased the likelihood of occurrence at the highest dose (1mg DHT/10g bw). Where control and low-dose subjects (0.25 mg DHT/10g bw) chirped mainly in response to phase-locked stimuli between -2 and 0 ms, high-dose subjects also commonly chirped in response to stimuli presented several milliseconds prior to their own EOD (–6 to +2 ms). A broader response window persisted more than 4 weeks after implantation. In both dosage groups, chirps included more pulses and had greater reductions in EOD amplitude and IPI. We interpret the chirp as a communicative signal, emitted in response to jamming challenge. Supported by PSC-CUNY grants to CBB.

### Sensory: Electrosensory

Keywords :communication; electrosensory; jamming avoidance

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-103**
**Presentation Time: 15:00 to 16:00**

## NEURAL CODING STRATEGIES AND BEHAVIORAL PERFORMANCE IN ELECTROCOMMUNICATION

**Kathryne Allen[1]; Gary Marsat[1]**

West Virginia University,Morgantown,USA[1]

To appropriately respond to a sensory stimulus, an animal must be able to efficiently code a representation of that stimulus within the central nervous system. Communication signals are specialized for different behavioral contexts, and a receiver must extract information efficiently and reliably. However, the most relevant information may vary dependent on context. There are challenges associated with both the detection of weak or transient signals as well as discrimination of fine details. It has been shown in several systems that the specialization of a coding strategy for one type of perception is often at the expense of the other. Here, we show that in a species of weakly electric fish, Apeteronotus leptorynchus, two coding strategies are employed for these separate tasks. We estimate how accurately sensory responses can mediate detection and discrimination of several communication signals (chirps) presented on various background frequencies (beats). Extracellular recordings of pyramidal cells within the Electrosensory Lateral Line Lobe of alert fish showed two distinct response patterns: either stereotyped burst discharge responses well suited for accurate detection, or a graded, heterogeneous response that contains enough information to discriminate between signals with slight variations. Behavioral assays show that these two type of neural responses correlate with perceptual abilities where burst-coded signals are not discriminated but other signals are. Our study suggest that efficient sensory processing relies on a match between neural coding strategies and perceptual tasks.

**Sensory: Electrosensory**

Keywords :weakly electric fish; communication; neural coding

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-104**
**Presentation Time: 15:00 to 16:00**

## EFFECTS OF A NEONICOTINOID PESTICIDE ON THE HONEYBEE ODOUR DISCRIMINATION.

**Mara Andrione[1]; Giorgio Vallortigara[1]; Albrecht Haase[1,2]**

University of Trento,Rovereto,Italy[1]; University of Trento,Povo,Italy[2]

Exposure to neonicotinoid pesticides is considered to be one of the main causes of honeybee decline. At sub-lethal doses, these chemicals have shown to disrupt a number of basic honeybee behaviours, ranging from navigation to olfactory learning and memory. For what concerns the latter, it is already known that the interference of neonicotinoids with acetylcholine signalling in the mushroom bodies (MBs), the brain centres responsible for multisensory integration and storage of complex memories, plays a key role. However, we hypothesise that some of the memory impairments could arise from an incorrect stimulus encoding. We have, thus, studied the effects of neonicotinoids upstream of the MBs, on the honeybee antennal lobes (ALs). For the first time, the effects of a common neonicotinoid on the AL output neurons, the projection neurons, were tested in vivo, through 2-photon microscopy calcium imaging. The method allows visualizing neural activity within the cells with high spatial and temporal resolution. We analysed the responses of single glomeruli to single odours, and the overall functionality of the AL throughout the treatment. Acute neonicotinoid treatment was demonstrated to affect the calcium response, in at least some of the glomeruli, by decreasing its amplitude. This effect was partially reversible. Discrimination was shown to be strongly impaired as well, as the representations of different odours in the AL space were not separate anymore after the treatment.

**Sensory: Olfaction and Taste**

Keywords :two-photon calcium imaging; honeybee; pesticides

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-105**
**Presentation Time: 16:00 to 17:00**

## ABSENCE OF FOOD ALTERNATIVES PROMOTES RISK-PRONE FEEDING OF UNPALATABLE SUBSTANCES IN HONEY BEES

**Maria Gabriela de Brito Sanchez[1,2]; Lucie Desmedt[1,2]; Lucie Hotier[1,2]; Martin Giurfa[1,2]; Rodrigo Velarde Montesinos[3]**

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Research on risk-prone feeding behavior has largely focused on energy budgets as determinant of the acceptance of noxious food in animals. Indeed, animals with low energy budgets are more prone to ingest aversive substances that are otherwise rejected. A less explored possibility is that risk-prone feeding arises from the absence of alternative feeding options, which could result in a "feeding-helplessness" changing the thresholds of noxious-food acceptance. We contrasted these two hypotheses in the honeybee, an insect in which feeding behavior has important economic consequences. We determined the toxicity of various feeding treatments and show that when bees can choose between a pure sucrose solution and a mixture of this sucrose solution and a noxious/unpalatable substance, they consume, as expected, the pure sucrose solution and reject the mixtures, irrespectively of their energy budget. Yet, when bees were presented with a single feeding option and their escape possibilities were reduced, they resigned their food preferences and consumed the previously rejected mixtures. This consumption was again independent of their energy budget. These findings are interpreted as a case of feeding helplessness, in which bees behave as if it were utterly helpless to avoid the potentially noxious food and consume it. They suggest that depriving bees of variable natural food sources through extensive monocultures combined with agrochemical treatments may have the undesired consequence of increasing their acceptance of food that would be otherwise rejected.

**Sensory: Olfaction and Taste**

Keywords :taste; noxious food,; honey bee

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-106**
**Presentation Time: 17:00 to 18:00**

## ONTOGENIC DEVELOPMENT OF MORPHOMETRIC HETEROGENEITIES AT THE VOMERONASAL PATHWAYS: THE SOCIAL RODENT OCTODON DEGUS AS A CASE IN POINT.

**Pedro Fernandez[1]; Scarlett Delgado[1]; Karina Buldrini[1]; Jorge Mpodozis[1]**

Universidad de Chile,Santiago,Chile[1]

In mammals, the vomeronasal system (VNS) has been associated with the detection of pheromone-like semiochemicals and with the orchestration of socio/sexual behaviors. The sensory ephitelium of the VNS, called the vomeronasal organ (VNO), features two types of chemosensitive neurons, each expressing either V1R or V2R receptor. In turn, VNO neurons inervate the accessory olfactory bulb (AOB), forming in it two segregated subdomains: anterior (aAOB) and posterior (pAOB), respectively. We studied the ontogeny of the VNS in the hystricognath rodent Octodon degus. At adult stage, O. degus exhibit a highly heterogeneus AOB, in which the aAOB have twice overall volume than the pAOB, and features more and larger glomeruli. We found that segregated projections of the VNO neurons to its corresponding AOB subdomains were clearly distinguishable at prenatal stages. However, at the AOB the anatomical organization and the expression of neural maturation markers reached an adult pattern only from P15. Measurements of the overall AOB volume start showing a bias towards the aAOB by P15, but this bias becomes evident at the glomerular layer only by P30. This bias increase in posterior stages, reaching an adult-like pattern only at P180. Moreover, we found that these morphometric differences were less marked in captivity-raised animals when compared with wild-raised animals. We conclude that morphometric differences between vomeronasal pathways arise in postnatal stages, suggesting that active semiochemical experience may be influencing the establishment of this heterogeneity.

**Sensory: Olfaction and Taste**

Keywords :vomeronasal; development; experience

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-107**
**Presentation Time: 18:00 to 19:00**

## PROCESSING HUMAN CUES IN THE MOSQUITO BRAIN

**Meg Younger[1]; Alison Ehrlich[1]; Leslie Vosshall[1,2]**

The Rockefeller University,New York,USA[1]; Howard Hughes Medical Institute,New York,USA[2]

Female mosquitoes require a blood-meal for reproduction, and show intense attraction to human hosts. They rely on host sensory cues, including carbon dioxide (CO2), and components of human body odor, such as lactic acid. These stimuli alone elicit little or no attraction, but in combination they synergize to trigger host-seeking behavior. After obtaining a blood-meal, female host-seeking behavior is switched off for several days. It is unknown where and how any human host cues are represented in the mosquito brain. It is also unknown how human host cues synergize to drive host attraction and ultimately trigger biting behavior, or how attraction is suppressed after a blood-meal. I am examining these questions in the dengue fever vector mosquito Aedes aegypti. I have generated transgenic mosquitoes that express the calcium indicator GCaMP6s, and have established a system for imaging activity in the antennal lobe of live mosquitoes using two-photon excitation microscopy. I am mapping responses in the antennal lobe to chemosensory cues, to generate the first odor map of the mosquito antennal lobe. I plan to explore how this map is modulated after blood-feeding and in the presence of the CO2. These experiments will provide the first insights into how human cues are processed in the brain of Aedes aegypti.

**Sensory: Olfaction and Taste**

Keywords :mosquito; antennal lobe; imaging

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-108**
**Presentation Time: 15:00 to 16:00**

## STIMULUS-INDUCED FREQUENCY MODULATION IN THE HONEYBEE ANTENNAL LOBE.

**Marco Paoli[1]; Luca Faes[1]; Nathan Weisz[2]; Renzo Antolini[1]; Giorgio Vallortigara[1]; Albrecth Haase[1]**

Università degli Studi di Trento,Trento,Italy[1]; University of Salzburt,Salzburg,Austria[2]

Miniaturized brains are relatively simple models to investigate chemosensory representation. In particular, insects' olfactory circuit provides an accessible system for studying the neuronal basis of information coding and processing. Calcium imaging analysis of the honeybee antennal lobe - the primary olfactory processing centre - is a well-established paradigm for the analysis of odour processing physiology. However, due to limited temporal resolution, signal analysis is mainly limited to a description of average activation patterns. In this study, we conducted high temporal resolution calcium imaging via fast-scanning two-photon microscopy. This allowed the analysis of olfactory representation in the time-frequency domain, revealing a new layer of information relative to the odour processing mechanism. With this approach we identified a low-frequency window (~3 Hz), whose intensity within the AL glomeruli is strongly modulated by olfactory information. Such frequency is reminiscent of the alpha oscillatory pattern identified in mammalian brains and displays a consistent intensity decrease during stimulation in a specific subset of AL glomeruli. This phenomenon, observed in all the tested honeybees, is independent of the olfactory cue and hold no apparent correlation with the glomerular activation response detected in the temporal domain. Indeed, this analysis reveals a novel feature of the AL neural network activity, which is stimulus-induced but not time-locked with stimulus delivery.

**Sensory: Olfaction and Taste**

Keywords :olfaction; honeybee; calcium imaging

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-109**
**Presentation Time: 16:00 to 17:00**

## GAIN MODULATION IN THE MOTION VISION PATHWAY

**Bart Geurten[2]; Robert Kossen[2]; Damiano Zanini[2]; Selina André[2]; Marion Silies[1]; Martin Göpfert[2]**

European Neuroscience Institute,Göttingen,Germany[1]; Georg-August University,Göttingen,Germany[2]

Visual inputs change vastly during locomotion. The motion vision system has to cope with different velocities rendered by different modes of locomotion and different sources such as ego or target motion. In insects visual interneurons change their response characteristics depending on their locomotion state (Chiappe et al., 2010; Rosner and Warzecha, 2011). Even though neuromodulators have been shown to create similar effects (de Haan et al., 2012; Longden and Krapp, 2010; Rien et al., 2013, 2012) in these inter-neurons, a locomotion dependent modulatory cell class is hitherto unknown. Here we present evidence for a new cell-class, which modulates these interneurons and thereby could tune the motion vision system to the locomotion type specific input. The newly discovered gain control cells have aborisations close to T4 and T5 neurons, which are the first motion and direction selective cells in the motion vision pathway. By interacting with both cell types GC1 might modulate the responses to brightness increments and decrements and thereby the inputs of all lobula plate tangential cells (LPTCs). The GC1 and its presynaptic partners could be the missing connection between afferences (Kim et al., 2015) and motion vision. Our characterization of GC1's connections and effect on the responses of LPTCs as wells as the flies behavior, is the first account of a global modulation of the complete motion vision pathway.

**Sensory: Vision**

Keywords :motion vision; gain control; drosophila

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-110**
**Presentation Time: 17:00 to 18:00**

## TRICHROMATIC COLOUR VISION IS INVOLVED IN VISUALLY-GUIDED MATING BEHAVIOUR OF TOADS


**Sergei Kondrashev[1]; Oleg Orlov[2]**

Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences,Vladivostok,Russia[1];
Institute for Information Transmission Problems, Russian Academy of Sciences,Moscow,Russia[2]



The retinal mechanisms of the amphibian colour vision were studied using visually-guided mating behaviour of the toad males (Bufo bufo, Bufo gargarizans) towards moving and stationary stimuli. Blue models were most effective for inducing characteristic mating reactions – approaching and clasping. A search of correlation between colour-discriminating abilities of amphibains in mating behaviour and chromatic properties of retinal ganglion cell classes has shown that in that behaviour the animals act as trichromats using three types of photoreceptors – red-, green- and blue-sensitive. The role of different types of photoreceptors was investigated in the laboratory under controlled light conditions, at 300—0.005 lx with a set of flat paper models matched for the toad's colour space so that they stimulated retinal photoreceptors at a given ratio.

In pairwise presentation, when two stimuli differed only by the excitation of blue-sensitive receptors but were equal in two others, the stimulus that was more "bluish" was preferred by the males. Excitation of the red- and green-sensitive receptors gave an inhibitory input to the mating reactions. It is supposed that green rods ([lambda]max=432 nm), which give input to the blue-sensitive retinal ganglion cells of the ON-type projected to the diencephalic n. Bellonci, should play a significant role in toad's colour choice at photopic and mesopic light levels. This work was supported in part by the Far Eastern Branch of the Russian Academy of Sciences (project no. 15-I-6-010).


**Sensory: Vision**


Keywords :amphibia; vision; diencephalon

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-111**
**Presentation Time: 18:00 to 19:00**

## THE ROLE OF COLOR VISION IN FLIGHT ORIENTATION IN DROSOPHILA MELANOGASTER

**Kit Longden[1]; Michael Reiser[1]**

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Many animals use the distribution of wavelengths of light across the sky and ground to navigate, notably ants, bees, locust, dung beetles, and pigeons. The solar sky is rich in light of all wavelengths, while the antisolar sky is proportionally richer in blue and UV light, and the ground is dimmer and richer in green light. Does Drosophila also exploit these cues? Learning experiments have demonstrated color vision in Drosophila, but its role in spontaneous behavior remains a mystery. For instance, color vision does not contribute to stabilizing responses to horizontal motion in Drosophila, but it is not known if color is involved in object tracking, responses to looms, or to stabilization of patterns mimicking the sky and ground. Meanwhile, many genetic tools are available to characterize the color processing circuitry in detail, when its involvement in a natural behavior has been identified. We developed a UV-green-blue back-projection display system for a tethered flight arena, and measured the fly's steering reactions to the movement of colored objects, and to a color-defined horizon. When the intensity of blue and green were balanced such that no optomotor response was observed, the flies did not respond to changes in the horizon, movements of objects, or to looms. The ongoing work is investigating how UV-green stimuli are processed. Our results show that chromatic motion cues do not contribute to the fly's orientation to blue-green objects and the horizon, even when this information indicates a potentially life-threatening loom.

**Sensory: Vision**

Keywords :color vision; motion vision; flight orientation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-112**
**Presentation Time: 15:00 to 16:00**

## HOW DOES LARVAL GROWTH AFFECT FRUIT FLY VISION AND FLIGHT BEHAVIOR?

**Jamie Theobald[1]; Pablo Currea[1]**

Florida International University,Miami,United States[1]

Holometabolous insects have a feeding stage that largely determines, after metamophosis, their final adult size. Fully fed larvae reject additional food and seek a site to pupate. Larvae that have not found enough food may still be able transform, but into smaller adults. In fruit flies small adults have notably smaller eyes. Laboratory maggots, which spend their days at optimal temperatures, humidities, and with abundant food, become uniformly large adults. Wild maggots rarely see such luxury. They face an uncertain future on ephemeral food sources, threatened by competitors, food shortages, dessication, temperature shifts, and scavengers. Hence only a fraction of wild flies attain the size of their lab counterparts. But smaller flies may still scale their organ sizes to optimize their physiology. Vision is notable because: 1) it generally scales with absolute, not relative size, so there are few options to scale down favorably, and 2) it is an indispensable sense for adult flies, who rely on visual input for their remarkable flight abilities. We set out to determine the visual consequences of smaller eyes on fruit flies. We found small eyes associated with small facet sizes, which in turn produced deficits in discriminating both dim light and high frequency aspects of visual scenes. We examined the effects of reduced visual abilities to flight performance.

**Sensory: Vision**

Keywords :drosophila; allometry; vision

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-113**
**Presentation Time: 16:00 to 17:00**

## NEURAL SUMMATION IN THE HAWKMOTH VISUAL SYSTEM BOOSTS CONTRAST SENSITIVITY AND INFORMATION RATE IN DIM LIGHT

**Anna Stöckl[1]; David O'Carroll[1]; Eric Warrant[1]**

Lund University,Lund,Sweden[1]

Most of the world's animals are active in dim light and depend on good vision for the tasks of daily life. Many have evolved visual adaptations that permit a performance superior to that of manmade imaging devices. In insects, optical adaptations improve sensitivity in dim light, but in addition, neural summation of light in space and time - which enhances the coarser and slower features of the scene at the expense of noisier finer and faster features - has been suggested to improve sensitivity in theoretical, anatomical and behavioural investigations. How these summation strategies function neurally is however presently unknown. Here we quantified spatial and temporal summation physiologically in the motion vision pathway of a nocturnal hawkmoth. We show that spatial and temporal summation combine supralinearly to substantially increase contrast sensitivity and visual information rate over four decades of nocturnal light intensity, enabling hawkmoths to see at light levels 100 times dimmer than without summation. Our results reveal for the first time how visual motion is calculated neurally in dim light, and how spatial and temporal summation improve sensitivity while simultaneously maximising spatial and temporal information, thus extending models of insect motion vision derived predominantly from diurnal flies.

**Sensory: Vision**

Keywords :neural summation; dim light vision; motion vision

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-114**
**Presentation Time: 17:00 to 18:00**

## THE NEURAL BASIS OF DIM-LIGHT VISION IN ECHOLOCATING BATS.

**Susanne Hoffmann[1]; Alexandra Bley[1]; Mariana Matthes[1]; Annika Quader[1]; Uwe Firzlaff[1]; Harald Luksch[1]**

Technische Universität München,Freising-Weihenstephan,Germany[1]

Echolocating bats mainly rely on their biosonar system for orientation during twilight.
But biosonar can be supported by vision, as many bat species have large eyes that are well adjusted to low light levels. Thus the question arises, what neural mechanisms that further facilitate the use of visual information under dim-light conditions may exist in these nocturnal animals? Surprisingly, the neural capabilities of the bat visual system have not been investigated, so far. We probed the superficial layers of the superior colliculus of the omnivorous bat Phyllostomus discolor and discovered three neural features that most likely contribute to the ability of echolocating bats to exploit visual information under dim-light conditions: 1) activity maxima of collicular neurons at low to moderate stimulus intensities make the bat's visual system most effective at low light levels. 2) extremely long neural response latencies enable temporal summation of visual information, which improves sensitivity. 3) strong oscillations in neural responses may mediate synchronization of activity within and between different levels of the bat's visual system and thus enhance the effectiveness of visual input. Given that knowledge about neural adaptations to dim-light vision is mainly based on studies done in non-mammalian species, our novel data provide a valuable contribution to this field. In addition, we could demonstrate that omnivorous bats represent a so far unknown but promising animal model to study the neurophysiological aspects of dim-light vision in nocturnal mammals.

**Sensory: Vision**

Keywords :echolocating bats; dim-light vision; superior colliculus

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-115**
**Presentation Time: 18:00 to 19:00**

## THE EFFECTS OF A NEONICOTINOID PESTICIDE ON THE LOOMING RESPONSE OF A MOTION DETECTION PATHWAY IN LOCUSTA MIGRATORIA

**Rachel Parkinson[1]; John R. Gray[1]**

University of Saskatchewan,Saskatoon,Canada[1]

Imidacloprid is a neonicotinoid pesticide used widely in agriculture. It is selectively toxic to insects, binding to insect nicotinic acetylcholine receptors (nAChR) with higher affinity than to the mammalian nAChR. We tested sublethal effects of imidacloprid on a behaviourally-relevant neural pathway in locusts (Locusta migratoria), which are important agricultural pests. The Descending Contralateral Movement Detector (DCMD) is a motion sensitive neuron in the locust brain that is involved in collision avoidance and escape from predators. Locusts were injected with 200ng imidacloprid while we recorded from the ventral nerve cord with a hook electrode. The response profile of the DCMD was affected in a time dependent manner: shortly after injection the neuron fired sporadically and did not respond to an approaching object. Twenty to thirty minutes after injection the DCMD resumed firing in response to the looming stimulus, but at a lower firing rate. A longer duration of the decay phase and shorter duration of the rising phase of the DCMD response profiles suggest systemic effects on a neural network upstream of the DCMD and impairment of an important motion detection system.

**Sensory: Vision**

Keywords :locust dcmd; neonicotinoid, imidacloprid; looming response

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-116**
**Presentation Time: 15:00 to 16:00**

## PREY AND PREDATOR SENSITIVE NEURONS IN CRABS

**Estela Lanza[1]; Daniel Tomsic[1]**

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The semiterrestrial crab Neohelice (previously Chasmagnathus) granulata is preyed upon by gulls and, in turn, this crab preys upon smaller crabs. The predator and prey behaviors of Neohelice are both visually guided. Field experiments revealed that a small dummy moving 10 cm above the ground elicits reliable escape responses, whereas the same dummy moving at ground level elicits strong chasing responses. Thus, crabs seem to apply a rule of thumb to decide whether to run away or to run after small moving objects. For this they probably possess feature detector neurons tuned to respond to small objects moving either above or below the horizon. Crabs offer the possibility of recording intracellularly from neurons of high visual centers in the living animal. In the past we have extensively recorded neurons from the lobula (third optic neuropil), which are sensitive to large moving objects. Recently, we began looking for the existence of small target movement detector (STMD) neurons, whose feature detector properties might reflect the crab´s behavioral sensitivity for small objects moving on or above the ground. At present, we have recorded some STMD elements of the optic lobe of the crab that appear to be good candidates to participate in the prey-predator object recognition task. These elements show preference for small rather than large moving objects and show sensitivity for elevation and direction of the object.

**Sensory: Vision**

Keywords :stmd; lobula; crab neohelice

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-117**
**Presentation Time: 16:00 to 17:00**

## VISUALIZING THE FOREST CANOPY THROUGH BIRD EYES

**Cynthia Tedore[1]; Dan-Eric Nilsson[1]**

Lund University,Lund,Sweden[1]

Using a camera custom-built to mimic the raw spectral data collected by the retinas of major groups of birds, we imaged diverse forest habitats in search of clues as to why birds and many other animals have ultraviolet (UV) sensitive photoreceptors. We also wanted to know why a greater proportion of birds inhabiting deciduous forests tend to have photoreceptors that are sensitive deeper into the UV than birds inhabiting exclusively rainforests. We discovered that, compared to blue photoreceptors, UV photoreceptors increase the chromatic contrast between the upper and lower surfaces of leaves. This is due to leaves transmitting proportionally less UV than blue light. We propose that this could add structural detail to all types of canopy habitats and could be especially beneficial for birds that glean arthropods from leaves, since prey items tend to occupy lower leaf surfaces. Increased chromatic contrast between leaf surfaces could enable rapid categorization of leaf surfaces, increasing the efficiency by which birds forage for prey in the canopy. Additionally, we found that birds with sensitivity deeper into the UV perceive higher chromatic contrast between leaf surfaces in temperate deciduous and wet schlerophyll forests, but not in tropical or subtropical rainforests, where leaves are thicker and attenuate similar amounts of long and short wavelength UV radiation. We propose that this structural difference in the leaves of different habitats may have contributed to the enigmatic visual tuning of avian photoreceptors.

### Sensory: Vision

Keywords :color vision; bird; ultraviolet

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-118**
**Presentation Time: 17:00 to 18:00**

## CHARACTERIZATION OF THE ACTIVITY OF LOBULA COLUMNAR ELEMENTS EVOKED BY DIFFERENT PARAMETERS OF VISUAL STIMULATION THAT INFLUENCE EVASIVE BEHAVIOUR IN CRABS.

**Mercedes Bengochea[3]; Damián Oliva[4]; Martin Beron DE Astrada[3]**

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Object motion detection provides essential cues for a wide variety of behaviors such as mate, prey, or predator detection. In insects and decapod crustaceans, encoding of object motion is associated to visual processing in the third retinotopic optic neuropil, the lobula. Due to the thin caliber of the small-field lobula columnar neurons, almost all we know about object motion detection arises from studies on their postsynaptic and larger lobula output neurons. Here we used calcium imaging to study the activity of the columnar neurons that feed onto the crab's lobula when stimulated by different parameters of object motion. We presented vertical edges translating horizontally that varied in speed, contrast and direction of motion. The high-speed edges produced the strongest calcium responses; the dark edges evoked greater responses than the clear ones; and calcium responses adapted to motion in one direction partially recovered when confronted to an edge running in the opposite direction. As lobula output neurons have been implicated in driving evasive behaviors, we also studied the modulation of the crab escape behavior to variations in the same visual parameters. We found a high correlation between the activity of the columnar neurons and the intensity of escaping. These results are consistent with the involvement of the lobula in object motion coding. Moreover, as the neurons studied originate in the second optic neuropil, the medulla, object motion information would indeed begin to be encoded in the medulla.

**Sensory: Vision**

Keywords :arthropod; calcium imaging; animal behaviour

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-119**
**Presentation Time: 18:00 to 19:00**

## STELLAR ORIENTATION WITH A SMALL MIND—HOW A BEETLE SEES THE MILKY WAY

**James Foster[1]; Basil El Jundi[1]; Marcus Byrne[2]; Marie Dacke[1]**

Lund University,Lund,Sweden[1]; University of Witwatersrand,Johannesburg,South Africa[2]

A starlit moonless night is one hundred million times dimmer than a sunny day. Nonetheless, under these conditions nocturnal dung beetles perform straight-line orientation with the same precision as related diurnal species under daylight conditions. Straight line travel is important to ball rolling dung beetles, since any delay in departure from the dung pile with a freshly sculpted dung ball risks a hijacking by another beetle. As such, these species have developed an accurate internal compass system, functioning efficiently within a brain the size of a grain of rice. Orientation using the dim light of the Milky Way, however, presents a number of challenges, including low photon flux, poor contrast, and a high degree of symmetry. Here we present behavioural evidence for the surprising robustness of straight-line orientation in nocturnal beetle Scarabaeus satyrus to each of these factors. This is presented alongside analysis of directional cues present in the Milky Way, recorded via whole-sky imaging at our field site in South Africa. With this information we aim to model the stellar orientation system of S. satyrus, with the end goal of a processing-efficient star orientation algorithm.

**Sensory: Vision**

Keywords :dim light; starlight; celestial orientation

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-120**
**Presentation Time: 15:00 to 16:00**

## TRADE-OFFS DRIVE DYNAMIC INVESTMENT IN NET-CASTING SPIDER NEUROANATOMY.

**Jay Stafstrom[1]; Eileen Hebets[1]; Peter Michalik[2]**

University of Nebraska - Lincoln,Lincoln,United States of America[1]; University of Greifswald, Greifswald,Germany[2]

In attempt to better understand the link between brain and behavior, it's common practice to compare differences in brain size to correlating behaviors or ecologies across species. However, similar comparisons of neuroanatomy taking place within-species garner various benefits. Here, we investigate the relative investment of visual processing centers and sensory integration centers in a species of spider that undergoes a dramatic behavioral and morphological shift upon maturity. Deinopis spinosa are nocturnal, net-casting spiders that possess massive secondary eyes used in their unique form of active foraging. Once mature, males cease foraging and their eye size decreases, inferring a decrease of reliance on vision, a sense extremely important within the juvenile stages of life. Using microcomputed X-ray technology, we calculated the volume of various processing centers in penultimate and mature male and female spiders, inferring investment from relative volume of focal brain regions. As expected, mature males invested relatively less than penultimate males in visual-only-processing centers (ON1 and ON2), while females do not show this trend. We also find a significant relative increase in arcuate body volume in mature males, another trend not seen in female D. spinosa. This brain region, previously described as a sensory integration center in a distantly related spider (Cuppiennius salei), may be responsible for processing information related to mate-searching in mature male spiders, likely chemical in nature.

**Sensory: Vision**

Keywords :sensory system trade-offs; visual specialist; net-casting spiders

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-121**
**Presentation Time: 16:00 to 17:00**

## RAPTOR CENTRAL FOVEA LACKS RODS AND DOUBLE CONES

**Mindaugas Mitkus[1]; Peter Olsson[1]; Matthew Toomey[2]; Joseph Corbo[2]; Almut Kelber[1]**

Lund University,Lund,Sweden[1]; Washington University School of Medicine,St. Louis,USA[2]

The bird retina contains six types of photoreceptors: rods, double cones and four types of single cones. Rods are active in dim light and mediate achromatic vision. Single cones are active in bright light and are known to mediate chromatic vision. Double cones have been suggested to be responsible for high acuity achromatic vision in birds. The fovea is the retinal region with the highest photoreceptor density, and therefore provides highest spatial resolution. In order to maximise resolution, the fovea should only contain photoreceptors contributing to high-resolution vision. We used immunohistochemistry and transmission electron microscopy to investigate foveal regions in the retina of five species of raptors. As expected, we found no rods in the central foveae, however, we also found double cone-free zones in the central foveae of four species. In three species of raptors, in which we studied opsin expression, we found VS and MWS cones. We thus assume that raptors have all four types of single cones in the central fovea. These findings suggest that double cones are not the only cones contributing to high acuity achromatic vision of birds, and that the high visual acuity in the raptor fovea can be mediated by single cones alone. In raptors with similar eye size as humans, spatial resolving power, based on single cone density, is similar or higher than that of humans. We suggest that doubles cones are absent from the central fovea because they take more space than single cones, thus reducing maximum possible cone density.

### Sensory: Vision

Keywords :raptor fovea; double cone-free zone; spatial resolution

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-122**
**Presentation Time: 17:00 to 18:00**

## VISUAL ANATOMY OF THE BAND-WINGED NIGHTJAR (SYSTELLURA LONGIROSTRIS): BINOCULAR SPECIALIZATIONS, DEEP RETINOTECTAL PROJECTIONS AND EVIDENCE FOR ANATOMICAL CONVERGENCE AMONG NOCTURNAL INSECTIVORES.

**Juan Esteban Salazar[1,2]; Pedro Fernández-Aburto[1]; Daniel Severín[1]; Tomás Vega-Zúñiga[3]; Javier A. Rodríguez-González[1]; Michel Sallaberry A.[2]; Jorge Mpodozis[1]**

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Most nocturnal birds present several visual specializations, such as frontally-oriented eyes, associated to scotopic visual conditions. Nightjars (Aves: Caprimulgidae) are predators that capture flying insects at night. Here we describe the main features of the visual system of the Band-winged Nightjar (Systellura longirostris). The visual field, determined by ophthalmoscopic reflection, exhibit an area of binocular overlap covering 40° (maximum) of its dorsal-anterior portion. The eyes showed a "nocturnal-like" corneal aperture/axial length quotient. Retinal ganglion cells (RGCs) were relatively scant, and distributed in an oblique-band pattern, with higher concentrations in the ventrotemporal quadrant. Intraocular injections of an anterograde neuronal tracer (CTB) labeled only the contralateral retinorecipient nuclei. Dorsal thalamus receives a massive retinal innervation, segregated in well differentiated subnuclei. In the optic tectum, retinal fibers span densely from layers 2-8, with very unusual fibers ending in layer 9. A thickening of all tectal layers was found in the anterior-dorsal tectum. Together, these results indicate that the Band-winged Nightjar exhibits retinal and tectal specializations associated with the binocular area of their visual field. RGC distribution observed is, to our knowledge, unique among birds, but similar to that of some visually-dependent insectivorous bats, suggesting that those features might be convergent in relation to feeding strategies. The unusual anatomy of retinotectal terminals that reach layer 9 requires further analysis since it is not observed in any other adult bird. We suggest that this feature could be related to nightjars' scotopic habits, or with a possible integration of visual and auditory afferents to the tectum.

**Sensory: Vision**

Keywords :caprimulgidae; scotopic; tectum

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-123**
**Presentation Time: 18:00 to 19:00**

## TETRACHROMATIC RETINA AND EXTRAORDINARY POLARIZATION SENSITIVITY IN THE EUROPEAN CORN BORER OSTRINIA NUBILALIS HÜBNER

**Gregor Belusic[1]; Andrej Meglic[1]; Katja Šporar[1,2]**

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Ostrinia nubilalis (Hübner, 1796) (Lepidoptera: Crambidae; european corn borer - ECB) is a crepuscular moth and a well known crop pest. Its population dynamics is frequently monitored with light traps.To understand the physiological basis for its visually driven behaviour, we analyzed its visual system using anatomical methods (light and transmission electron microscopy) and electrophysiological methods (ERG, single cell recordings). ECB has a pair of ocelli with two sensitivity maxima in the UV (360 nm) and green (520 nm). The retina has superposition optics with well developed distal rhabdoms in the clear zone. Each ommatidium contains 9-12 photoreceptor cells with spectral sensitivity maxima in the green (540 nm), blue (480 nm), violet (407 nm) and UV (356 nm). Most photoreceptors have microvilli arranged in a fan-like shape and consequently negligible polarization sensitvity. Each facet in the main retina has one or two blue-sensitive photoreceptors with straightly aligned microvilli and the highest polarization sensitivity (PS > 250) among all studied animals. Additionally, the retina is equipped with a large dorsal rim area, subtending ca. 150 facets with crossed microvilli. ECB has a retinal substrate for tetrachromatic vision and polarization vision driven behaviour, such as long range migration.

**Sensory: Vision**

Keywords :ostrinia nubilalis; colour vision; polarization vision

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-124**
**Presentation Time: 15:00 to 16:00**

## COLOR VISION RE-EVOLUTION IN THE DEEP SEA? STORY OF 100 TELEOST FISH GENOMES.

**Zuzana Musilova[1,2]; Fabio Cortesi[2,3]; Michael Matschiner[4]; Martin Malmstrøm[4]; Ole Tørresen[4]; Reinhold Hanel[5]; Sissel Jentoft[4]; Karen Carleton[6]; Justin Marshall[3]; Walter Salzburger[2]**

Charles University in Prague,Prague,Czech Republic[1]; University of Basel,Basel,Switzerland[2]; University of Queensland,Brisbane,Australia[3]; University of Oslo,Oslo,Norway[4]; Thuenen Institute,Hamburg,Germany[5]; University of Maryland,Maryland,USA[6]

Color vision in vertebrates is based on different visual proteins (opsins) in the photopic cone receptors of the retina, while the scotopic rod receptors mostly express a single visual gene (rhodopsin) thought to mediate color blind vision under ‘dim-light’ conditions. Numerous duplications of the opsin genes in teleost fish genomes extended the molecular substrate for subsequent adaptation to variable light conditions. Deep-sea fishes evolved several physiological adaptations, including larger eyes or rod-only retinas, to counteract the low-light conditions of their environment. However, the molecular mechanisms of dim-light-only vision and the associated loss of color vision remains poorly understood. Here we report opsin gene evolution based on 100 genomes spanning teleost phylogeny, with emphasis on the deep-sea fish lineages. We found strong evidence for various cone opsin losses and pseudogenization in many of the deep-sea fish species, confirming the absence of conventional cone-opsin based color vision in these lineages. However, we also found that two deep-sea fish orders, which have lost some of their cone opsins, have consequently evolved up to 30 different rhodopsins with the potential to perceive various dim-light wavelengths. Retinal transcriptomes confirmed the expression of multiple rhodopsins within the retina of several of these species, which strongly supports our findings of what might as well be the first evidence for rhodopsin-based color vision in vertebrates.

**Sensory: Vision**

Keywords :opsin; gene duplication; deep-sea fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-125**
**Presentation Time: 16:00 to 17:00**

## BEHAVIOURAL AND PHYSIOLOGICAL ESTIMATES OF SPATIAL CONTRAST SENSITIVITY IN FIDDLER CRABS.

**Jan M. Hemmi[1]; Monika Siekelova[1]; Yuri Ogawa[1]; Julian C. Partridge[1]**

University of Western Australia,Perth,Australia[1]

What animals see when they move through the world depends on their visual resolution and their ability to see contrast. The spatial contrast sensitivity function describes the limits to both those visual parameters and estimates the combined effects of resolution and sensitivity on an animal's ability to gather information. Behavioural measures of contrast sensitivity are time-consuming and can be impossible, so alternative measures such as anatomical estimates of spatial resolution and Pattern-ElectroRetinoGrams (PERGs), which allow the full contrast sensitivity function to be measured, are required. PERG measurements from compound eyes are rare. The fiddler crab Uca vomeris has vertically elongated compound eyes that anatomically support a higher vertical than horizontal resolution (1.5 vs 0.4 cycles/degree). We used a sister species (Uca dampieri) in an optokinetic paradigm to obtain behavioural estimates of horizontal contrast sensitivity in restrained and actively walking crabs and compared vertical and horizontal contrast sensitivities using PERGs. The results from both behaviour and physiology confirm anatomical predictions of acuity for horizontally moving stimuli comprising vertically orientated bars. Restrained crabs achieved a contrast threshold of 5% and a visual acuity of 0.4 cycles/deg. Moving crabs are on average more sensitive to contrast. However, we found little difference in the physiological response to vertical versus horizontal gratings. It is not clear whether this lack of a difference reflects insufficient sensitivity in the PERG or whether the assumptions underlying the anatomical estimates overestimated vertical resolution.

**Sensory: Vision**

Keywords :constrast sensitiviy; visual resolution; sensory physiology

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-126**
**Presentation Time: 17:00 to 18:00**

## VISUAL SYSTEM DIVERSITY AMONG CLOSELY RELATED CORAL REEF CARDINALFISHES

**Martin Luehrmann[1]; Karen L. Carleton[2]; Karen L. Cheney[3]; Justin Marshall[1]**

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Colour vision is essential in the life of many animals; yet colour perception can vary greatly between species. Fishes are a good example of this variability: different species are generally found to tune the maximum absorbance of their retinal photoreceptors to the prevalent ambient light, and therefore range from red-shifted visual systems in freshwater to blue-shifted in oceanic waters. Coral reef fishes, however, seem to defy this principle. While coral reefs offer a largely uniform light environment, the photoreceptor spectral sensitivities among coral reef fishes are highly diverse. The reason for this diversity is unknown, but one hypothesis suggests that intricate species-specific colour tasks – such as mate choice, conspecific recognition or predation – drive visual system diversification. However, there is currently little empirical evidence to support a correlation between visual pigment tuning and specific behavioural tasks, independent of environmental lighting conditions. To disentangle this question, I investigate the visual systems of several Cardinalfish species (Apogonidae), coral reef fishes that inhabit shallow reefs, share coral-habitats and exhibit similar prey preferences, in an attempt to control for potential effects of these and instead elucidate potential effects of other,

less obvious, traits. Here we show qualitative and quantitative differences in 1) visual opsin gene expression; 2) retinal photoreceptor topography and 3) photoreceptor spectral sensitivities between closely related species. These indicate visual system specializations which may help elucidating small-scale functional specializations among coral reef fishes that demand equally small-scale visual system adaptations, such as photoreceptor tuning.

### Sensory: Vision

Keywords :colour vision; visual ecology; coral reef fish

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-127**
**Presentation Time: 18:00 to 19:00**

## FUNCTIONAL SIGNIFICANCE OF ADAPTATION IN OPTIC FLOW-BASED SPATIAL VISION OF AERIAL INSECTS - A MODELING STUDY

**Jinglin Li[1]; Jens Lindemann[1]; Martin Egelhaaf[1]**

Neurobiology & CITEC (Cognitive Interaction Technology Center of Excellence),Bielefeld,Germany[1]

For aerobatic fliers such as flies or bees, successful extraction of the depth structure of the often cluttered surroundings is indispensable in many behavioral contexts. Thereby these insects rely on the cues contained in the retinal image motion ('optic flow') that they actively shape their flight by separating rotational saccades from translational intersaccadic intervals. Only the optic flow induced by translational ego-motion contains spatial information. When extracting spatial information from the retinal motion patterns in natural environments the visual motion pathway has to cope with the vast dynamic range of environmental parameters, which is far beyond the range a neuron can encode with sufficient sensitivity. For example, the light conditions dynamically vary over 9 decades both on a long timescale due to the day-night cycle and on a short timescale as a consequence of the characteristic flight strategy of insects in natural environments. This requires visual systems to be adaptive. By modeling the visual motion pathway containing adaptive mechanisms at each processing stage based on electrophysiological data and by employing stimuli mimicking translational flight in natural environments, we analyzed the consequence of these adaptive processes and assessed their functional significance for spatial vision. The findings of this study may be generalized to other adaptive biological motion vision systems, and part of the analyzed adaptive mechanisms are currently implemented in an artificial visual system.

**Sensory: Vision**

Keywords :optic flow; spatial vision; computational modeling

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-128**
**Presentation Time: 15:00 to 16:00**

## COMPARISON OF THE VISUAL CAPABILITIES OF AN AMPHIBIOUS AND AN AQUATIC GOBY INHABITING TIDAL MUDFLATS

**Masayuki Yoshida[1]; Tomo Takiyama[1]; Sawako Hamasaki[1]**

The tidal mudflats provide rich environments that are inhabited or utilized by a great variety of organisms. The mudskipper Periophthalmus modestus and the yellowfin goby Acanthogobius flavimanus are gobiid teleosts inhabiting the intertidal mudflats in estuaries. While P. modestus has an amphibious lifestyle and forages on the exposed mudflat during low tide, the aquatic A. flavimanus can be found at the same mudflat at high tide. Retinal ganglion cell topography revealed that both species possess an area in the dorso-temporal region of the retina, indicating high acuity in the lower frontal visual field. In addition, P. modestus has a minor area in the nasal portion of the retina, shaping the horizontally extended high ganglion-cell density area. This possibly reflects the need for horizontal sight on the exposed mudflat in P. modestus. Behavioral experiments were performed to examine postural and eye direction control when orienting toward the object of interest. When the target situated below eye level, both species direct their visual axes to the target just before a rapid approach toward it. A characteristic feature of the orienting behavior of P. modestus was that they aimed at the target located above eye level by rotating the eye and lifting the head before jumping to attack it. This behavior could be an adaptation to terrestrial feeding habitat in which buoyancy is irrelevant.

**Sensory: Vision**

Keywords :retinal topography; fish; foraging behavior

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-129**
**Presentation Time: 16:00 to 17:00**

## EFFECTS OF LIGHT VARIATIONS IN CELL PROLIFERATION IN THE RETINA OF FISH AUSTROLEBIAS CHARRUA

**Ines Berrosteguieta[1]; Juan Carlos Rosillo[1]; Anabel Fernandez[1,2]**

Instituto de Investigaciones Biológicas Clemente Estable,Montevideo,Uruguay[1]; Facultad de Ciencias,Montevideo,Uruguay[2]

Animals obtain information from the environment using a variety of senses, such sensory information is critical for adaptation and survival. Austrolebias charrua fishes are native and inhabit temporary ponds. These fishes are macroptic and have a great sexual dimorphism, where males courts females using visual information. Variations in lighting conditions of temporary ponds, due to the natural process of drying, can cause changes in the plasticity of sensory organs such as the retina. One way to study these processes is the differential detection of proliferative and neurogenic activity. We have previously shown that ciliary marginal zone (CMZ) of A. charrua's retina exhibit a high proliferative rate that is related to growth and adult neurogenesis. Adult fish were exposed to two experimental conditions: one group was maintained with natural light, and another group in constant darkness. Both groups received the same treatment that involves the injection of two cell proliferating markers (CldU and IdU), with different survival times: 30 days and 24 h respectively. Then, animals were fixed by perfusion. Proliferation markers were revealed by immunohistochemistry with different fluorophores and slices were analyzed in confocal microscope (Olympus FV300). A significant increase of proliferation was observed in the CMZ and in another retinal zones in darkness condition. An increased of CldU-positive nuclei was observed in the retinal inner nuclear layer. We conclude that enhanced proliferation in different areas of the retina is necessary to increase the amount of photoreceptors and neurons in darkness conditions, for processing visual information.

**Sensory: Vision**

Keywords :retina; proliferation; plasticity

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-130**
**Presentation Time: 17:00 to 18:00**

## RAPID, COORDINATED EYE GROWTH IN DIVING BEETLE LARVAL EYES.

**Elke Buschbeck[1]; Shannon Werner[1]; Annette Stowasser[1]; Aaron Stahl[1]; Madeline Owens[1]**

University of Cincinnati,Cincinnati,USA[1]

Vision is a prominent sense in many organisms, and for eyes to function properly all components have to develop in a coordinated fashion so that lenses project focused images on respective retinas. Substantial data continues to become available on how such coordination is established in vertebrates, but some of the most basic questions in this regard remain unanswered for arthropods. Holometabolous insect larvae typically undergo dramatic growth around ectdysis, and we find that the large image-forming larval eyes of the diving beetle Thermonectus marmoratus grow to ~130% of their original size at the transition from second to third instars. Lenses of second instars produced good images until the end of their larval instar stage, but become non-functional immediately after molting until approximately 8 hours post-molt, at which point they have reformed with longer focal lengths. Interestingly, the eye tubes already lengthen within the first hour post-molt. The rapidity of this elongation suggests that eye enlargement could be mediated osmotically; preliminary experiments indicate that this indeed is the case. To investigate mechanisms of eye growth further we developed an opthaomoscope for live retinal imaging that allows us to directly determine the refractive state of T. marmoratus larval eyes under different experimental conditions. In addition we established molecular methods allowing us to monitor gene expression and perform RNAi. Our results thus far indicate that knocking down a key lens protein leads to myopia, and that (in contrast to vertebrates) visual input may not be necessary to coordinate eye growth in Thermonectus.

**Sensory: Vision**

Keywords :emmetropia; insect vision; optics

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-131**
**Presentation Time: 18:00 to 19:00**

## NOW YOU SEE IT, NOW YOU DON'T: HOW MUCH DARKNESS DOES IT TAKE TO DISRUPT BEHAVIOURAL COLOUR DISCRIMINATION IN ANURAN AMPHIBIANS?

**Carola Yovanovich[1]; Sanna Koskela[2]; Noora Nevala[2]; Sergei Kondrashev[3]; Kristian Donner[2]; Almut Kelber[1]**

Lund University,Lund,Sweden[1]; University of Helsinki,Helsinki,Finland[2]; Russian Academy of Sciences,Vladivostok,Russia[3]

For most vertebrates, the visual world turns monochromatic at night because the cone photoreceptors used for colour vision are not sensitive enough to be functional, whereas the highly light-sensitive rod photoreceptors come in a single spectral sensitivity flavour, not allowing for the signal comparison needed for wavelength discrimination. However, amphibians have two distinct spectral classes of rods: the green-sensitive, with peak sensitivity at 500 nm, and the blue-sensitive, only found in this group, with peak sensitivity at 430 nm. Because of this dual rod system, it has been repeatedly suggested that they might be able to see colours at light intensities in which most animals can barely -if at all- see anything. Determining the threshold for colour vision is critical to elucidate which photoreceptors are involved in this ability throughout the light range in which vision is functional, and to unravel which role, if any, rod photoreceptors play in colour vision. We tested colour vision thresholds in two anuran species using three different behavioural approaches to determine the light intensity threshold of colour discrimination. All tests yielded similar values, showing that amphibians' ability to see colours persists at light levels in which other vertebrates have lost it. However, at light levels close to the absolute visual sensitivity threshold the colour discrimination performance is lost, meaning that in that range the two spectrally different kinds of rods cannot support colour vision.

**Sensory: Vision**

Keywords :frog; colour vision; threshold

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-132**
**Presentation Time: 15:00 to 16:00**

## INTEGRATING MULTIPLE VISUAL INPUTS IN THE FLY

**Ben Hardcastle[1]; Daniel Schwyn[1]; Karin Bierig[2]; Holger Krapp[1]**

Imperial College,London,UK[1]; Max Planck Institute for Biological Cybernetics,Tuebingen,Germany[2]

In blowflies, two visual systems input to the gaze stabilization system: the motion vision pathway provided by the compound eyes, and the ocelli, which signal light intensity changes in the dorsal visual hemisphere. Individually, these pathways cover different dynamic input ranges and incur different processing delays. The signals provided by these two pathways are integrated and used to effect appropriate movements of the head to stabilize gaze, but the underlying mechanisms have not yet been studied quantitatively. In behavioural experiments we simulated body roll and measured compensatory head rotations in response to oscillations of a false-horizon at up to 10 Hz. We found that the ocellar input reduces the response delay by an average of 5 ms but does not significantly affect the response gain, suggesting a non-linear integration of compound eye and ocellar signals. We are now performing intracellular recordings from descending neurons receiving input from the motion vision pathway and the ocelli in response to the same visual stimulus used in our behavioural experiments. This will allow us to study how the signals are combined to give the behavioural output observed.

**Sensory: Vision**

Keywords :multisensory integration; gaze stabilization;

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-133**
**Presentation Time: 16:00 to 17:00**

## ELECTRIC ORGAN DISCHARGE MODULATIONS IN THE PULSE-TYPE ELECTRIC FISH MICROSTERNARCHUS (GYMNOTIFORMES) EXPOSED TO A JAMMING STIMULUS

**José Alves Gomes[1]; Thiago Petersen[1]; Clifford Keller[2]; Christopher Braun[3]**

Instituto Nacional de Pesquisas da Amazonia,Manaus,Brasil[1]; University of Oregon,Eugene,USA[2]; CUNY,New York,USA[3]

The goal of the present work is to describe the EOD modulations produced by the pulse-type electric fish (genus Microsternarchus) in the presence of an interfering (jamming) electrical stimulus. We used 28 fish collected in tributaries of the Rio Negro, Amazonas, Brazil. The fish’s own EOD (S1) was recorded by a pair of silver electrodes near the fish's head and tail. An interfering signal (S2), amplitude matched to the S1, was presented through a pair of silver electrodes placed perpendicularly to the fish's head, at a fixed distance. Two types of experiments were conducted: 1) Delta Frequency (DF), where the S2 was presented for 15 s with an initial frequency difference from the S1 of between -5 and +5Hz; and 2) Delta Phi (Dphi), where the S2 was phase-locked (with values from O° to +/-180°) with the S1, over a 10 s period. Changes in the S1 EOD rate were related to the polarity of the DF or Dphi signals: EOD rises are most common for negatives DF or Dphi, whereas EOD rate falls were more common for positives DF or Dphi. Only females produced EOD interruptions (brief: 39 to 91 ms; or long: 2 to 39 s). Short chirps (<15 ms) were more commonly in males. “Phasic behaviors” (lock, scanning and skipping) were also observed. A neurophysiological model similar to Brachyhypopomus is supported by these data.

**Social Behavior**

Keywords :microsternarchus; eod modulation; jamming stimulus

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-134**
**Presentation Time: 17:00 to 18:00**

## ADULT FEMALE RATS ARE MORE SENSITIVE THAN JUVENILES TO COCAINE'S EFFECTS ON SEXUAL BEHAVIOR

**Daniella Agrati[1]; Luna Machado[1]; Marcela Ferreño[1]; Natalia Uriarte[1]; María José Zuluaga[1]; Annabel Ferreira[1]**

Facultad de Ciencias, UdelaR,Montevideo,Uruguay[1]

The sexual behavior of female rats is highly motivated and its expression has been associated with dopaminergic mesocorticolimbic activity. Because during adolescence this system is still developing, it could be speculated that the effect of dopaminergic agonists on sexual motivation will differ between adolescent and adult female rats. To test this hypothesis we assessed the preference for male vs female in a Y-maze with three choice chambers (male, female and empty) and the sexual behavior with a male, of late adolescent (45-55 days-old) and adult (100-120 days-old) female rats during the proestrous stage of their estrous cycle after the administration of cocaine (0.0, 5.0, 10.0 and 20.0 mg/kg ip). We observed that juvenile and adult females exhibited a clear preference for the male, which was not modified by cocaine administration. All doses of cocaine increased ambulation of the females in the Y-maze, an effect that was higher in adult compared to juvenile rats. Interestingly, only the highest dose of cocaine reduced sexual proceptivity and receptivity in adult, but not juvenile, females. Thus, during proestrus, adult females are more susceptible than late adolescents to the effects of cocaine' acute administration on motor activity and sexual behavior. These results provide elements for understanding age-related changes of the dopaminergic system, as well as its role on the regulation of female's sexual behavior. Financial support: CSIC I+D-SNI-PEDECIBA

### Social Behavior

Keywords :sexual behavior; dopaminergic system; adolescence

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-135**
**Presentation Time: 18:00 to 19:00**

## SEXUAL BEHAVIOR AND MATING PLUGS IN THE COLOMBIAN ORB-WEB SPIDER LEUCAUGE ACUMINATA (ARANEAE, TETRAGNATHIDAE)

**Linda Carolina Hernández Duran[2]; Anita Aisenberg[1]; Jorge Molina[2]**

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Different reproductive strategies are used by males to ensure female remating avoidance. Examples of these strategies are seen in arthropods, in which mating plugs are placed in the female genital opening impeding or reducing the possibility of extra matings. In Leucauge orb web spiders, females defy the rules, because they produce a substance that is necessary for efficient copulatory plug formation during or after mating. Females produce plugs depending on male performance before and after mating, but there is plug variation between species. Leucauge acuminata is a very abundant spider in Cundinamarca, Colombia, however the sexual behavior of this species is completely unknown. Our aim was to describe courtship and copulatory behavior of L. acuminata and check whether copulatory plugs occur in this species. For that purpose we performed field samplings and analyzed the occurrence of copulatory plugs, and performed staged matings with virgin females under laboratory conditions (n=20). We observed that 25% percent of the females collected at the field showed copulatory plugs. Courtship duration was 173 ± 171.9 sec (mean ± SD) and copulation 1235 ± 803.4 sec. Male behaviors such as palpal insertions and tapping of the female were positively related with copulatory plug formation. We discuss the possibility of female choice on male copulatory performance and compare the results with the information available for other species of the genus.

### Social Behavior

Keywords :mating plug; leucauge acuminata; male performance

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-136**
**Presentation Time: 15:00 to 16:00**

## CHARACTERISATION OF NESTMATE RECOGNITION CUE LEARNING IN APIS MELLIFERA AND CAMPONOTUS CONSOBRINUS

**Susie Hewlett[1]; Andrew Barron[1]**

Macquarie University,Sydney,Australia[1]

Nestmate recognition is essential for the function of social insect societies. While nestmate recognition has been a major focus of evolutionary research, the mechanisms underlying social bond formation in insects remain unclear. Here I report a new bioassay for nestmate discrimination that will enable analysis of how and when nestmate affiliation develops in A. mellifera and C. consobrinus. Previous laboratory bioassay designs tend to focus on the simultaneous behaviour of two or more individuals, making it impossible to decide if all or one has successfully discriminated a nestmate or not. Furthermore, the reaction of recipients to a treated individual is usually studied, revealing the timing of cue acquisition but not the mechanism of recognition cue learning. I have designed a new bioassay in which the focal animal can detect the odour of live nestmate and non-nestmate conspecifics. More time spent in proximity with their nestmate will indicate successful nestmate recognition. By comparing the responses of focal animals of different ages and different amounts of experience with nestmates, we can infer the olfactory learning processes involved and make testable predictions about the underlying neural mechanisms. Comparison of two insect species with comparable society structures will provide greater insight for subsequent mechanistic predictions.

**Social Behavior**

Keywords :nestmate recognition; hymenoptera; olfactory learning

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-137**
**Presentation Time: 16:00 to 17:00**

## PLASTICITY OF SENSORY SYSTEMS, SYNAPSES, AND BEHAVIOR IN A REMARKABLY POLYMORPHIC ANT: THE NEUROBIOLOGY OF SPECIALIZATION IN A SOCIAL SYSTEM

**Darcy Gordon[1]; James Traniello[1]**

Boston University,Boston,United States[1]

Social organization in insects may feature striking morphological differentiation and task specializations among workers, providing excellent opportunities to explore relationships between morphology, neural circuitry, and behavior. The ant Pheidole rhea is characterized by three morphological worker groups: minors, majors, and supersoldiers. This remarkable polymorphism allows us to explore behavioral plasticity and how it is underscored by variation in sensory structures and higher-level integration at the level of the individual, subcaste, and colony in a dynamic social context. We hypothesize task specialization has shaped the nervous systems of workers to adaptively process information from different sensory environments, resulting in divergences in sensory perception and integration centers in the brain that produce behavioral output. We use P. rhea as a model to determine how behavioral repertoire is linked to sensory structures and synaptic organization using scanning electron microscopy, immunohistochemistry, and confocal microscopy. The size and number of compound eye facets, the type and distribution of antennal sensilla, and synaptic complexes (microglomeruli) of mushroom body calyxes were measured to examine the relationship of sensory system differentiation to information processing. Results suggest there is significant overlap in behavioral repertoire between subcastes, but each subcaste has different propensities for task performance. The relationship between behavioral specialization and plasticity in light of differences in sensory perception and variation in information processing (microglomeruli) will be discussed.

### Social Organization

Keywords :neuroecology; social brain evolution; distributed intelligence

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-138**
**Presentation Time: 17:00 to 18:00**

## DAILY THERMAL FLUCTUATIONS DURING PUPAL DEVELOPMENT AFFECT THE MUSHROOM BODY SYNAPTIC CONNECTIONS IN THE ADULT ANT BRAIN

**Agustina Falibene[1]; Flavio Roces[1]; Wolfgang Rössler[1]; Claudia Groh[1]**

University of Würzburg,Würzburg,Germany[1]

Social insects are able to control the correct development of their brood by regulating the temperature they are exposed to by different mechanisms. Camponotus mus ants expose their brood to daily thermal fluctuations moving it inside the nest following a circadian rhythm. At the middle of the photophase they translocate the brood to 30.8°C, and 8 h later they move it back to 27.5°C. We investigated whether the daily thermal fluctuations experienced by the pupae affects the synaptic organization in the adult brain, in particular the mushroom body (MB) sensory input regions (calyces). Neuropil volumes and number of synaptic complexes (microglomeruli, MG) in the olfactory (lip) and visual (collar) regions were quantified in freshly emerged workers that had been reared at different amplitudes of thermal variation (but the same mean temperature) or different constant temperatures. Thermal regimes affected particularly the large olfactory non-dense lip region of the MB while changes in the dense lip and the visual collar were less evident. The thermal fluctuation experienced by the pupae through the nurses' thermal preferences for brood translocation (amplitude 3.3°C) increased the MG formation in the calyces when compared with smaller or higher thermal amplitudes (0, 1.5, 9.6°C) or constant temperatures (25.4, 35°C). We conclude that the precise thermoregulatory control of brood rearing in ants generates area-specific effects on synaptic neuropils in the adult brain. Differences in the neuronal circuitry would affect further processing of sensory information and learning abilities in ants. Supported by DFG SFB-1047 'Insect timing' (B5, B6 and C1).

### Synaptic Plasticity

Keywords :mushroom body; temperature; insects

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-139**
**Presentation Time: 18:00 to 19:00**

## EXPERIENCE-INDEPENDENT AND –DEPENDENT PLASTICITY IN OPSIN GENE EXPRESSION AND IN PRIMARY AND SECONDARY VISUAL CENTERS OF THE ANT CAMPONOTUS RUFIPES

**Annekathrin Lindenberg[1]; Ayse Yilmaz[1]; Stephanie Mildner[1]; Flavio Roces[1]; Johannes Spaethe[1]; Wolfgang Rössler[1]; Claudia Groh[1]**

In the polymorphic ant Camponotus rufipes, media sized workers undergo an age-related polyethism: after nursing tasks inside the nest, workers switch to multimodal foraging tasks in the environment. During field studies, we could show that foragers of C. rufipes are mainly night active, but are able to shift their foraging activity to daylight conditions. In the present study, we investigate whether this transition is accompanied by adaptations in peripheral and central visual systems. Our results show that C. rufipes workers of all tested ages express three genes encoding ultraviolet (UV), blue (BL) and long wavelength (LW) sensitive opsins in their retina, which are likely to provide the substrate for trichromatic color vision. Expression levels of all three opsin genes increased significantly within the first two weeks of adult life and following light exposure. Interestingly, the volumes of the optic neuropils (lamina, medulla, lobula) showed corresponding volume increases. In the MB collar, volumes and densities of synaptic complexes (microglomeruli, MGs) increased with age as well. Light exposure for 4 days induced a decrease in MG densities followed by an increase after extended light exposure. This shows that plasticity in retinal opsin gene expression and structural neuroplasticity in primary and secondary visual centers comprise both 'experience-independent' and 'experience-dependent' elements. Our results indicate that structural plasticity is driven by both intrinsic factors and visual experience, which is likely to play an important role in the timing of behavioral transitions from nursing to foraging. Supported by DFG SFB 1047 (B3, 5, 6, C1).

### Synaptic Plasticity

Keywords :camponotus rufipes; opsin genes; mushroom body

**Poster Session I, March 31, 15:00 - 19:00 h.**
**Poster Number: I-140**
**Presentation Time: 15:00 to 16:00**

## SEARCHING FOR MUSCLE MEMORY OF VOCAL MOTOR SKILLS IN THE BRAIN OF FEMALE CANARIES

**Mariana Rocha[1]; Jes Dreier[2]; Jonathan R. Brewer[2]; Manfred Gahr[1]; Michiel Vellema[3]**

Max Planck Institute for Ornithology,Seewiesen,Germany[1]; University of Southern Denmark,Odense,Denmark[2]; University of Southern Denmark,Odense,Denmark[3]

Practicing a motor task like riding a bike improves performance, and although the acquired motor skills degrade if practice is ceased, recovery is much faster when practice is resumed. This phenomenon, known as ‘savings’, is still poorly understood, and implies that the muscle memory formed with initial practice is maintained thereafter. We investigate a possible brain mechanism of vocal motor savings in canaries. Female canaries don’t usually sing but will produce song when treated with testosterone, which also induces the restructuring of the song control system, the set of interconnect brain nuclei controlling song production. When re-treated with testosterone, female canaries who previously produced song, will return to similar levels of song performance much faster, as indicated by a steeper increase in syllable production rate. However, it is unknown where this muscle memory is stored. Nucleus HVC, which is involved in controlling song syllable timing and part of both the motor pathway driving song production and the cortico-basal ganglia feedback loop for song learning, seems like a likely candidate. We investigate changes in the density of dendritic spines, possibly involved in memory storage, of Golgi-impregnated HVC neurons of female canaries. We hypothesize that spine density increases with the first testosterone-induced singing experience, stabilizing thereafter, even when testosterone is removed and song production ceases, indicating a possible mechanism for muscle memory storage of vocal motor skills.

**Synaptic Plasticity**

Keywords :muscle memory; hvc; birdsong

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-01**
**Presentation Time: 15:00 to 16:00**

## SENSORY INNERVATION OF THE VOCAL ORGAN OF A SONGBIRD

**Macarena Faunes[1]; J Martin Wild[1]**

University of Auckland,Auckland,New Zealand[1]

As for human speech, song learning and maintenance in songbirds depends on auditory feedback, but little is known about the presence or role of other forms of sensory feedback. Here we studied the sensory innervation of the syrinx of the zebra finch. The syrinx is a specialization of the junction between the trachea and the bronchi. Its inner surface is covered with collagen-rich membranes that form vocal fold-like structures (the labia) that vibrate as the bird exhales, producing sound. Externally, it is covered with muscles that adduct and abduct the labia, modulating the acoustic frequencies produced on each side. By a combination of immunohistochemistry, immunofluorescence and neural tracing with subunit B of cholera-toxin (CTB), we analyzed the peripheral and central sensory endings of the hypoglossal nerve branch that supplies the syrinx (ts nerve). We show the presence of substance P-immunopositive free nerve endings throughout the luminal surface of the trachea, in the collagen-rich syringeal membranes, and in the syringeal muscles. Furthermore, by transganglionic tracing following injections in the ts nerve, we identified as putative central targets of these receptors the lateral part of the caudal nucleus of the descending trigeminal tract, certain subnuclei of nucleus tractus solitarius, and the lateral part of the principal sensory trigeminal nucleus. Further studies are needed to unveil the sensory modalities of these receptors and the connections of their specific synaptic targets.

**Anatomy & Neuroanatomy**

Keywords :somatosensory feedback; substance p; syrinx

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-02**
**Presentation Time: 16:00 to 17:00**

## BREAKING HALLER'S RULE: CONSEQUENCES OF BRAIN ISOMETRY IN MINUTE PARASITIC WASPS

**Emma Van Der Woude[1]; Hans Smid[1]**

Wageningen University,Wageningen,the Netherlands[1]

Haller's rule states that small animals have relatively larger brains than large animals. So far, the only known species that scales brain size linearly with body size is the minute parasitic wasp Trichogramma evanescens. Linear brain scaling allows these wasps to decrease brain size beyond the abilities of animals that do follow Haller's rule. Small wasps consequently have extremely small brains, which could be facilitated by plasticity in the complexity of brain morphology. We compared complexity of the olfactory system in small and large T. evanescens using a combination of confocal laser scanning and scanning electron microscopy. We focussed on the number and size of glomeruli inside the antennal lobes, and length and number of olfactory sensilla on their antennae. Results show that small and large wasps have similarly sized olfactory sensilla, and most types occur in equal numbers. They also have equal numbers of glomeruli in the antennal lobe. Next, we studied how brain size affects brain performance in small and large wasps. We used classical conditioning procedures to study memory retention after a single visual or olfactory learning trial. We found equal memory retention levels and memory duration in small and large wasps. Our results indicate that isometric brain scaling in T. evanescens is not facilitated by plasticity in the complexity of the olfactory system, and that memory retention is not affected by having small brains. The smallest insects may not need to compromise brain structure and performance.

### Anatomy & Neuroanatomy

Keywords :allometry; plasticity; olfactory system

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-03**
**Presentation Time: 17:00 to 18:00**

## HIGHER ACTIVITY IN THE RIGHT SEPTUM OF CHICKS (GALLUS GALLUS) EXPOSED TO ELEMENTARY MOTION CUES RELATED TO ANIMACY PERCEPTION

**Elena Lorenzi[1]; Uwe Mayer[1]; Orsola Rosa Salva[1]; Giorgio Vallortigara[1]**

University of Trento,Rovereto,Italy[1]

The septum is an evolutionarily well-conserved part of the limbic system among vertebrates. It is known to be involved in many aspects of social behavior and is considered as a key node of the social behavior network. The detection of animate creatures is fundamental for survival and social interaction. Simple shapes moving in a self-propelled fashion (implying the presence of an internal energy source), are spontaneously perceived as animated and engage attention since infancy. Autonomous changes in speed are one of the cues associated with animacy perception. We were able to demonstrate that newly hatched visually naïve chicks prefer a simple object that changes its speed (accelerating-decelerating) to an identical object that moves at constant speed, suggesting that these mechanisms are predisposed and active at birth. To study the neuronal basis of this phenomenon, we exposed two groups of visually naïve chicks to either one of the two stimuli and visualized brain activity by an immunohistochemical staining of the immediate early gene product c-Fos. Results suggest a differential involvement of the right septum between the two groups. Subjects exposed to speed changes showed higher activation, implying the involvement of this social brain area in processing of elementary visual cues to animacy. We also measured activity in the intermediate medial mesopallium (an area involved in filial imprinting in chicks), arcopallium and nucleus taeniae (avian homologues to the mammalian amygdala). The activity in these areas was not different between the two groups, suggesting that the difference found in septum is region specific.

### Anatomy & Neuroanatomy

Keywords :septum; animate motion; chicks (gallus gallus)

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-04**
**Presentation Time: 18:00 to 19:00**

## DEVELOPING A STOMATOPOD OPTIC LOBE: NEURAL ORGANIZATION BENEATH THE DOUBLE-RETINA EYE OF LARVAE OF ALIMA PACIFICA

**Thomas Cronin[1]; Chan Lin[1]**

UMBC,Baltimore,USA[1]

Stomatopod crustaceans have unusual compound eyes, with dorsal and ventral hemispheres separated by two to six ommatidial rows called the midband. In two- midband-row species, such as Alima pacifica, midband photoreceptors supply two sets of enlarged lamina cartridges adjacent to those of the ventral hemisphere. A gap in the lamina exists at the location of the missing four midband lamina cartridges. How this arrangement develops is unknown. We studied the optic lobes of late-stage A. pacifica larvae. Such larvae have double-retina eyes; the developing adult retina sits adjacent to the larval one. We found that photoreceptor axons from the larval compound eye project to a larval lamina split into dorsal and ventral halves by developing tracts of the adult eye. The halves project to two medullas, which subsequently converge to a bilobed lobula. However, photoreceptors of the developing adult eye project to a single adult lamina located above the larval lamina. Each adult lamina cartridge aligns with one larval cartridge. Projections from the adult lamina supply a new adult medulla directly below the midband photoreceptors, which sends axons to the same lobula as the larva. Our results suggest that axons of the larval photoreceptors and optic-lobe interneurons guide the ingrowth of adult photoreceptor axons and neurons of the corresponding neuropils. The distinct adult medulla appears to be an evolutionary innovation associated with the midband.

**Anatomy & Neuroanatomy**

Keywords :stomatopod; optic lobe; metamorphosis

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-05**
**Presentation Time: 15:00 to 16:00**

## EXPLORATION OF THE NEURAL ARCHITECTURE SERVING THE ELABORATE VISUAL SYSTEM OF STOMATOPODS (MANTIS SHRIMPS).

**Hanne H. Thoen[1]; Nicholas J. Strausfeld[2]; Justin Marshall[1]**

University of Queensland,Brisbane,Australia[1]; University of Arizona,Tucson,USA[2]

Stomatopods (mantis shrimps) have the most elaborate visual systems known amongst all invertebrates, with specialised photoreceptors detecting up to 12 different spectral channels in addition to both linear and circular polarised light. Specialised photoreceptors are arranged in an equatorial band (midband) that divides the eye into an upper and lower hemisphere. The midband receptors detect colour and circular polarised light, while the hemispheres detect achromatic and linear polarised light. How this information is processed remains elusive. Results from behavioural and neuroanatomical experiments suggest a processing network distinct from that of other animals. Here we present the first detailed description of stomatopod visual neuroanatomy, through the optic lobes to the brain's central complex (CX). The midband information channels remain relatively segregated from the hemispheral channels, at least until the lobula, where laterally extending collaterals of midband relays intersect hemispheric presentation in the lobula, thereby indicative of channel integration. Subsets of neuronal relays from the lobula project to numerous distinct neuropils consisting of ensembles of micro and macroglomeruli. These are homologous to the optic glomerular complex of insects and have been identified in other malacostracan crustaceans. However, such numerous glomeruli appear to be special to stomatopods. Finally, we consider the stomatopod CX relative to similar structures in insects and crustaceans. With a prominent protocerebral bridge, a divided central body and paired noduli, the stomatopod CX is similar to those of insects rather than other crustaceans, implying either a close evolutionary relationship between stomatopods and insects or a fascinating example of convergent evolution.

**Anatomy & Neuroanatomy**

Keywords :stomatopods; vision; neuroanatomy

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-06**
**Presentation Time: 16:00 to 17:00**

## INSULIN EFFECT ON APPETITIVE BEHAVIOUR DEPENDS ON HONEYBEE AGE

**Carolina Mengoni Goñalons[2]; Marie Guiraud[1]; María Gabriela De Brito Sanchez[1]; Walter M. Farina[2]**

Université de Toulouse,Toulouse,France[1]; Universidad de Buenos Aires,CA de Buenos Aires,Argentina[2]

Worker honeybees (Apis mellifera) perform different tasks throughout their adultlifespan. While young workers remain inside the nest performing maintenance and brood caring duties, older ones gather resources outside. It has been proposed that the insulin signalling pathway contributes to age related changes in task performance of eusocial insects. Insulin levels are higher in foragers than in food processors and nurses. As transition between tasks implies a differential use of sensory modalities, we wished to evaluate the effect of insulin on olfactory and gustatory sensitivity as well as on appetitive olfactory learning of preforager workers. Bees of known age reared either in the laboratory or in the hive were abdominally injected with 1 µl of insulin or Hepes buffer. Spontaneous responses toward odours, sucrose sensitivity and olfactory learning were tested immediately after insulin injection by examining the proboscis extension response. Insulin injected bees had higher spontaneous odour responses, independently of their age or their rearing environment. Sucrose sensitivity and odour discrimination during olfactory conditioning were differently affected by insulin according to age; whereas insulin injected younger workers increased their gustatory responsiveness and showeddiminished learning abilities, older bees showed the opposite behaviour. In sum, insulin improves chemosensory responsiveness in young workers, but impairs their odour discrimination. Thus, the insulin pathway would be readily mature in these young bees, although they are still performing inhive activities. These results show a strong effect of insulin on appetitive behaviour, which reinforces the variable behavioural repertoire found in the honeybee worker caste throughout adulthood.

### Behavioral Plasticity

Keywords :honeybee; insulin; chemosensory perception

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-07**
**Presentation Time: 17:00 to 18:00**

## EVALUATION OF COGNITIVE, MOTOR AND SOCIAL PHENOTYPES IN TWO RODENT MODELS OF NEURODEGENERATIVE DISEASE

**Lionel Muller Igaz[1]; Pablo Roberto Silva[1]; Julio Armando Alfieri[1]**

IFIBIO Houssay (UBA-CONICET),Buenos Aires,Argentina[1]

Frontotemporal Dementia (FTD) and amyotrophic lateral sclerosis (ALS) are two human neurodegenerative diseases associated to mislocalization and aggregation of the nuclear protein TDP-43. We have previously shown in mice that inducible overexpression of human nuclear wild-type TDP-43 protein (hTDP-43-WT) or a cytoplasmically localized form (hTDP-43-NLS) in forebrain neurons evokes neuropathological changes that recapitulate several features of TDP-43 proteinopathies. We conducted a variety of behavioral tests to evaluate the effect of TDP-43 on motor, cognitive and social function. Our results indicate that hTDP-43-NLS mice develop motor abnormalities, including a dramatically altered rotarod performance, a spontaneous hyperlocomotor phenotype and pathological abnormal limb clasping as early as 2-4 weeks post transgene induction. hTDP-43-NLS mice also showed altered social investigation behavior, a hallmark feature of FTD patients. Furthermore we found significant deficits in cognitive function in novel object recognition, inhibitory avoidance and Y-maze tests at 1 month post-induction. We also determined that young hTDP-43-WT transgenic mice, in opposition to hTDP-43-NLS mice, present a normal motor phenotype compared to control littermates, as assessed by rotarod performance, spontaneous locomotor activity and a milder degree of spasticity. We are currently performing a broader behavioral characterization which suggests an impairment in cognitive and social domains in the absence of overt motor abnormalities, providing further validation for the use of these mice to model different aspects of FTD/ALS. These results will contribute to address in vivo the pathogenic mechanisms underlying TDP-43 proteinopathies.

### Behavioral Plasticity

Keywords :memory; tdp-43; sociability

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-08**
**Presentation Time: 18:00 to 19:00**

## NEURAL MECHANISMS OF COURTSHIP COMMITMENT IN DROSOPHILA MELANOGASTER

**Joshua Lillvis[1]; Kaiyu Wang[1]; Daniel Bath[1]; Barry Dickson[1]**

Janelia Research Campus,Ashburn,USA[1]

Successful completion of goal-directed behaviors often requires commitment in the face of adversity. In Drosophila courtship, copulation success frequently necessitates that males remain committed to courting for several minutes in response to stimulatory cues that may be only intermittently present. Here, we examine neural mechanisms underlying courtship commitment by focusing on one aspect of male courtship behavior: wing extension. Previous work has shown two neuron classes, P1 and pIP10, which can produce courtship-like wing extension and song when activated. Acute activation of P1 neurons produces persistent courtship behavior in isolated males as measured by wing extension. Activation of pIP10 neurons produces only transient wing extension. Using thermogenetic and optogenetic activation, silencing, and neuronal epistasis behavior experiments as well as ex vivo electrophysiology experiments we show that pIP10 is a command-like neuron, functionally excited by P1, and necessary to produce P1-induced and naturally occurring pulse song, the major component of wing extension. Using ex vivo calcium imaging experiments, we found that acute pIP10 activation produced a transient increase in pIP10 calcium concentration. Conversely, acute P1 activation induced persistent calcium concentration increases in P1 and pIP10. Blocking cholinergic receptors eliminated the P1-induced persistent calcium concentration increase in pIP10 but not P1, suggesting that the persistent increase in P1 calcium concentration was due to intrinsic properties of P1. The results suggest that commitment to courtship behavior may be due, in part at least, to intrinsic P1 properties that convert acute excitatory signals into persistent responses that are propagated to downstream command-like neurons.

### Behavioral Plasticity

Keywords :drosophila; courtship; goal-directed behavior

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-09**
**Presentation Time: 15:00 to 16:00**

## EARLY HANDLING PROMOTES RESILIENCE TO PRENATAL STRESS-INDUCED DEFICITS IN JUVENILE RATS

**Melissa Pavez-Fox[1]; Alexies Dagnino-Subiabre[1]**

Universidad de Valparaíso,Valparaíso,Chile[1]

Experiences during early life play a key role in programming an individual's phenotype to cope with later-life environment. During this critical period of brain development, an adverse environment (stressful experiences) can impair specific circuits that underlie emotional and cognitive functioning and behavior. Specifically, stress during gestation is a risk factor for several psychiatric disorders. Notwithstanding, nursing is critical period in which maternal care can exert long lasting changes in an individual's functioning and behavior. The aim of this study was to determine whether a protocol to increase maternal care (early handling) can counteract prenatal stress-induced deficits in anxiety and depression-related behaviors in infant rats. For the purposes of this study, male and female rats were subjected to a gestational stress. An experimental group of rats were subjected to an early handling protocol while animals of the control group were not. Between postnatal day 24 and 28, anxiety-like behaviors were evaluated in both an open field environment and in elevated maze tests. Depression-like behavior was also evaluated through social interaction and a forced swim test. In a sex-dependent manner, the early handling protocol was able to decrease the effects induced by gestational stress, decreasing anxiety and depressive-like behaviors. These results suggest that early handling promotes resilience to behavioral deficits induced by prenatal stress.

### Behavioral Plasticity

Keywords :prenatal stress; early handling; resilience

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-10**
**Presentation Time: 16:00 to 17:00**

## ERYTHROPOIETIN PROMOTES NEURAL PLASTICITY AND SPATIAL MEMORY RECOVERY IN FIMBRIA- FORNIX–LESIONED RATS

**Susana Delgado-Ocaña[1]; William Almaguer-Melian[1]; Daymara Mercerón-Martínez[2]; Nancy Pavón-Fuentes[1]; Esteban Alberti-Amador[1]; Rilda León-Martínez[1]; Nuris Ledón[3]; Jorge Alberto Bergado-Rosado[1]**

Centro Internacional de Restauración Neurológica,La Habana,Cuba[1]; Centro de Neurociencias de Cuba,La Habana,Cuba[2]; Centro de Inmunología Molecular,La Habana,Cuba[3]

Erythropoietin (EPO) upregulates the mitogen activated protein kinase (MAPK) cascade, a central signaling pathway in cellular plastic mechanisms, and is critical for normal brain development. We hypothesized that EPO could modulate the plasticity mechanisms supporting spatial memory recovery in fimbria-fornix–transected animals. Fimbria-fornix was transected in 3 groups of rats. Seven days later, EPO was injected daily for 4 consecutive days within 10 minutes after training on a water maze task. Our results show that EPO injections 10 minutes after training produced a substantial spatial memory recovery in fimbria-fornix lesioned animals. In contrast, an EPO injection shortly after fimbria-fornix lesion surgery does not promote spatial-memory recovery. Neither does daily EPO injection 5 hours after the water maze performance. EPO, on the other hand, induced the expression of plasticity-related genes like arc and bdnf, but this effect was independent of training or lesion. This finding supports our working hypothesis that EPO can modulate transient neuroplastic mechanisms triggered by training in lesioned animals.

Consequently, we propose that EPO administration can be a useful trophic factor to promote neural restoration when given in combination with training.

### Behavioral Plasticity

Keywords :erythropoietin; fimbria-fornix lesion; neural plasticity

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-11**
**Presentation Time: 17:00 to 18:00**

## THINK BEFORE YOU LEAP: SENSORIMOTOR PLANNING PRIOR TO TAKEOFF ENABLES ACCURATE LANDING IN AN ECHOLOCATING BAT

**Eran Amichai[1]; Yossi Yovel[1]**

Organisms display a hugely diverse and incredibly sophisticated array of sensory systems to extract information about their environment. Sensing the environment, however, is only one side of the story; to achieve its goals an animal must act upon the information gained by its senses. For echolocating bats, this requires sensorimotor integration operating on several levels, including control of flight mechanisms, but also control of sound emission to optimize sensory acquisition. Bats fly fast and suffer from a short bio-sonar detection range. This combination necessitates them to react rapidly upon detection and to execute exact motor plans when approaching landing or prey. To study bats' use of sensorimotor planning we trained bats to fly to a target at different distances, and analyzed their echolocation parameters immediately before takeoff to quantify sensory input and assess the bat's perception of target distance. We compared perceived target distance to motor execution and sensorimotor feedback loops: velocity patterns, in-flight echolocation sequence, and buzz initiation timing. We found that bats execute a sensorimotor plan as much as 1,200ms prior to landing, which is determined by the sensory input prior to takeoff: bats adjusted their sensory acquisition sequence to target distance from the moment of takeoff, strongly suggesting they first estimate the flight distance and then take off. In combination with fine flight control this allowed them to approach landing at the same sensorimotor phase: they decreased their velocity and initiated the buzz at a constant distance to the target, regardless of the initial distance at takeoff.

### Behavioral Plasticity

Keywords :sensorimotor; echolocation; bat

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-12**
**Presentation Time: 18:00 to 19:00**

## MPOA AND MPFC ACTIVATION PATTERNS AFTER THE CO-EXPRESSION OF MATERNAL AGGRESSION AND SEXUAL BEHAVIOR IN POSTPARTUM ESTROUS RATS

**Marcela Ferreño[1]; Gabriela Bedó[1]; María JOSÉ Zuluaga[1]; Natalia Uriarte[1]; Annabel Ferreira[1]; Daniella Agrati[1]**

Facultad de Ciencias; Universidad de la República,Montevideo,Uruguay[1]

Postpartum estrous (PPE) females are maternal and sexually motivated, and when tested in their home-cages with pups and a male intruder, they co-express maternal-aggressive and sexual responses towards the male. The neural circuits implicated in the regulation of maternal and sexual behaviors are greatly overlapped; however it is unknown how these circuitries work when both behaviors are co-expressed. As the medial preoptic area (MPOA) has a main role in the regulation of maternal and sexual behaviors and the medial prefrontal cortex (mCPF) is implicated in decision making and task switching, we hypothesized that during the co-expression of maternal aggression and sexual behavior the activity of these areas differs to the one observed when females perform only one of these behaviors. To test this hypothesis we quantified c-Fos inmunoreactivity on MPOA and mPFC of five groups of PPE females: sexual control (SxC, 2.5h without pups/undisturbed), maternal control (MC, with pups/undisturbed), aggression (Ag, with pups/confronted to a female), sexual (Sx, 2.5h without pups/ confronted to male) and sexual/aggression- SxAg (with pups/confronted to male). Groups that had recent interaction with pups (MC, Ag and SxAg) exhibited elevated c-Fos expression in MPOA that was further enhanced in some sub-regions of this area of females that experienced sexual interaction (Sx and SxAg).

Moreover, cingulate and prelimbic sub-regions of mPFC showed the greatest number of c-Fos reactive neurons in SxAg females. Although preliminary, these results suggest that the co-expression of antagonist behaviors –maternal aggression and sexual behavior- requires a more complex processing in prefrontal areas.

### Behavioral Plasticity

Keywords :postpartum estrus; motivation; c-fos expression; ;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-13**
**Presentation Time: 15:00 to 16:00**

## VOCAL LEARNING AND INFORMATION CONTENT IN THE ACOUSTIC COMMUNICATION OF BATS

**Yosef Prat[1]; Mor Taub[1]; Yossi Yovel[1]**

Tel Aviv University,Tel Aviv,Israel[1]

Language is often regarded as a defining feature of human culture. However, it is still unclear which linguistic aspects are human specific. The evolution of language is shrouded in mystery due to the challenge in inferring behavioral traits from fossils, and since parallels to communication systems of other animals are rare. We study the extremely social and vocal Egyptian fruit bat (Rousettus aegyptiacus). We kept adult bats and reared pups in controlled conditions, and continuously monitored their vocal behavior for many months. We recorded hundreds of thousands of vocalizations and identified their social contexts. Our huge dataset revealed that the ontogeny of vocal communication in young pups includes vocal learning, driven by a process which is reminiscent of babbling behavior in human babies. Moreover, after pinpointing some of the learned attributes in the natural bat repertoire we manipulated pups vocal ontogeny, using playbacks during infancy. We further analyzed the adult vocal repertoire. However, in contrast to other studies which emphasized vocalizations in extreme social situations, such as courtship or alarm, we studied ordinary chatters which accompany everyday, mostly aggressive, interactions. These mundane vocalizations dominate the vocal communication of many species but are often overlooked in acoustic studies. We found significant differences between vocalizations produced by, and even addressed to, different individuals, and between vocalizations emitted in different behavioral contexts. Given this complexity we conclude that bats can be used as a model for the study of vocal communication and language evolution.

### Communication

Keywords :animal communication; language evolution; vocal learning

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-14**
**Presentation Time: 16:00 to 17:00**

## WHAT'S ALL THE BUZZ ABOUT? - A NOVEL FORM OF SEISMIC COMMUNICATION IN CHAMELEONS

**Michael Smith[1]; Steve Huskey[1]; Christopher Anderson[2]; Kenneth Barnett[3]**

Western Kentucky University,Bowling Green,USA[1]; Brown University,Providence,USA[2]; New York Department of Environmental Conservation,Albany,USA[3]

Vibratory communication via substrate contact is used in a diverse range of taxonomic groups. One group that has been understudied in terms of vibratory communication is reptiles, likely because their sound production and reception capabilities are often rudimentary. An exception to this is the veiled chameleon (Chamaeleo calyptratus), which produces a low-frequency buzzing sound emanating from the throat region which can transmit vibrations down branches to other conspecifics. We have started to study the process of vibratory production and reception in chameleons. We hypothesize that this low frequency vibration is produced via contraction of muscles around an out-pocketing of the trachea known as the gular pouch. Gular pouches were dissected, photographed, and characterized in terms of size and volume in 25 species. Considerable variability in gular pouch size was found between species. Skin from the toe pads and tail of C. calyptratus were dissected and examined via light microscopy and transmission electron microscopy for potential specializations for vibration detection. In addition, auditory- and vibratory-evoked potentials will be recorded to measure the sensitivity of C. calyptratus, and other chameleon species, to sound and vibration. This work will contribute to our understanding of the biology and behavior of chameleons specifically, but may also provide insights into the evolution of seismic communication generally.

**Communication**

Keywords :seismic communication; chameleons; gular pouch

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-15**
**Presentation Time: 17:00 to 18:00**

## SYRINGEAL KINEMATICS AND SOUND EXCITATION IN THE AVIAN VOCAL ORGAN

**Jeppe Rasmussen[1]; Christian Herbst[1]; Coen Elemans[1]**

University of Southern Denmark (SDU),Odense,Denmark[1]

In contrast to laryngeally vocalizing mammals, birds vocalize using a uniquely avian vocal organ, the syrinx, located around the tracheobronchial junction and suspended in an air sac of the respiratory system. Because of the extreme difficulty in obtaining in vivo measurements of syringeal dynamics, we lack empirical evidence to precisely map motor function onto neural circuitry. We used a novel experimental paradigm to image syringeal dynamics under controlled conditions ex vivo. Spatiotemporal analysis of the oscillating sound-producing structures shows that a caudo-cranial travelling tissue surface wave is present, which is essential to maintain self-sustained oscillations during sound production. Furthermore, our data demonstrate a close association between the timing of opening/closing events and sound generation events within single oscillatory cycles across a range of species. Our data establish that birds use a myoelastic-aerodynamic (MEAD) mechanism as the primary physical mechanism for sound production with strong similarities to mammalian MEAD systems. Additionally, we used our ex vivo paradigm to test the applicability of alternative and less-invasive techniques, such as electroglottography (EGG), for quantifying syringeal dynamics. Preliminary data show a strong correlation between EGG signal and syringeal dynamics in vitro, making EGG a promising tool to quantify syringeal dynamics in vivo

### Communication

Keywords :syrinx; bird; electroglottography

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-16**
**Presentation Time: 18:00 to 19:00**

## ACOUSTIC CHARACTERISTICS OF COURTSHIP VOCALIZATIONS IN MALE NEOTROPICAL DEER

**Patricia Black Decima[1]; Alejandra Hurtado[1]; J. M. B. Duarte[2]; Ana Maria Nievas[2]; Mirta Santana[1]; Flavia Rodriguez[1]**

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Male polygynous deer rut vocalizations have contributed to understanding the mechanisms of mammalian sound production and radiation, and to their functions in male-male competition and female choice, using source-filter theory as a guide. However, there is almost no information on Neotropical cervid vocalizations, although they represent 6 genera and 18 species. The genus Mazama has 10 species of forest deer with spike antlers, which are difficult to distinguish. The objective was to record and analyze acoustic parameters in available Neotropical deer, especially Mazama, to see whether differences between species and genera could be used in identification or act as reproductive barriers. Deer recorded included Mazama americana, M. gouazoubira , M. nemorivaga , M. nana, Odocoileus virginianus, Hippocamellus antisensis and Blastocerus dichotomus. Courtship vocalizations produced during interactions with females or humans were recorded and analyzed with Praat 5.3.64. Analysis of duration and frequency parameters (mean, maximum, minimum) showed different means for all species. Statistical analysis (linear hierarchical models) of parameters in 3 species revealed significant differences in duration between M. nemorivaga and M. gouazoubira and in all frequency parameters between M. americana and M. gouazoubira. Individual differences were all significant. These short, low intensity vocalizations are different among species and individuals and may serve as an identification guide and be used by females in sexual selection.

### Communication

Keywords :mazama, bioacoustics, brocket deer; ;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-17**
**Presentation Time: 15:00 to 16:00**

## MICROHABITAT DISTRIBUTION OF WEAKLY ELECTRIC FISH POPULATIONS IN NEOTROPICAL HABITATS

**Till Raab[1]; Juan F. Sehuanes[1]; Jörg Henninger[1]; Jorge A. Molina[2]; Haleh Fotowat[3]; Rüdiger Krahe[4]; Jan Benda[1]**

Eberhard Karls Universität Tübingen,Tübingen,Germany[1]; Universidad de los Andes,Bogotá,Colombia[2]; University of Ottawa,Ottawa,Canada[3]; McGill University,Montreal,Canada[4]

Weakly electric fish have been extensively studied in the laboratory for more than half a century. In order to advance our knowledge about their behavior, taxonomy, and ecology, field studies become more and more important. Central for identification and segregation of individual fish is a detailed characterization of the fish's electric organ discharge (EOD). For wave-type fish this is the fundamental frequency (EODf) and the structure of its harmonics. This information is needed for taxonomic characterizations and is the basis for estimating the statistics of natural electrical stimuli as well as describing spatial distribution and ecological niches of weakly-electric-fish communities. We recorded electric signals of mainly Apteronotus rostratus and A. leptorhynchus, but also of Eigenmannia humboldtii, Sternopygus dariensis, and Brachyhypopomus occidentalis in about 100 m long transects of small rivers in Panama and Colombia. We developed algorithms for an automatic segregation and characterization of individual fish allowing us to characterize the spatial organization of the fish and the distribution of EODfs. Most A. rostratus resided solitary along the bank slope, but we also found a large congregation of about 20 individuals. A. leptorhynchus was hiding under rocks evenly spaced with less than half a meter distance. Frequency differences extended up to 400 Hz, but could be less than 2 Hz for close-by fish. With our algorithms low quality recordings can be reliably analyzed and thus make transect recordings more feasible.

### Communication

Keywords :weakly electric fish; electric organ discharge analysis; spatial distribution

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-18**
**Presentation Time: 16:00 to 17:00**

## VOICE DISCRIMINATION IN ZEBRA FINCHES

**Frederic Theunissen[1]; Julie Elie[1]**

University of California, Berkeley,Berkeley,United States[1]

Communication calls in birds can convey three main types of information: who, where and what. This information can be orthogonal, for instance the same individual might produce different types of communication calls. Previous studies have shown that zebra finches can recognize the identity of a conspecific producing song (used by males in courtship behaviour) or distance calls (a loud contact call). Using a conditioning experiment, here we show that male and female zebra finches are also able to discriminate calls produced by two different individuals in the other call categories of the zebra finch repertoire: the alarm calls, aggressive calls, soft contact calls used in short distance communication, nest calls and whine calls used in pair bonding behaviour, and begging calls and long tonal calls used by juveniles. Zebra finches are therefore capable of recognizing the voice of the emitter for all call types found in their repertoire. We are currently investigating, whether learning to recognize caller identity in one category generalizes to other call categories, which would be the first demonstration of true voice recognition in a non-human animal. In parallel, we have analysed the acoustical features that carry information about identity in each call category. Whereas spectral shape and pitch saliency play a crucial role for separating call types, we found that mean pitch and pitch profiles contain information about the caller's sex and individuality. These behavioural and acoustical analyses lay the foundation for the exploration of voice coding in the avian auditory system.

### Communication

Keywords :voice recognition; zebra finch; acoustical analysis

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-19**
**Presentation Time: 17:00 to 18:00**

### CO-ADAPTATION OF ELECTRIC ORGAN DISCHARGES AND CHIRPS IN SOUTH AMERICAN GHOST KNIFEFISHES (APTERONOTIDAE)

**G. Troy Smith[1]; Jacquelyn Petzold[1]; Gary Marsat[2]**

Indiana University,Bloomington,USA[1]; West Virginia University,Morgantown,USA[2]

Apteronotid fish communicate with electric organ discharges (EODs) and EOD modulations (chirps). Fish cannot detect each other's EODs directly. Rather, other EODs are detected via beats resulting from interfering EODs. Chirps are detected as transient disruptions in these beats. Chirp perception depends on both chirp structure and beat structure, and thus on the EODs that generate beats. The effect of EOD frequency on chirp detection has been well-studied in Apteronotus leptorhynchus. This study examines relationships between EODs, beats, and chirp conspicuousness across other species. Beat waveform varied nonlinearly with EOD waveform. Moderately complex EODs were faithfully represented in beat waveforms. However, for sinusoidal or very complex EODs, small changes in EOD waveform did not change the beat substantially. Thus, beat structure encodes EOD waveform, but discriminating small waveform differences is possible only for moderately complex EODs. Next, we asked whether EOD waveform was co-adapted with chirp structure across species. We constructed 'hybrid' chirps with the chirp structure of one species but EOD waveforms of other species. We compared the conspicuousness of each species' chirps on conspecific vs heterospecific EOD waveforms. Chirp parameters affected conspicuousness; "big" chirps were more conspicuous. Most species' chirps were also more conspicuous on slow (10 Hz) beats than on fast (100 Hz) EOD beats. EOD waveform also influenced chirp conspicuousness, but in ways that interacted with chirp structure and EOD frequency. These findings suggest that chirp structure and EOD properties may coevolve to optimize chirp detectability. Supported by NSF IOS 0950721 and NIHCD T32049336.

**Communication**

Keywords :electric fish; signal perception; signal evolution

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-20**
**Presentation Time: 18:00 to 19:00**

## TEMPORAL VARIABLES IN HONEYBEE FORAGING REGULATION AND ITS ERGONOMICS: FIRST INSIGHTS FROM A THEORETICAL APPROACH

**Gonzalo Corti Bielsa[1,2]**

Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires,Buenos Aires,Argentina[1]; Consejo Nacional de Investigaciones Científicas y Técnicas,Buenos Aires,Argentina[2]

The understanding of how a honeybee (Apis mellifera) colony allocates its workforce under natural conditions is probably in its beginnings. Experimental data mimicking natural conditions suggest that a wider range of behavioral phenomena is hidden or collapsed to few aspects in the most of the experimental analyses that explore honeybee foraging activity. Since these experiments are the grounds upon most of the explanatory theoretical models are build, frequently these models fail to address some important features of the foraging system. Some models have incorporated the processing subsystem as an important part of the foraging regulation, i.e. successful nectar foragers transfer the collected food by mouth-to-mouth contacts (trophallaxis) to other group into the hive, the food processors. Once they completed a nectar load, food processors unload it in the storing area of the hive. However, theoretical approaches miss the modulation of forager behavior under low reward flow regimes (similar to natural situation), where individuals modulates the amount of food they collect in each foraging visit. We present a first version of an agent-based model of foraging activity including these issues. Food sources deliver nectar at rates make agents modulate the nectar volume they gather at the feeding site. Foraging and processing systems are included, as well as a detailed model of trophallaxis. According to our simulations, the saturation level of the processing subsystem, as well as some key parameters for foragers decision making, such as the mean time until starting the nectar unloading to a processor and it variance depend not only on the proportion of foragers and processors, but also on the modulation of the time outside the hive and the load collected in the field, both variables controlled by the reward experience of the honeybee at the food source.

### Computational Modeling

Keywords :apis mellifera; foraging regulation; time variables

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-21**
**Presentation Time: 15:00 to 16:00**

## ENCODING MODELS REVEAL HOW AND WHEN THE MEANING OF COMMUNICATION CALLS IS EXTRACTED BY THE AVIAN AUDITORY CORTEX

**Julie Elie[1]; Frederic Theunissen[1]**

University of California Berkeley,Berkeley,USA[1]

Understanding how the brain extracts meaning from vocalizations is a central question in auditory research. Here, we use a very large library of zebra finch vocalizations to investigate how the avian auditory system extracts invariant features to categorize communication sounds according to their social meanings despite the acoustical variability inherent to renditions and vocalizers. Focusing on neurons in primary and secondary auditory areas that we identified as coding information about the vocalizations' meaning, we decrypt the neural computations underlying the neurons' selective and invariant properties by comparing the performances of two encoding models. Using the framework of Generalized Linear Models and regularization techniques, the first model (A) uses solely the acoustic properties of the sounds to predict the neural response while the second model (A+S) combines these properties with the vocalizations' semantic grouping. The goodness of fit of these models are compared, and then measured by rating the likelihood between a floor value obtained from a null model and a ceiling value obtained from an optimal model. We found linear neurons, for which the A model is tuned to the spectro-temporal features of a given category, and non-linear neurons which responses are best explained by non-linear transformations of spectro-temporal features that emphasize semantic categorization. In addition, the time-varying property of our models reveals the evolution of the semantic coding through the course of a call presentation: following a 70ms period where neurons tend to be linearly tuned to acoustic features, semantic information significantly enhances the prediction of the neural response for a 80 ms window centred around 110 ms.

### Computational Modeling

Keywords :vocal communication; avian cortex; semantic categorization

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-22**
**Presentation Time: 16:00 to 17:00**

## FROM DENDRITIC CHANNELS TO ESCAPE BEHAVIOR: A COMPUTATIONAL AND NEUROETHOLOGICAL APPROACH TO LOCUSTS' PREDATOR DETECTION

**Richard Dewell[1]; Fabrizio Gabbiani[1,2]**

Baylor College of Medicine,Houston,USA[1]; Rice University,Houston,USA[2]

Successfully escaping predation requires not just reliable detection of approaching predators, but successfully discriminating non-threatening stimuli as well. In locusts, visual discrimination of approaching predators can be accomplished by a single neuron within each optic lobe. This lobula giant movement detector neuron (LGMD) integrates inputs from every photoreceptor of the ipsilateral eye, following two intermediate processing stages within the lamina and medulla. Complex, nonlinear processing allows the LGMD to reliably detect looming stimuli and activate downstream neurons initiating escape. We used a combination of physiology, behavior, and computational modeling to investigate the role of the active conductances within the dendrites of the LGMD of Schistocerca americana to better understand the neural computations implemented within this looming sensitive neuron and their role in escape behavior. We demonstrated that an h-current selectively increases responses to spatially coherent approaching objects and that this increased LGMD activity increased escape behavior. Additionally, a 4-AP dependent, slowly inactivating K+ current within the LGMD selectively decreases responses to spatially incoherent looming stimuli. Detailed reconstructions of the LGMD have been used to create a multi-compartmental model within the NEURON simulation environment. With this model we show that this coherence preference depends on the retinotopic arrangement of excitatory synaptic inputs, and the interactions between the h-current and K+ current inactivation. Thus, by applying computational techniques we are able to produce a mechanistic description bridging between membrane channels and behavior.

### Computational Modeling

Keywords :looming; lgmd; integration

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-23**
**Presentation Time: 17:00 to 18:00**

## MODELING LATENCY CODE PROCESSING IN THE ELECTRIC SENSE

**Leonel Gómez-Sena[1]; Jacob Engelmann[2]; Juan Ignacio Sanguinetti-Scheck[1]**

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Understanding the coding of sensory information under the temporal constraints of natural behavior is not yet well resolved. Spike timing and latency coding can maximally exploit the timing of neural events to make fast computing elements. The electric sense of mormyrid fish provides a convenient model to study this coding scheme. The sensory input is an ordered spatial pattern of current densities which is coded in the precise timing of primary afferent spikes. The neural circuits of the processing pathway are well known and the system exhibits the best known illustration of corollary discharge, which provides the reference to decode the sensory afferent latency pattern. A theoretical model is proposed to integrate the principal traits of the neural processing structure and to study sensory interaction with motor-command driven corollary discharge signals. This has been used to explore neural coding strategies at succeeding stages in the network and to examine the simulated network capacity to reproduce output neuron responses. The model shows that the network has the ability to resolve primary afferent spike timing differences in the sub-millisecond range and that this depends on the coincidence of sensory and corollary discharge-driven gating signals. In the integrative and output stages of the network, corollary discharge sets up a temporally structured pattern of excitation and inhibition within the network whose balance is then modulated locally by sensory input. These mechanisms give the system a robust capacity to extract behaviorally meaningful features of the electric image with high sensitivity over a broad working range.

**Computational Modeling**

Keywords :electrosensory lobe; neural networks; sensory processing

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-24**
**Presentation Time: 18:00 to 19:00**

## CHOOSING THE TYPE OF ROUTE TO LEARN AND FOLLOW IN CLUTTERED ENVIRONMENTS: A MODEL ANALYSIS

**Olivier Bertrand[1,2]; Jens Peter Lindemann[1,2]; Martin Egelhaaf[1,2]**

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Central-place foragers, such as bees and ants, travel back and forth between food locations and their nest. To reach their goal they tend to follow idiosyncratic routes. Several visual mechanisms underlying route learning and following have previously been proposed, but the reasons for different routes have been left aside. In cluttered environments the animal may attempt to learn the shortest route, but – assuming that it should avoid collisions with obstacles – it may also strive for the safest route, i.e. the route minimizing the risk of collision. Moreover, the animals may be displaced from their learned course, e.g. by a gust of wind, and then need to relocate it by some search strategy. These problems are addressed here by computational modeling. We found that the best type of route to learn depends on both the search strategy and the topology of the environment, when locomotion is constrained by a collision avoidance mechanism. When displaced from the learned route, the animal could do either a random or a deterministic search, e.g. by following the direction minimizing the risk of collision. We found that learning the safest route is better than learning the shortest one, especially when a deterministic search after a displacement is used. The advantage of the safest route is reduced when the search starts far away from the route.

### Computational Modeling

Keywords :navigation; cluttered environments; collision avoidance

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-25**
**Presentation Time: 15:00 to 16:00**

## POSTNATAL NEUROGENESIS IN THE PULSE TYPE WEAKLY ELECTRIC MORMYRID MORMYRUS RUME.

**María Castelló[1,2]; Isabel Barreiro[1,2]; Kirsty Grant[3]; Frank Kirschbaum[4]**

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Mormyrids' adult brain attains a great structural complexity and a high development of brain regions involved in electrosensory information as the rombencephalic cerebellum -almost 50% of brain volume- and electrosensory lateral line lobe and the mesencephalic torus semicircularis and optic tectum (Meek and Nieuwenhuys, 1988) .This results from the differential growth along ontogeny of dorsal regions of the neural tube associated to differences in region-specific neurogenesis (Finlay et al., 1998; Ito et al., 2007; Sylvester et al. , 2011). We have previously found several proliferation zones along the neuraxes of Mormyrus rume early larvae, some of which persist during adulthood. To further characterize proliferating cells and brain neurogenic capacity during the larval period (about 12-30 dah) we used a pulse-type protocol to label proliferating cells (10 mM BrdU, 2 h) followed by immediate fixation or 3-7 days survival. We used immunohistochemistry to study: a) distribution of proliferating cells and expression of transcription factors as the neural progenitors marker SOX2, and b) distribution and differentiation of derived cells by demonstration of c-localization of BrdU and early (HuC/HuD; doublecortin) or late (bIII tubulin, GABA, paravalbumin) neuronal markers. The widely distributed proliferation zones were populated by SOX + cell, some of which were BrdU+. Three to 7 days after BrdU administration, derived cells migrated long distances –as in the OB, cerebellum, optic tectum, and to a lesser extent in the hypothalamus-. Some newborn cells express DCX or HuC /HuD their indicating neuronal phenotype.

### Development

Keywords :postnatal neurogenesis; teleosts; brdu

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-26**
**Presentation Time: 16:00 to 17:00**

## REDUCED MATERNAL CARE AND PHYSICAL EXERCISE AFFECT AGE-RELATED COGNITIVE DECLINE AND MICROGLIAL EXPRESSION IN THE RAT DENTATE GYRUS.

**Lane Krejcova[1]; Camila M Lima[1]; Marcus A Olivera[1]; Izabela N F Almeida[1]; Daniel G Diniz[1]; João Bento-torres[1]; Antonio Pereira[1]; Manuella Batista-de-oliveira[2]; Andreia A C Lopes[2]; Rosangela F M Silva[2]; Ricardo Abadie-Guedes[2]; Angela Amancio Dos Santos[2]; Denise S Lima[2]; Pedro Fernando C Vasconcelos[3]; Colm Cunningham[4]; Rubem C A Guedes[2]; Cristovam W P Diniz[1]**

Universidade Federal do Pará,belem,brazil[1]; Universidade Federal de Pernambuco,RECIFE,BRAZIL[2]; Instituto Evandro Chagas,ananindeua,brazil[3]; Trinity College Dublin,dublin,ireland[4]

Reduced maternal care induces epigenetic changes in the brain, with long-term physiological and behavioural consequences. Aging has been associated with neuroinflammation and exercise is suggested to reverse these effects. However, it is not known whether age-related microglial changes are affected by early conditions. We investigated whether age-related cognitive decline and microglial expression in DG are influenced by reduced maternal care and exercise. Wistar rats suckled in litters of either 6 or 12 pups/dam were raised in groups of 2 or 3 from the 21st post-natal day onwards. Maternal behaviour during the suckling period was assessed. At four (young adult) or 23 (aged) months-old, half of the rats underwent progressive daily treadmill exercise for five weeks, while the others remained sedentary. After performing tests of recognition for spatial location and object identity, subjects were sacrificed and had their brains processed for selective microglia/macrophages immunolabeling with anti-IBA-1 antibodies. The number of microglias in DG were estimated by unbiased stereology. We found that: 1) Subjects reared in large litters were less licked and remained out of the nest more frequently than animals reared in small litters. 2) Ageing and sedentary lifestyle lead to impairment of object recognition and spatial memory, while exercise ameliorated those deficits in subjects from small litters. 3) Reduced maternal care and aging increased the number of microglias in DG; exercise produced the opposite effect. Our data suggest that maternal care and exercise influence microglial proliferation in DG and such changes are associated with cognitive performance during aging.

**Development**

Keywords :maternal care; microglia; cognitive performance

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-27**
**Presentation Time: 16:00 to 17:00**

## GROUNDING THE FLYING CARP

**Allen Mensinger[1]**

University of Minnesota,Duluth,USA[1]

The silver and bighead carp are invasive fish species that have spread throughout the Mississippi River drainage and are threatening the Laurentian Great Lakes. These filter feeding fishes have negatively impacted aquatic ecosystems, and with few natural predators, are often the dominant species in infected areas. The silver carp has a unique jumping strategy when startled which has been well documented in popular videos, however the factors that initiate the jumping remain poorly understood. Laboratory and field studies were conducted on the silver carp in an attempt to isolate the factors mediating this behavior and perhaps find the fish's Achilles fin. As the startle response often is triggered by passing watercraft, underwater audio of motorboats were recorded and played back to the fish. These broadband sounds proved more effective than pure tones in repelling the fish. Sound playbacks also significantly reduced the number of crossing attempts by the fish through a small channel in a barrier. Field studies examined the effects of near and far field sound on the jumping behavior. Therefore, bioacoustics shows promise as a means of managing these invasive fish species.

### Ecology

Keywords :startle response; management fish species;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-28**
**Presentation Time: 15:00 to 16:00**

## SPECIES-DIFFERENCES IN SEROTONIN RECEPTOR EXPRESSION IN HOMOLOGOUS IDENTIFIED NEURONS CORRELATE WITH DIFFERENCES IN NEUROMODULATION AND BEHAVIOR

**Paul Katz[1]; Arianna Tamvacakis[1]**

Georgia State University,Atlanta,USA[1]

Species-differences in behavior could be caused by differences in neural circuitry or the modulation of circuitry. The nudibranch molluscs, Tritonia diomedea and Hermissenda crassicornis differ in swimming behavior. Tritonia swims by rhythmically flexing its body in the dorsal and ventral (DV) directions, whereas Hermissenda swims by flexing from side-to-side. The central pattern generator (CPG) for DV swimming in Tritonia contains a serotonergic neuron (DSI) that modulates the strength of synapses made by another swim CPG neuron (C2). DSI stimulation or exogenous serotonin (5-HT) enhances C2 synaptic strength by increasing transmitter release from C2. In contrast, neither DSI stimulation nor 5-HT application increases C2 synaptic strength in Hermissenda. Here we examine whether this species-difference in neuromodulation is caused by expression of different 5-HT receptor genes in C2 homologues. We identified seven 5-HT receptor subtype genes from Tritonia and Hermissenda brain transcriptomes, including two subtypes that had not been previously described in molluscs. C2 neuronal somata were isolated from Tritonia brains and receptor expression in single neurons was examined using absolute quantitative real-time PCR (qPCR). The 5-HT2a receptor had the highest expression level in Tritonia C2 neurons.

5-HT1b receptor genes were expressed at a lower level, whereas 5-HT2b, 5-HT4, and 5-HT6 were not expressed compared to genomic DNA controls. Unlike its homolog in Tritonia, C2 in Hermissenda did not express 5-HT2a receptors. We are currently testing other receptor genes. These results suggest that 5-HT2a receptors might underlie species-differences in the neuromodulation, which could affect the production of behavior. Supported by NSF-IOS-1120950.

### Evolution

Keywords :transcriptome; mollusca; central pattern generator

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-29**
**Presentation Time: 16:00 to 17:00**

## QUANTITATIVE GENETIC ANALYSIS OF BRAIN SIZE VARIATION SUPPORTS THE MOSAIC MODEL OF BRAIN EVOLUTION IN STICKLEBACKS

**Kristina Noreikiene[1]; Gábor Herczeg[1,2]; Abigél Gonda[1]; Gergely Balázs[2]; Arild Husby[1]; Juha Merilä[1]**

University of Helsinki,Helsinki,Finland[1]; Eötvös Loránd University,Budapest,Hungary[2]

The mosaic model of brain evolution suggests that different brain regions are relatively free to evolve independently from each other. However, such independent evolution is possible only if genetic correlations among the different brain regions are less than unity. In this study, we estimated heritabilities, evolvabilities and genetic correlations of relative size of the brain and its different regions in the three-spined stickleback (Gasterosteus aculeatus). Results showed that heritabilities were low (average h2 = 0.24), suggesting a large plastic component to brain architecture. However, evolvabilities of different brain parts were moderate, suggesting the presence of additive genetic variance to sustain a response to selection in the long term. Genetic correlations among different brain regions were low (average rg = 0.40). These results, along with those from analyses of phenotypic and genetic integration, indicate a high degree of independence between different brains regions, suggesting that responses to selection are unlikely to be severely constrained by genetic and phenotypic correlations. Thus, this study provides a strong support for the mosaic model of brain evolution. However, the genetic correlation between brain and body size was high (rg = 0.89) which may constraint the independent evolution of brain and body size in sticklebacks.

### Evolution

Keywords :evolvability; genetic correlation; heritability

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-30**
**Presentation Time: 17:00 to 18:00**

## VISION FROM WATER TO AIR - MOLECULAR COMPARISON ACROSS THREE INDEPENDENT TRANSITIONS IN FISHES

**Fabio Cortesi[1]; Karen Cheney[1]; Justin Marshall[1]; Terry Ord[2]**

The University of Queensland,Brisbane,Australia[1]; University of New South Wales,Sydney,Australia[2]

Imagine living a thousand meters below sea level surrounded by darkness but for a few bioluminescent rays of light. Now imagine living on a meadow, three thousand meters above sea level, where the plethora of light can cause blindness anytime. There are many examples of animals that have adapted their vision to cope with different light conditions; however understanding the molecular basis of these adaptations remains often challenging. Thanks to recent technological advances, it has now become feasible to study the evolution and function of vision, along with its underlying molecular machinery (opsins and the visual pathway genes), one-on-one, in nature. Here, we report the molecular basis for vision – from water to air – based on the genomic and transcriptomic comparison of three fish families from different evolutionary lineages: combtooth blennies (Blennioidei; Blenniidae), mudskippers (Gobioidei; Oxudercinae), and four-eyed fishes (Cyprinodontiformes; Anablepidae). We show that while four eyed fishes take full advantage of their opsin repertoire to simultaneously see above and underwater, vision in the amphibious/terrestrial blennies and mudskippers underwent a different evolutionary pattern. This includes the loss of short-wavelength tuned genes (SWS1 'UV' and SWS2B 'violet') possibly due to enhanced UV exposure and, to potentially compensate for the loss in wavelength perception, the expression of a second, shorter-shifted 'blue' gene (SWS2As).

**Evolution**

Keywords :visual evolution; fish opsins; water-land transitions

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-31**
**Presentation Time: 18:00 to 19:00**

## ORIGINS OF TETRODOTOXIN AND MOLECULAR EVOLUTION IN THE VOLTAGE-GATED SODIUM CHANNELS OF POISONOUS NEWTS (TARICHA GRANULOSA).

**Patric Vaelli[1]; Kevin Theis[2]; Emma Coddington[3]; Heather Eisthen[1]**

Michigan State University,East Lansing,United States[1]; Wayne State University,Detroit,United States[2]; Willamette University,Salem,United States[3]

Tetrodotoxin (TTX) is a potent neurotoxin that inhibits electrical signaling in excitable cells through selective block of voltage-gated sodium channels (VGSCs). Many diverse animals, including species of worms, crabs, octopuses, puffer fishes, frogs and newts, possess TTX as a defensive compound. However, rough-skinned newts (Taricha granulosa) possess the highest concentrations of TTX in any animal due to a coevolutionary interaction with TTX-resistant predatory garter snakes. Despite our extensive knowledge of the ecological consequences surrounding TTX toxicity in this system, the evolutionary origins of TTX, as well as the molecular basis for TTX resistance in the VGSCs of rough-skinned newts, have not been examined. Furthermore, the physiological properties of highly TTX-resistant VGSCs are largely unknown. In all other animals examined, TTX is produced by symbiotic bacteria inhabiting the skin and internal organs of host animals. We are characterizing the microbiome in T. granulosa using next generation sequencing and ecologically-guided cultivation to identify potential TTX-producing symbionts. To examine the evolution of TTX resistance in this lineage, we have also sequenced the VGSC genes in newts. We find numerous mutations in the highly conserved pore-loop regions, the sites where TTX binds the channel, in all six newt VGSCs. Overall, our research suggests that newts may serve as an excellent model system for understanding the roles of animal-microbial symbiosis in shaping adaptive evolution in the nervous system.

### Evolution

Keywords :neurotoxins; voltage-gated ion channels; amphibians

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-32**
**Presentation Time: 15:00 to 16:00**

## NEUROPEPTIDES IN THE REGULATION OF THE ECDYSIS INNATE BEHAVIOR IN THE KISSING BUG RHODNIUS PROLIXUS

**Sheila Ons[1]; Juan Pedro Wulff[1]**

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Introduction: At the end of each developmental stage, insects and other Ecdysozoans perform a sequence of stereotyped innate behaviors culminating in ecdysis. These behaviors are accurately regulated by neuropeptides; the major components of the peptidergic signaling networks controlling ecdysis are Corazonin, Ecdysis Hormone, Eclosion Hormone, and Crustacean Cardioactive Peptide. However, these regulatory pathways are much better characterized in holometabola than in hemimetabola. Orcokinins are members of the "basal neuropeptide set" found in every insect species analyzed until now, even though their physiological function was not well determined to date. Our results indicate a central role of Orcokinin neuropeptides in the regulation of ecdysis behavior in the Chagas' disease vector Rhodnius prolixus. Methods: We used RNAi technique to silence the expression of neuropeptide Orcokinins and other components of the peptidergic pathways controlling ecdysis in Rhodnius prolixus. We used immunohistochemistry and/or qRT-PCR in order to study the expression pattern of these genes in different tissues and throughout the days from blood feeding until ecdysis. Results/Conclusion: Our results indicate that Orcokinins are central components of the peptidergic network regulating ecdysis in Rhodnius prolixus; they control ecdysis behavior and the expression of classical ecdysis-related hormones. Together with previous data, the results point to a conserved role of Orcokinins in the regulation of innate behaviors in insects.

### Genetics, Epigenetics & Behavior

Keywords :insects; molting; hormones

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-33**
**Presentation Time: 16:00 to 17:00**

## FUNCTIONAL DISSECTION AND ORGANIZATION OF DESCENDING INTERNEURONS DURING FLIGHT CONTROL IN DROSOPHILA.

**Wyatt Korff[1]; Shigehiro Namiki[1]; William Rowell[1]; Michael Dickinson[1,2]; Gwyneth M. Card[1]**

HHMI Janelia Research Campus,Ashburn,United States[1]; California Institute of Technology,Pasadena,United States[2]

As flies traverse complex environments, they continuously integrate sensory information and send motor commands that can influence complex behaviors. These signals pass from the fly's brain to motor areas in the Ventral Nervous System via a population of descending interneurons (DNs). After anatomically characterizing half of the approximately 350 DNs that pass through the neck of Drosophila, we generated a library of 190 'cell-type specific' driver lines using the split-GAL4 technique. Using CsChrimson, we optogenetically activated each of the DN types to study their role in flight behaviors, specifically take off, landing, and flight control. Using a tethered flight prep and a high resolution behavioral apparatus, we identified DNs that could cause short or long-mode take off behaviors, DNs that cause leg extensions analogous to those seen during landing, and DNs that modulate wing beat amplitude (WBA). We identified cell types that are found as single paired DNs as well as cell types that are found as populations with multiple pairs of morphologically similar DNs. Interestingly, when activating driver lines targeting one such population DN type, DN045, we found significant increases in WBA that directly correlate with how many cells were targeted, suggesting a this DN type may serve as a throttle during flight. By combining the detailed anatomical and functional characterization of DNs, we are beginning to understand the functional organization of information flow in Drosophila for flight behaviors.

**Genetics, Epigenetics & Behavior**

Keywords :neural control; behavior; flight

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-34**
**Presentation Time: 17:00 to 18:00**

## CREATION OF BRAIN-WIDE FUNCTIONAL MAPS IN DROSOPHILA MELANOGASTER

**Alice Robie[1]; Kristin Branson[1]**

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We created behavior-to-anatomy functional maps for the fruit fly, Drosophila melanogaster. These brain-wide maps identify both putative neural substrates of behavior and the genetic tools to target these regions. To provide access to this data for the community, we created an interactive software tool to allow users to generate and browse these maps. To create the maps, we performed a behavioral screen of thermogenetic neural activation phenotypes using the GAL4-UAS system to target expression of dTrpa1 to sparse subsets of neurons. We video recorded the behavioral phenotypes of 2215 GAL4 lines from the Janelia GAL4 collection, at the permissive temperature for dTrpa1, a temperature sensitive cation channel. We developed an automated analysis pipeline that processed the >20,000 videos in our collection: tracking the pose and position of flies throughout the videos and then annotating the behaviors of the flies using automatic classifiers created with our machine-learning software, JAABA. This behavior data was then correlated with the neural anatomical data from the Janelia Fly Light project. This anatomical data was used to create a clustering of the brain based of co-expression throughout the collection; we termed these clusters supervoxels. For each supervoxel, we then found the correlation between expression in that supervoxel and the performance of a behavior. Using this method, we created maps of behavior to anatomy for the fruit flies' central brain. Additionally, we validated these maps by creating intersectional split-GAL4 lines and demonstrated that the resulting sparser lines generated the expected behavior when activated.

**Genetics, Epigenetics & Behavior**

Keywords :behavior; neuroanatomy; drosophila

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-35**
**Presentation Time: 18:00 to 19:00**

### THE MORMYRID GENOME: PROJECTS, PROSPECTS AND NEW TOOLS FOR NEUROETHOLOGY

**Jason Gallant**[1]

Michigan State University,East Lansing,USA[1]

Motivated by recent successes in comparing gene expression across major lineages of electric fishes, and the recent completion of the E. electricus genome, we announce the sequencing and assembly of the genome of the mormyrid Paramormyrops kingsleyae. We constructed a variety of short-read Illumina based read libraries to sequence the genome at approximately 83x coverage. Using the ALLPATHS-LG algorithm, together with BioNano optical mapping, our latest assembly is composed of approximately 4,000 scaffolds with an N50 contig length of 37 kb and an N50 scaffold length of 3 Mb. A variety of quality metrics suggest that the genome assembly is highly complete, representing ~95% of all coding regions. By leveraging a custom-generated repeat library, transcriptome datasets sequenced from all major tissues, and complete proteomes of 3 additional vertebrates, we annotated this assembly using the MAKER pipeline. We have identified approximately 29,000 genes and their splice variants, 90% of which have an annotation edit distance score of 0.5 or higher, indicating high quality in annotation. The availability of two sequenced electric fish genomes opens unprecedented opportunity for comparative biologists to understand the molecular basis of the numerous convergences between gymnotiforms and mormyrids. In addition, the availability of genomic data has facilitated the development of new molecular tools in our laboratory which can be utilized to interrogate gene function in vivo.

### Genetics, Epigenetics & Behavior

Keywords :genome; electric fish; mormyrid

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-36**
**Presentation Time: 15:00 to 16:00**

## CELLULAR CONTRIBUTIONS TO POLARIZATION VISION IN DROSOPHILA

**Mathias F. Wernet**[1]

Freie University Berlin,Berlin,Germany[1]

The e-vector orientation of polarized skylight is an important stimulus for many navigating animals. Furthermore, polarized reflections are known to facilitate the detection or avoidance of water surfaces. Our fully automated behavioral paradigm for the analysis of Drosophila population responses revealed that orientation responses to changes in e-vector orientation presented to the dorsal half of the eye are mediated by UV-sensitive R7 and R8 cells with long visual fibers (Lvf) located in the 'Dorsal Rim Area' (DRA). In contrast, orientation responses to linearly polarized light presented ventrally rely on different ommatidia where R7 and 'outer photoreceptors' (cells with short visual fibers, Svf) manifest reduced rhabdomeric twist, leading to increased polarization sensitivity. We are interested in the differences between neural circuitry of Lvf and Svf photoreceptors processing polarized light versus chromatic information. For the genetic dissection of the neural circuits underlying polarotactic orientation responses we use systematic, reversible neuronal inactivation in combination with large collections of GAL4 driver lines expressed in the optic lobes, as well as the central brain. Preliminary data identifies cell types specifically required for dorsal ('sky') versus ventral ('reflection') alignment behavior, indicating the neural circuits guiding these responses show important differences. We are expanding our efforts towards (1) functional characterization of targeted cells using genetically encoded calcium sensors, and (2) comparison of the transcriptome of polarization-sensitive photoreceptors (as well as their downstream circuit elements) with other circuit elements involved in wavelength-dependent behaviors.

### Genetics, Epigenetics & Behavior

Keywords :polarized light; circuitry; drosophila

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-37**
**Presentation Time: 16:00 to 17:00**

## GENE KNOCKDOWN IN A MORMYRID ELECTRIC FISH USING SPLICE-BLOCKING MORPHOLINO

**Savvas Constantinou[1]; Sophia Sdao[2]; Fernando Fernandez[3];Jason Gallant[1]**

Michigan State University,East Lansing,United States of America[1]; University of Wisconsin-Madison,Madison,United States of America[2]; University of Puerto Rico at Cayey,Cayey,Puerto Rico[3]

The electric organ (EO), used for predation as well as navigation and communication, has convergently evolved from skeletal muscle in six separate lineages of fishes. Recent studies have begun to investigate the molecular mechanisms of these organs; however, tools to manipulate gene function in vivo are presently lacking. Toward this end, we sought to interfere with a gene of known importance in the EO: the sodium channel gene scn4aa. Scn4aa is normally expressed in the muscles of teleost fishes, but is expressed only in EOs of electric teleost fishes, where it has undergone significant positive selection affecting ion channel kinetics. In this study we developed a splice-blocking vivo-morpholino that specifically targets the scn4aa mRNA and examined its effects on electric organ discharge (EOD) production. We injected the mormyrid, Brienomyrus brachyistius, daily for four consecutive days with either morpholino (N=2) or saline (N=2) and assessed EOD amplitude. We found a significant decline in EOD amplitude over four days of treatment with morpholino compared to saline. We intend to verify the morpholino effect molecularly via RT-PCR and subsequent sequencing, utilize a morpholino control, and also increase our sample size. In morpholino-treated individuals the scn4aa RT-PCR product will be longer than in saline-treated individuals, as the morpholino forces inclusion of a normally spliced intron. The results of this study outline and validate a convenient tool for gene function analysis and provide insight into the role of scn4aa in the evolution, development, and physiological function of EOs. Supported by NSF Grant #1455405

### Genetics, Epigenetics & Behavior

Keywords :gene knockdown; morpholino; scn4aa

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-38**
**Presentation Time: 17:00 to 18:00**

## LIGHT-INDUCIBLE TRANSCRIPTOMIC AND EPIGENOMIC CHANGES UNDERLYING BRAIN PLASTICITY IN HONEYBEES

**Nils Becker[1]; Robert Kucharski[2]; Sylvain Foret[2]; Wolfgang Rössler[1]; Ryszard Maleszka[2]**

Behavioral Physiology & Sociobiology (Zoology II), University of Würzburg,Würzburg,Germany[1]; The Australian National University,Canberra,Australia[2]

The ability of neuronal tissue to change, both functionally and physically, as a result of either developmental programs or activity-dependent factors is manifested at several levels ranging from molecular/cellular modifications to more global alterations like reorganization of neuronal circuits or maps. Exposure of honeybees to light induces structural plasticity in the mushroom bodies at an important behavioral transition when worker bees leave the dark hive environment for outdoor foraging associated with long-distance visual navigation. We investigated the effects of light exposure on gene transcription and DNA-methylation in honeybees to unravel the molecular mechanisms involved in light-induced neuronal-plasticity. We compared gene expression in brain compartments of 1- and 7-day old light-exposed honeybees with age-matched dark-kept individuals. We revealed several differentially expressed genes (DEGs), novel and conserved, including genes with reported roles in neuronal-plasticity. Most of the DEGs show age-related changes in the amplitude of light-induced expression and are likely to be both developmentally and environmentally regulated. Some of the DEGs are either known to be methylated or implicated in epigenetic processes suggesting that responses to light exposure are at least partly regulated at the epigenome level. Further, light alters the DNA-methylation pattern of a candidate DEG for structural neuronal plasticity, and the transcription of a microRNA. This confirms the usefulness of our approach to identify candidate genes for neuronal plasticity and provides evidence for the role of epigenomic processes in the interplay between the genome and environment.

### Genetics, Epigenetics & Behavior

Keywords :plasticity; epigenetic; gene expression

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-39**
**Presentation Time: 15:00 to 16:00**

## APPETITIVE AND AVERSIVE PHEROMONES INDUCE OPPOSED MODULATIONS OF APPETITIVE SUCROSE RESPONSIVENESS AND LEARNING AND MEMORY PERFORMANCES IN HONEY BEES

**David Baracchi[1,2]; Jean-Marc Devaud[1]; Patrizia D'Ettorre[2]; Martin Giurfa[1]**

Université Paul Sabatier, Toulouse III, France,Toulouse,France[1]; Université Paris 13, Paris Cité, France,Paris,France[2]; Université Paul Sabatier, Toulouse III,Toulouse,France[3]; Université Paris 13,Paris,France[4]

Pheromones are chemical messengers eliciting stereotyped behavioural and/or physiological responses in receivers. Besides their well-documented function as communication signals, pheromones have been recently shown to act as “modulators” of cognitive phenomena, facilitating or inhibiting associative learning and memory. We used Apis mellifera to study the effect of exposure to one appetitive pheromone (geraniol) and two alarm pheromones (IPA and 2-heptanone) on sucrose responsiveness, appetitive learning and memory performances. Sucrose responsiveness was measured via the proboscis extension response (PER) to increasing concentrations of sucrose solution. Learning and memory via the olfactory PER differential conditioning (one odour is paired with sucrose and the other remains non-rewarded). We found that alarm pheromones induced a significant decrease of sucrose responsiveness so that 40% and 60% of bees exposed to IPA and 2-hepanone respectively, did not respond to any sucrose concentration. In bees that responded to sucrose, geraniol and 2-heptanone induced an increase and a decrease of the bees’ sucrose responsiveness respectively, while IPA had no effect. Bees exposed to geraniol not only improved their learning performance, but had also better memory retention up to 24 hours than control bees exposed to mineral oil. By contrast, 2-heptanone strongly inhibited appetitive learning and memory retention up to three days following conditioning with respect to controls. Contrary to our expectations and previous results, IPA did neither modulate appetitive learning nor memory performance. Overall, these results suggest that pheromones provide contextual information that makes subsequent learning and memory more or less relevant for the context signalled by conspecifics.

**Learning & Memory**

Keywords :behavioural plasticity; animal cognition; pheromones

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-40**
**Presentation Time: 16:00 to 17:00**

## OCTOPUS LEARNING AND MEMORY IS MEDIATED BY AN EXTREMELY LARGE NEURAL NETWORK THAT IS YET ORGANIZED IN A SIMPLE TWO-LAYER FEEDFORWARD CONNECTIVITY

**Benny Hochner[1]; Ana Luiza Turchetti Maia[1]; Tal Shomrat[1,2]**

The Hebrew Univresity of Jerusalem,Jerusalem,Israel[1]; Ruppin Academic Center,Michmoret,Israel[2]

Learning and memory (L&M) networks have evolved independently multiple times and their size and level of complexity differ dramatically. The octopus vertical lobe (VL) is an exceptionally large L&M network, with 25 million neurons – 2-4 orders of magnitude larger than insects' mushroom-body. Yet, the VL is organized as a simple feed forward two-layer perceptron. Indeed, the VL contains only three neuron types organized in a 'fan-out fan-in' feedforward connectivity. 1,800,000 superior frontal lobe neurons (SFLn) transmit integrated sensory information to 25,000,000 inexcitable amacrine interneurons (AM) in the VL. These converge sharply onto 65,000 large efferent neurons (LN). Many, if not all LNs, are GABAergic, suggesting that learning modulates the inhibition exerted on other brain areas. The SFLn>AM synapses are glutamatergic while the AM>LN synapses are cholinergic. During learning, the weights of the SFLn>AM connections are modulated by activity-dependent LTP. Serotonin reinforces and octopamine suppresses LTP induction, suggesting that these neuromodulators convey positive and negative reward signals to the VL. Recapitulating these findings in a descriptive model explains passive avoidance learning in the octopus attack behavior. How can such a simple network control complex behavior? Networks evolution was probably driven by their computational properties (Shomrat et al 2011). In marine animals brain size is less energetically constraining, perhaps allowing a larger and simpler neural solution, while in flying insects or birds the need for smaller, energetically more efficient brains may result in more complex networks. Therefore, the cephalopod VL system is ideal for understanding complex L&M behaviors. Support: ISF, BSF, NIPS

**Learning & Memory**

Keywords :synaptic plasticity; neural networks; cephalopod mollusks

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-41**
**Presentation Time: 17:00 to 18:00**

## MEMORY-RELATED NEURAL PLASTICITY IN THE HEMIELLIPSOID BODIES, THE CRAB'S "MUSHROOM BODIES".

**Francisco Maza[1]; Fernando Locatelli[1]; Avishag Shkedy[1]; Julieta Sztarker[1]; Alejandro Delorenzi[1]**

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The corpora pedunculata (or mushroom bodies) are complex paired structures in the brain of invertebrate species vastly studied in insects. Since their description in the mid-1850, the corpora pedunculata have been considered to be higher-order brain centers involved in multimodal sensory integration and memory. Although morphologically diverse, a corpora pedunculata common ground plan was described across different invertebrates. Moreover, it has been proposed that the mushroom bodies and the vertebrate pallium evolved from the same structure in a common ancestor circa 600 million years ago. In crustaceans, neuropils sharing a similar pattern with the corpora pedunculata are the hemiellipsoid bodies (HBs), which have been proposed to have an evolutionary common origin. Here, we show in the crab Neohelice granulata morphological and immunohistochemical studies that parallel the results of well described HBs in other crustaceans. Golgi impregnation shows that, like the MBs in insects, the HB globuli cells project to a tract that is subdivide into lobes and claw cells were present. HBs present CaMKII immunoreaction and neurogenesis. Additionally, we found by in vivo calcium imaging that the intrinsic neurons of the crab's HBs respond to both mechanical and visual stimulation. Remarkably, specific changes to a visual danger stimulus are induced by a training protocol that generates associative memory. These results provide the first in vivo physiological evidence that supports the idea that the HBs, the crustaceans' mushroom bodies, are involved in memory processes.

### Learning & Memory

Keywords :hemiellipsoid bodies; memory; calcium imaging

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-42**
**Presentation Time: 18:00 to 19:00**

## INVOLVEMENT OF FRONTAL CORTEX IN SUCCESSIVE NEGATIVE CONTRAST

**Rafi Kliger[1]; María Inés Sotelo[1]; Mauricio Roberto Papini[2]; Rubén Néstor Muzio[1]**

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When animals trained to receive a large reward experience a surprising decrease in reward magnitude, their performance deteriorates below the level of a control group always exposed to the small reward magnitude. This phenomenon, called successive negative contrast (SNC) has been found in both consummatory (cSNC) and instrumental (iSNC) procedures. Some authors postulate that the neural mechanisms involved in the cSNC and iSNC are not the same. While there is evidence for the involvement of prefrontal cortex areas in cSNC, no such cortical participation has been reported for iSNC. Lesions in the ventrolateral orbital cortex and the insular cortex suppress the cSNC effect, whereas lesions in the anterior cingulate cortex delay the recovery (i.e., facilitate the cSNC).

The goal of this research is to study the role of these areas in an instrumental situation of contrast (iSNC) measuring neural activity. Two groups of rats received one trial per day in a runway situation: 32-4 (rewarded with 32 pellets during 12 daily trials and 4 pellets during other 12 daily trials) and 4-4 (rewarded always with 4 pellets). When animals showed the iSNC effect they were sacrificed. This protocol took place twice. First, brain slices were stained with silver nitrate and nucleolar organizer regions (NORs) sizes were compared. The second time, the c-Fos technique was used to register the neural activation of immediate early genes. Activity between brain areas was compared. The difference between procedures and techniques is discussed.

**Learning & Memory**

Keywords :successive negative contrast; rats; prefrontal cortex activity

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-43**
**Presentation Time: 15:00 to 16:00**

## LINKING VARIATION IN LEARNING ABILITY WITH REGIONAL BRAIN METABOLISM IN FORAGERS OF THE ANT NOVOMESSOR COCKERELLI

**Rebekah Keating Godfrey[1]; Wulfila Gronenberg[1]; Dieu MY Nguyen[1]; Rachel Davidson-Knapp[1]; Leyla Sadatmousavi[1]**

University of Arizona,Tucson,United States[1]

Social insects, including ants, show remarkable associative learning capability with interindividual variation in learning ability linked to colony-level division of labor. Foraging ants rely on a variety of cognitive skills to locate and retrieve food items, and previous studies have shown that foragers are more adept at learning than ants performing brood care. Studies in our own lab reveal high interindividual variation in learning ability within foragers of the desert ant, Novomessor cockerelli. Since the onset of foraging in ants is associated with changes in corpulence and gene expression linked to metabolic activity, we ask if observed differences in forager learning ability are associated with global or region-specific differences in brain metabolism. Using odor conditioning of the maxilla-labium extension response, we quantified differences in learning across a group of foragers and used cytochrome oxidase (COX) histology to measure metabolic activity in the brains of these individuals. We test if global brain metabolism varies across foragers and whether learning ability predicts differences in metabolic activity in primary sensory processing regions or higher-order associative learning centers. Preliminary analysis indicates ants with the most robust learning responses show greater metabolic activity exclusively in the mushroom bodies, an associative learning region of the insect brain.

**Learning & Memory**

Keywords :formicidae; insect cognition;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-44**
**Presentation Time: 16:00 to 17:00**

## EFFECT OF OLFACTORY CONDITIONING WITH DIFFERENT OUTCOMES ON ANTENNAL MOVEMENTS IN HONEY BEES

**Hanna Chole[1]; Pierre Junca[1]; Jean-Christophe Sandoz[1]**

EGCE laboratory (Evolution, Genomes, Behavior and Ecology),Gif-sur-Yvette,France[1]

In order to survive, animals must produce adaptive behaviors when facing potentially positive (food) or negative (danger) situations. In honey bees, two olfactory conditioning protocols have been developed to study appetitive and aversive Pavlovian associations on restrained individuals in the Laboratory. In the appetitive conditioning of the proboscis extension response (PER), an odor (CS) is associated with sucrose solution (US), while in the aversive conditioning of the sting extension response (SER), an odor CS is associated with an electric or thermal shock US. Each protocol is based on the measurement of a different behavioral response (proboscis vs sting) which both provide binary responses (extension or not). These limitations render the measure of the acquired hedonic value of an odor CS difficult without testing the animals in a freely moving situation. Here we study the effect of both olfactory conditioning types on the movements of crucial sensory organs for bees: their antennae. We thus developed a tracking system for monitoring harnessed bees' antennal movements at a high frequency rate. Differential appetitive conditioning had a strong effect on antennal movements, bees responding to the reinforced odorant with a marked forward motion of the antennae and a strong velocity increase. By contrast, differential aversive conditioning had little effect on antennal movements. Antennal movements may represent a conditioned response taking place during appetitive conditioning, providing a possible advantage to bees when foraging in natural situations.

**Learning & Memory**

Keywords :antennal movements; learning; honeybee

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-45**
**Presentation Time: 17:00 to 18:00**

## SAME CONTEXT, DIFFERENT OBJECTS, LONG-TERM MEMORY FAILURE IN OBJECT RECOGNITION.

**María Villar[1]; Paul Marchal[1]; Cecilia Martinez[1]; Pamela Lopes[1]; Fabricio Ballarini[1]; Haydée Viola[1]**

Institute of Cellular Biology and Neuroscience, “Prof. E. De Robertis”, School of Medicine, UBA,Ciudad Autónoma de Buenos Aires,Argentina[1]

With the aim of assessing if object recognition long-term memory (OR-LTM) formation is susceptible to retrograde interference (RI), we submitted rats to two sequential familiarization sessions using the same arena but changing the identity of the pair of objects presented. Separate groups of subjects were tested in order to evaluate the LTM for both objects. We investigated the existence of a RI process, if it could operate within the consolidation window and what kinds of events were able to interfere with OR-LTM. Furthermore, given the involvement of hippocampus (Hp) and medial prefrontal cortex (mPFC) in several recognition memories, we assessed the involvement of these structures in OR-LTM formation by using local infusion of muscimol. Our results suggest that OR-LTM formation is retrograde interfered by a new (but not familiar) object explored in the same arena, within a critical time window. In the test session performed three hour after familiarization, STM expression is not affected but LTM measured 24h after familiarization is impaired, therefore RI acts on the consolidation process. Moreover, local inactivation of the dorsal Hp or mPFC previous to the exploration of the second object pair impaired its LTM consolidation restoring the LTM of the first pair. On the whole, these data suggest that both Hp and mPFC are involved in processing OR tasks which LTM formation is susceptible to RI by the spatial/temporal overlapping of two distinct memory traces consolidations.

**Learning & Memory**

Keywords :object recognition; retrograde interference; rats

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-46**
**Presentation Time: 18:00 to 19:00**

## OLFACTORY CUES AND DECISION MAKING IN A NECTIVOROUS ANT

**Roxana Josens[1,2]; Alina Giacometti[1,2]**

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The use of olfactory cues has been extensively studied in social insects and its relevance for the biology of ants is well known. The nectivorous ant Camponotus mus forages on extrafloral nectaries or on homopteran honeydew. Foragers gather nectar and transport this food into the nest where it is distributed to their nestmates through trophallaxis, which is also involved in the recruitment of other foragers. Even when C. mus do not forage on flower nectar, a specific floral odor -linalool- is more easily learned than other odorants. We studied ants exposed to linalool during trophallaxis and then, we evaluated if this experience could affect subsequent decision making during foraging. Ants that experienced linalool during trophallaxis choose the correct arm in a Y-maze and also ingested more from a solution with this odor than other ants that experienced other odor during trophallaxis. We also present preliminary results of electrophysiological response of the antenna to linalool. In addition to their potential applications for improving sugary baits for ant controlling, these findings provide new insights about how ants make the decisions during foraging. Financial support: CONICET (PIP-112-201101-00472).

**Learning & Memory**

Keywords :ants; olfactory learning; linalool

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-47**
**Presentation Time: 15:00 to 16:00**

## THE EMOTIONAL TAGGING: STRESS AND THE PROMOTION OF DURABLE MEMORIES

**Pamela Lopes Da Cunha[1]; Maria Eugenia Villar[1]; Fabricio Ballarini[1]; Manuel Lopez Pasos[1]; Haydee Viola[1]**

Long -term memory (LTM) formation requires protein synthesis. We have demonstrated that a weak learning task which only induces short-term memory (STM) can be stabilized into LTM if another closer and novel experience provides the necessary proteins. It was postulated that these proteins could be capture at transient tagged sites induced by the weak learning task by a process referred to as behavioral tagging. As it is widely known that stress can modulate synaptic plasticity and enhace memory consolidation we decided to investigate whether acute stress could promote the formation of LTM from a weak training by providing the proteins necessary. For this purpose, rats were subject to a weak training (spatial object recognition-SOR) that only induce STM and, at different times close to training, they were exposed to stressful event (elevated plataform –EP- for 30 min). We studied the dependence of this phenomenon on protein synthesis and also on glucocorticoids (GR) and mineralocorticoids receptors (MR) activity in the dorsal hippocampus.

**Learning & Memory**

Keywords :stress; behavioral tagging; rat

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-48**
**Presentation Time: 16:00 to 17:00**

## A NEW BIOASSAY TO QUANTIFY LEARNING IN MOSQUITO LARVAE (AEDES AEGYTPTI): ESCAPE RESPONSE DECREASES DUE TO HABITUATION

**Fernando Guerrieri[1]; Hugo Baglan[1]; Claudio Lazzari[1]**

CNRS - Université François-Rabelais de Tours,Tours,France[1]

Habituation is a form of non-associative learning widely studied in vertebrates and invertebrates. In spite of its relevance for being vector of infectious diseases, learning has hardly been studied in the mosquito Aedes aegypti. Moreover, larval stages have been neglected as model organisms, although they are active, aquatic and perform stereotyped behavioural responses, such as the escape response when disturbed. In this study, we first aimed at confirming habituation of escape response in mosquito larvae (4th instar). Then, we determined how long larvae were able to remember habituation. Larvae were individually stimulated with a visual stimulus inducing the escape response. We set up an original protocol for testing larvae individually, allowing the control of different parameters (inter-trial interval, stimulus intensity and duration) that are crucial for the study of cognitive abilities. After 15 trials, the escape response of mosquitoes was significantly lower, thus confirming habituation. Retention was confirmed up to 1 hour after the last habituation trial. This original bioassay will open new avenues into the study of the physiology of learning and memory in mosquito larvae, for the analysis of the effects of chemicals in the water, the characterisation of the cognitive abilities related to the life history of different mosquito species across preimaginal stages.

**Learning & Memory**

Keywords :mosquito; learning; larva

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-49**
**Presentation Time: 17:00 to 18:00**

## SHORT AND LONG-LASTING BEHAVIORAL CONSEQUENCES OF AGONISTIC ENCOUNTERS BETWEEN MALE DROSOPHILA MELANOGASTER.

**Severine Trannoy[1]; Jill Penn[2]; Kenia Lucey[1]; David Popovic[3]; Edward A. Kravitz[1]**

Harvard Medical School,Boston,USA[1]; School of Science and Technology,Lawrenceville,USA[2]; Ludwig-Maximilians-University Munich,Munich,Germany[3]

In many animal species, learning and memory have been found to play important roles in regulating intra- and interspecific behavioral interactions in varying environments. In such contexts, aggression is commonly used to obtain desired resources. Previous defeats or victories during aggressive interactions have been shown to influence the outcome of later contests, revealing loser and winner effects. In this study, we asked whether short- and/or long-term behavioral consequences accompany victories and defeats in dyadic pairings between male Drosophila melanogaster and how long those effects remain. The results demonstrated that single fights induced important behavioral changes in both combatants and resulted in the formation of short-term loser and winner effects. These decayed over several hours, with the duration depending on the level of familiarity of the opponents. Repeated defeats induced a long-lasting loser effect that was dependent on de novo protein synthesis whereas repeated victories had no long-term behavioral consequences. This suggests that separate mechanisms govern the formation of loser and winner effects. This study aims to lay a foundation for future investigations exploring the molecular mechanisms and neuronal circuitry that participate in the development of these social memories. “Supported by NIGMS”

**Learning & Memory**

Keywords :aggression behavior; loser/winner effects; drosophila melanogaster

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-50**
**Presentation Time: 18:00 to 19:00**

## CHANGES OF ELECTRICAL CHARACTERISTICS INDUCED BY PRIORITY POLLUTANT HORMONES IN LYMNAEA IDENTIFIED NEURONS

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Increasing concentration of priority pollutant hormones (included on the European Union's watch list of emerging pollutants) in aquatic ecosystems is a priority issue of environmental protection. Animals living under aquatic conditions are especially sensitive against these pollutants, affecting their adaptive behavior and homeostasis. Following the determination of the relevant concentrations (1-10 ng/L) of synthetic oral contraceptives (SOCs) in the catchment area of Lake Balaton and River Zala, we investigated adaptive changes induced by these agents in the pond snail, Lymnaea stagnalis. Intracellular electrophysiological recordings were performed from various components (modulatory interneurons, motoneurons, CPG cells) of identified networks responsible for controlling feeding and respiration. Snails were injected with a mix of SOCs (progesterone, drospirenone, levonorgestrel, gestodene). It was found that hormone treatment decreased the firing frequency of the feeding modulatory interneurons via increasing the amplitude of their Ca2+ currents. This effect seemed to be cell type specific, since in the case of the respiratory CPG cells there were no such changes.

Feeding motoneurons also showed decreased activity, since their responsiveness to external sucrose stimulus was reduced. At the behavioral level, hormone treated snails displayed a lower feeding (rasping) activity to feeding stimulus, compared to control. We conclude that priority pollutant hormones may perturb regulatory processes of aquatic organisms, and Lymnaea can be indicative for it. Supported by a grant of the National Brain Project, No. KTIA_NAP_13-2-2014-0006.

**Learning & Memory**

Keywords :electrophysiology; priority pollutant hormones; behavior

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-51**
**Presentation Time: 15:00 to 16:00**

## COGNITIVE BIAS IN CICHLID FISH: PESSIMISTIC FISH SHOW INCREASED CORTISOL LEVELS

**Eliane Gonçalves De Freitas[1,2]; Camila Nomura Boscolo[1]; Ana Paula Montedor[1,2]; Roselene Costa-Ferreira[1]; Rui Oliveira[3,4]**

Universidade Estadual Paulista - UNESP,São José do Rio Preto,Brasil[1]; Centro de Aquicultura da UNESP,São José do Rio Preto,Brazil[2]; Instituto Gulbenkian de Ciências,Oeiras,Portugal[3]; ISPA - Instituto Universitário, Lisbon,Portugal[4]

Cognitive bias consists in consistent evaluation of an ambiguous stimulus as either negative or positive. Thus it can be used to infer overall affective states in animal species besides humans. We developed an assay to identify pessimistic/optimistic bias in a cichlid fish (Nile tilapia) and its association with steroid hormones related to stress (cortisol), and social rank (testosterone and 11-ketotestosterone). We used a place learning paradigm for fish to discriminate between a positive (P) and a negative (N) location (i.e, with vs. without food reward). After this training phase, the food reward was presented half-way between the positive and negative locations (i.e. ambiguous location, A). Fish that took longer to approach the A location were considered pessimistic, whereas those that were faster to reach A were classified as optimistic. Blood was collected to test for associations between cognitive bias and hormone levels. Pessimistic fish had higher cortisol levels than optimistic ones. In contrast, there were no significant differences in androgen levels between optimistic and pessimistic fish. Thus, cognitive bias was demonstrated in fish for the first time, and pessimism seems to be associated with a heightened activity of the stress axis.

### Cognition

Keywords :cognitive bias; stress; steroid hormones

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-52**
**Presentation Time: 16:00 to 17:00**

## MULTISENSORY REPRESENTATION OF SOCIAL FAMILIARITY IN THE SONGBIRD BRAIN

**Isabelle George[1]; Hugo Cousillas[2]; Laurence Henry[2]; Martine Hausberger[1]**

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Social skills and preferences are thought to emerge from greater exposure to and hence familiarity with some social signals rather than others. The ability to differentiate and categorize familiar and unfamiliar individuals and to build a multisensory representation of known individuals emerges from successive social interactions, in particular with adult, experienced models. In different species, adults have been shown to shape the social behavior of young by promoting selective attention to multisensory cues. The question of what representation of known conspecifics adult-deprived animals may build therefore arises. Here we show that starlings raised with no experience with adults fail to develop a multisensory representation of familiar starlings. Electrophysiological recordings of neuronal activity throughout the primary auditory area of these birds, while they were exposed to audio-only or audiovisual familiar and unfamiliar cues, showed that visual stimuli did, as in wild-caught starlings, modulate auditory responses but that, unlike what was observed in wild-caught birds, this modulation was not influenced by familiarity. Thus, adult-deprived starlings seem to fail to discriminate between familiar and unfamiliar individuals. This suggests that adults may shape multisensory representation of known individuals in the brain, possibly by focusing the young's attention on relevant, multisensory cues.

**Cognition**

Keywords :audiovisual; primary auditory area; european starling

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-53**
**Presentation Time: 17:00 to 18:00**

## VISUAL POP-OUT IN BARN OWLS: FROM BEHAVIOR TO NEURAL CORRELATE?

**Julius Orlowski[1]; Yoram Gutfreund[2]; Hermann Wagner[1]**

RWTH Aachen,Aachen,Germany[1]; Technion,Haifa,Israel[2]

To us humans, an item pops out if it differs from its surroundings in one feature, such as motion or orientation. In that case it, the target, is detected effortlessly and independently of the number of other items, the distracters. We want to know, to what extend such pop-out perception - and its neural correlates - exists in barn owls. Barn owls lack significant eye movements, therefore their gaze can be tracked with a head mounted microcamera, the OwlCam. In a set of behavioral experiments we confronted three barn owls carrying OwlCams with search arrays containing one target and 15 – 63 distracters. The target was either oriented differently or moving in a different direction
from the distracters. When trained to search and fixate the targets, search times did not depend on the number of distracters. Thus, we conclude that targets for owls tend to pop out. Next we searched for neural correlates in the visual wulst, considered the homologue to the mammalian striate cortex We recorded the responses of neurons in wulst to motion and orientation singletons, pop-out arrays, and uniform arrays. Preliminary data shows that responses to both array types were suppressed (surround suppression). For motion, neural responses were stronger for the pop-out condition than for the uniform condition. This effect was weaker for orientation. The findings demonstrate orientation
and motion pop-out perception in an avian species and suggest that its neural correlates can be found in the avian homologue to the visual cortex.

**Cognition**

Keywords :visual search; owlcam; visual attention

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-54**
**Presentation Time: 15:00 to 16:00**

## MICROCT FOR MODELLING THE BLOWFLY NECK MOTOR SYSTEM

**Peter Swart[1]; Holger Krapp[1]**

Imperial College, London,UK[1]

Flying insects use visual, mechanosensory, and proprioceptive information to control their movements, both when on the ground and when airborne. Exploiting visual information for motor control is significantly simplified if the eyes remain aligned with the external horizon. In fast flying insects, head rotations relative to the body enable gaze stabilisation during high-speed manoeuvres or externally caused attitude changes due to turbulent air. Previous behavioural studies into gaze stabilisation suffered from the dynamic properties of the supplying sensor systems and those of the neck motor system being convolved. Specifically, stabilisation of the head in dipteran flies responding to induced thorax roll involves feed forward information from the mechanosensory halteres, as well as feedback information from the visual systems. To fully understand the functional design of the fly gaze stabilisation system as a whole, we need to investigate the neck motor system independently. Through X-ray micro computed tomography (µCT), high resolution 3D data has become available, and through staining techniques developed in collaboration with the Natural History Museum London, detailed anatomical data can be extracted. This resulted in a full 3-dimensional anatomical representation of the 22 neck muscle pairs and neighbouring cuticula structures which comprise the blowfly neck motor system. Currently, these µCT data are being used to infer function from structure by creating a biomechanical model (work-in-progress) of the neck motor system. This will be used to determine the specific function of each muscle individually, and is likely to
inform the design of artificial gaze stabilisation systems.

### Motor Systems

Keywords :blowfly; micro-ct; gaze stabilisation

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-55**
**Presentation Time: 16:00 to 17:00**

## CELLULAR AND NETWORK ADAPTATIONS FOR SUPERFAST MOTOR CONTROL IN THE RATTLESNAKE CROTALUS ATROX

**Boris Chagnaud[1]; Deborah Angelè[1]; Tobias Kohl[2]; Felix Felmy[3]**

LMU University Munich,Munich,Germany[1]; Technische Universität München,Freising-Weihenstephan,Germany[2]; Tierärztliche Hochschule Hannover,Hannover,Germany[3]

Superfast muscles are highly specialized muscles that exceed the contraction rates of muscles involved in locomotion. While these superfast muscles are present across vertebrates, the neuronal circuits driving these muscles have not received much attention. To this date neuronal circuits controlling superfast muscles have only been studied in the hindbrain of vocalizing fishes. Superfast motor control, however, is not only limited to hindbrain levels, but also occurs in the spinal cord. Here we investigated at a single cell and network level the superfast spinal system that drives the shaker behavior in the rattlesnake Crotalus atrox. To differentiate the adaptations of the shaker circuit from general rattlesnake spinal cord features, we additionally investigated the properties of spinal segments involved in locomotor behavior. To test for differences in the local neuronal circuitry, we evoked field potentials in the ventral roots of an isolated spinal cord preparation. We show that weak differences between the two systems are present. Tract tracing of the ventral roots identified ventrally located motoneurons that varied in size and number between the two systems. Using patch clamp recordings of spinal cord slices, we characterized the motoneuronal membrane properties. We found specific adaptations of the shaker motoneurons for high frequency firing similar to the ones in vocalizing fishes. Our results suggest that independent of hindbrain or spinal control similar adaptations have evolved for superfast motoneuronal control.

**Motor Systems**

Keywords :spinal cord; shaker system; locomotion

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-56**
**Presentation Time: 17:00 to 18:00**

## ELECTROTONICALLY COMPACT NEURONS WITH COMPLEX AND VARIABLE MORPHOLOGIES PRODUCE ROBUST, STEREOTYPED PHYSIOLOGY

**Adriane Otopalik[1]; Alexander Sutton[1]; Eve Marder[1]**

Brandeis University,Waltham,United States[1]

The neurons of the crustacean stomatogastric ganglion (STG) exhibit physiological waveforms and circuit-level output that are invariant across animals and robust to environmental perturbations. How STG neurons generate stereotyped and robust activity despite remarkable inter-animal variability in their neuronal morphologies, remains a puzzle. We focally photo-uncaged glutamate to probe the distributed electrical properties of one STG neuron type, the gastric mill (GM) neuron. We measured glutamate reversal potentials at numerous positions across the neuronal structure, varying in their distance from the somatic recording site. Precise distance measurements between the stimulated sites and somata were generated from 3-dimensional reconstructions of dye-fills of these same neurons. Although response amplitudes vary across the neuronal structure, glutamate reversal potentials are invariant. This work demonstrates a neuronal circuit wherein its constituent neurons are geometrically complex, yet electrotonically compact. This lack of electrical compartmentalization compensates for inter-animal variability in neuronal morphology and, in principle, would allow pre-synaptic inputs to impinge on GM neuronal activity in a stereotyped manner, regardless of synaptic site location. In this way, electrotonic compactness contributes to the robust nature of the neuronal and circuit physiology in this central pattern generating circuit. This work is supported by F31NS092126 to AO and R37NS017813 to EM.

**Motor Systems**

Keywords :stomatogastric ganglion; glutamate uncaging; morphology

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-57**
**Presentation Time: 18:00 to 19:00**

## TIMER MODULES FOR PULSE PERIOD AND CHIRP DURATION ARE DISTRIBUTED ALONG THE CRICKET ABDOMINAL GANGLIA

**Pedro Jacob[1,2]; Berthold Hedwig[1]**

University of Cambridge,Cambridge,United Kingdom[1]; Champalimaud Centre for the Unknown,Lisbon,Portugal[2]

Cricket acoustic signalling represents an evolutionary highly successful invertebrate communication system, with a variety of species-specific song patterns. Male crickets sing by rhythmic activity of the wing motoneurons with each closer activity generating a sound pulse. Sound pulses are grouped in chirps or trills and organized in calling songs. In four different cricket species, intracellular recordings in the A3 abdominal opener-interneuron, during fictive singing, demonstrated rhythmic spike activity in phase with the wing-opener motoneurons. Depolarization of this neuron elicits the species-specific pulse pattern but it does not provide the timing for chirps and trills.

In G. bimaculatus recordings in the A4 and A5 ganglia reveal interneurons that control the timing of the chirp pattern. Spike activity in these chirp controlling neurons elicits monosynaptic EPSPs in the A3 opener-interneuron driving the generation of pulses. Furthermore, in singing crickets the application of microlesions to the abdominal connectives and ganglia, demonstrate specific contributions of individual ganglia to song pattern generation. Cuts of the connectives posterior to the A3 ganglia altered the chirp structure of the song while preserving the generation of single pulses, whereas cuts posterior to A4 dramatically increased the variability of pulses/chirp. These results suggest a spatially distributed organization of the cricket singing-network along the abdominal ganglion chain, with a timer module for pulse generation in A3 and modules for the control of the chirp pattern in A4 and A5. Independent changes in these modules might be the basis for the evolution of very diverse species-specific song patterns.

**Motor Systems**

Keywords :central pattern generator; sound production; evolution

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-58**
**Presentation Time: 15:00 to 16:00**

## CENTRAL-PATTERN-GENERATORS AND HIGHER-MOTOR-CENTER INTERPLAY IN LOCUST WALKING

**Daniel Knebel[1,2]; Jan Rillich[2]; Yaniv Assaf[1,4]; Hans-Joachim Pflueger[3]; Amir Ayali[1,2]**

Tel Aviv University,Tel Aviv,Israel[1]; Tel Aviv University,Tel Aviv,Israel[2]; Free University Berlin,Berlin, Germany[3]; Tel Aviv University,Tel Aviv,Israel[4]

Insect walking is among the most efficient locomotion patterns in nature; with its six legs, the insect can perform various gaits, with varying speeds in an unpredictable environment. The neuronal infrastructure controlling the legs is composed of independent central-pattern-generators (CPGs), which are highly modulated by sensory and descending inputs. Here, we sought to decipher the "default" functional connectivity and interaction scheme among the thoracic CPGs in the desert-locust, in the absence of sensory inputs. Using an isolated nervous system preparation and restricted differential application of the muscarinic agonist Pilocarpine, we found that different thoracic ganglia possess different bi-lateral coupling. Moreover, due to a dominance of ipsilateral synchrony, each ganglion is capable of inflicting its own coupling pattern onto the other ganglia. We further explored how the subesophageal-ganglion (SEG), a higher motor center, modulates the coupling among the legs CPGs. In-vivo manganese-enhanced-MRI experiments demonstrated that the SEG is indeed active during walking. Further findings suggest that the SEG has an instrumental effect on contralateral coupling. In accordance with such a role, we found that the SEG descending activity correlates with synchronized output of contralateral CPGs. Our results map the baseline interactions between the legs' CPGs, which serve as the substrate for sensory input modulation in coordinating functional walking. While the default thoracic scheme is an ipsilateral-dominant one, the SEG has an integrating role in mediating both sides of the system. Such highly modulatory infrastructure contributes to generating the great variability of insect walking patterns.

### Motor Systems

Keywords :central-pattern-generators; locomotion; locust

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-59**
**Presentation Time: 16:00 to 17:00**

## A MODEL FOR THE SONG SYSTEM IN SERINUS CANARIA

**Rodrigo G. Alonso[1]; Marcos A. Trevisan[1]; Ana Amador[1]; Franz Goller[2]; Gabriel B. Mindlin[1]**

University of Buenos Aires,Buenos Aires,Argentina[1]; University of Utah,Salt Lake City,United States[2]

Song production in songbirds is controlled by a network of nuclei distributed across several brain regions, which drives respiratory and vocal motor systems to generate sound. We built a model for birdsong production, whose variables are the average activities of different neural populations within these nuclei of the song system. We focus on the predictions of respiratory patterns of song, because these can be easily measured and therefore provide a validation for the model. We test the hypothesis that it is possible to construct a model in which (1) the activity of an expiratory related (ER) neural population fits the observed pressure patterns used by canaries during singing, and (2) a higher forebrain neural population, HVC, is sparsely active, simultaneously with significant motor instances of the pressure patterns. We show that in order to achieve these two requirements, the ER neural population needs to receive two inputs: a direct one, and its copy after being processed by other areas of the song system. The model is capable of reproducing the measured respiratory patterns and makes specific predictions on the timing of HVC activity during their production. We tested these predictions by making single units measurements in HVC projecting neurons (i.e. those antidromically activated by stimulation in RA nucleus) in anaesthetised Canaries. These results are compatible with our model and suggest that vocal production is controlled by a circular network rather than by a simple top-down architecture.

### Motor Systems

Keywords :birdsong; song system; motor control

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-60**
**Presentation Time: 17:00 to 18:00**

## FLEXION REFLEX CAN INTERRUPT AND RESET THE SWIMMING RHYTHM

**Ari Berkowitz[1]; Matthew S. Elson[1]**

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The spinal cord can generate the hip flexor nerve activity underlying leg withdrawal (flexion reflex) and the rhythmic, alternating hip flexor and extensor activities underlying locomotion and scratching, even in the absence of brain inputs and movement-related sensory feedback. It has been hypothesized that a common set of spinal interneurons mediates flexion reflex and the flexion components of locomotion and scratching. Leg cutaneous stimuli that evoke flexion reflex can alter the timing of (i.e., reset) cat walking and turtle scratching rhythms; in addition, reflex responses to leg cutaneous stimuli can be modified during cat and human walking and turtle scratching. Both of these effects depend on the phase (flexion or extension) of the rhythm in which the stimuli occur. However, similar interactions between leg flexion reflex and swimming have not been reported. We show here that a tap to the foot interrupted and reset the rhythm of forward swimming in spinal, immobilized turtles if the tap occurred during the swim hip extensor phase. In addition, the hip flexor nerve response to an electrical foot stimulus was reduced or eliminated during the swim hip extensor phase. These two phase-dependent effects of flexion reflex on the swim rhythm and vice versa together demonstrate that the flexion reflex spinal circuit shares key components with or has strong interactions with the swimming spinal network, as has previously been shown for cat walking and turtle scratching. Thus, leg flexion reflex circuits likely share key spinal interneurons with locomotion and scratching networks across limbed vertebrates generally.

**Motor Systems**

Keywords :central pattern generation; spinal cord; locomotion

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-61**
**Presentation Time: 18:00 to 19:00**

## NEURAL CODING OF TIMBRE IN BIRDSONG

**Santiago Boari[1,2]; Ana Amador[1,2]**

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Given two sounds of same pitch, loudness and duration, timbre is the acoustical property responsible for the identity of the sound source. Timbre is a multidimensional attribute that is most elusive to describe. Some of these dimensions have been identified and explored in psychoacoustics experiments conducted on human subjects, but an objective way to measure timbre is yet to be determined. In this work, we studied the contribution of attack time to the sound identity. Attack time is a well-established dimension of timbre: it is the time it takes for the sound envelope to reach its first maximum. Zebra finches (Taeniopygia guttata) present a remarkable opportunity to study timbre in complex vocalizations as they present a wide syllable repertoire that contains a large number of syllables with a rapid attack time and a slower decaying envelope. In addition, previous experimental evidence showed that telencephalic neurons in HVC respond in a highly selective fashion to auditory presentations of the Bird’s Own Song (BOS) while not responding to the reversed song. Therefore, we used HVC neural activity as a measure of BOS recognition. We generated a modified BOS in which the sound envelope of each syllable was reversed (MOD). This effectively switches the attack and decay times of each syllable while maintaining the rest of the acoustical properties intact. We have found that these changes in the attack time lead to a decrease in the neural response of HVC units, unveiling a neural representation of timbre in HVC.

**Motor Systems**

Keywords :bird's own song; timbre; vocal production

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-62**
**Presentation Time: 15:00 to 16:00**

## USING INFORMATION THEORY TO DETERMINE THE CENTRALIZATION OF CONTROL FOR LOCOMOTION IN COCKROACHES

**Izaak Neveln[1]; Simon Sponberg[1]**

Georgia Tech,Atlanta,United States[1]

Control of legged locomotion relies on complex systems, yet strategies employed by animals such as cockroaches allow for robust navigation through varied environments. A fundamental aspect of locomotion concerns the tradeoffs between centralizing control to precisely coordinate limb movements versus decentralizing control to mitigate delay and allow independent control. As animals move faster, one might expect that the need for coordination becomes more important but that centralization is made more difficult due to limiting bandwidth. We look for signatures of centralized locomotor control at high speeds using an information theoretic approach. We measure the mutual information (MI) between control signals and two kinematic state variables: a local measure of leg extension and a global measure of the overall limb kinematics. We specifically measure the MI between the spikes of a single extensor motor neuron and the maximally informative dimensions (MIDs) of these continuous kinematic output variables. MI informs how much the control signal reduces the possible variability in the output variable and vice versa without assumptions of a particular model. To find the MIDs we use a global optimization simulated annealing approach. Using a large data set of rapid cockroach running over flat terrain we find that there is more MI shared between the control signal and the global kinematic variable than the local leg kinematic variable. These results indicate strong coupling between control of legs even when running at high speeds, implying a highly centralized control architecture.

### Motor Systems

Keywords :mutual information; centralization; locomotion

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-63**
**Presentation Time: 16:00 to 17:00**

## SLOW WAVE SLEEP IN THE POSTPARTUM RAT AND ITS LITTER WEIGHT GAIN ARE POSITIVELY CORRELATED AND PROMOTED AFTER HALOPERIDOL TREATMENT

**Luciana Benedetto[1]; Mayda Rivas[1]; Joaquin Gonzalez[1]; Florencia Peña[1]; Annabel Ferreira[4]; Pablo Torterolo[1]**

School of Medicine,Montevideo,Uruguay[1]; School of Medicine,Montevideo,Uruguay[2]; School of Science,Montevideo,Uruguay[3]; School of Science,Montevideo,Uruguay[4]; School of Science,Montevideo,Uruguay[5]

The stimulus of suckling elicits milk ejection (ME), an event associated with slow wave sleep (SWS). Litter weight gain (LWG) is an indirect measure of ME and does not occur if mother rats are sleep deprived. Haloperidol (HAL), a dopamine antagonist receptor, facilitates ME and LWG in addition to promote SWS in male rats. We aim to determine if HAL promotes SWS in postpartum rats and if there is a correlation between SWS and LWG. On postpartum days 6-8, mother rats (n=4) previously implanted for polisomnographic recording were treated with HAL (0.4 mg/kg, i.p.) or vehicle, 3 hours after dam-litter separation and 1 hour before reunion. Sleep-wakefulness cycle was recorded during 4 hours immediately after reunion; litter weight was measured before and after recordings. Preliminary results show that LWG of HAL dams tended to be higher (9.1±1.8%) than LWG of controls dams (5.5±0.7%, p=0.063). In addition, HAL increased SWS (127.5±13.4 min) compared to vehicle (87.4±4.7min, p=0.029). Also, sleep latency from pup reunion was reduced after HAL treatment (3.5±0.8min) compared to vehicle (9.2±0.9min, p=0.012). Finally, there was a positive correlation between LWG and SWS (r=0.90, p=0.002). Our findings evidence that HAL induces SWS as in male rats, and suggest a relation between SWS and ME.

### Neuroendocrinology

Keywords :haloperidol; sleep; milk ejection

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-64**
**Presentation Time: 17:00 to 18:00**

## THE MALE INTRASEXUAL AGGRESSION OF THE WEAKLY ELECTRIC FISH, GYMNOTUS OMARORUM, AS MODEL SYSTEM FOR THE STUDY OF NON-BREEDING TERRITORIAL AGGRESSION

**Cecilia Jalabert[1]; Laura Quintana[1]; Ana Silva[1,2]**

Instituto de Investigaciones Biológicas Clemente Estable,Montevideo,Uruguay[1]; Facultad de Ciencias, Universidad de la República,Montevideo,Uruguay[2]

Agonistic behavior arises in the competition between co-specifics for the access to limited resources. Resource holding power (RHP) and resource value, which are commonly asymmetric between sexes, determine contest outcome. In the non-breeding inter and intrasexual territorial aggression of the sexually monomorphic weakly electric fish, Gymnotus omarorum, neither RHP nor resource value are asymmetric among sexes. In this study, we first evaluated in intact dyads of G. omarorum, whose sex was determined post-mortem by gonadal inspection, if the dynamics, motivation, and levels of aggression were influenced by the sex composition of the dyad in non-breeding agonistic encounters. Dyads with 5-20% weight difference between contenders were tested in a plain arena of equally-sized compartments. First attack latency, contest duration, and attack rate of both dominants and subordinates were similar among inter and intrasexual dyads (male-male (n=6), male-female (n=5) and female-female (n=5)). Though these data support that motivation and aggression levels do not depend on sexual combination of the dyad and allow us to do behavioral comparisons across sexes, it is mandatory to select the sex of the dyads in advance to explore the neuroendocrinological bases of this agonistic behavior. Therefore, we secondly evaluated if surgical sex identification by testes inspection previous to encounter affected agonistic behavior by comparing intermale dyadic contests (5-20% weight asymmetry between contenders) of pre sexed males (n=6) and of intact males (n=6). Surgery did not affect predicted dominance relationships nor locomotor and electric patterns of male-male aggression in comparison to intact individuals. Financed by PEDECIBA, ANII_FCE_1_2011_6180, ANII_FCE_3_2013_100495.

### Neuroendocrinology

Keywords :teleost; non-breeding agonistic behavior; inter and intrasexual contests

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-65**
**Presentation Time: 18:00 to 19:00**

## EFFECT OF KETANSERIN IN THE REGULATION OF SATIETY AND THE FEEDING BEHAVIOR OF CARPENTER ANTS.

**Alina Giacometti[1]; Rodrigo Velarde[1]; Roxana Josens[1]**

IFIBYNE - CONICET,Buenos Aires,Argentina[1]

Biogenic amines control and modulate many behaviors across animals. In insects, serotonin is associated with feeding behaviors. Oral administration of serotonin depresses sucrose solution feeding in Camponotus mus ants. Here we investigated in this species 1) whether orally administered ketanserin, a selective antagonist for some serotonin receptors, promotes feeding on sucrose solutions; and 2) if the temporal dynamics of ketanserin action are altered when using dimethyl sulfoxide (DMSO) as a carrier. First, we measured the individual feeding behavior on a 15%(w/w) sucrose solution in foragers that had been previously treated orally either with 0,75µl of a 30% w/w sucrose solution with or without ketanserin (2.10-3 M). In the second experiment, the same groups were compared but ketanserin was dissolved in DMSO before being added to the sucrose solution. The feeding motivation of the colonies was assessed every day prior to the experiments. Ketanserin promoted feeding only when the feeding motivation of the colonies was intermediate. This effect occurred between 3 and 4.5 hours after treatment in the first experiment. DMSO accelerated the onset of this effect. The load ingested by ketanserin treated ants was higher than that of controls in both experiments while intake rates did not vary. The bigger loads in the ketanserin treated ants were mainly due to higher feeding times, suggesting an altered perception of the satiety level. We show that ketanserin produces an effect contrary to that of serotonin in the individual feeding behavior that can be modulated by the motivational status of the colony.

### Neuromodulation

Keywords :ants; ketanserin; feeding behavior

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-66**
**Presentation Time: 15:00 to 16:00**

## DIFFERENTIAL AMINERGIC MODULATION OF DESCENDING BRAIN NEURONS – A POTENTIAL MECHANISM FOR DECISION MAKING IN CRICKET SOCIAL BEHAVIOR

**Stefan Schöneich[1]; Ann-Juliane Breitenbach[1]; Nicole Naumann[1]; Paul A. Stevenson[1]**

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Mechanical stimulation of the antennae in crickets can elicit various behaviors, including courtship and aggression, that are themselves subject to modulation by the biogenic amine octopamine. We have identified several descending interneurons in the cricket brain that respond to mechanical stimulation of the antennae (Schöneich, Schildberger, Stevenson; J Comp Neurol, 2011), and now report that they are modulated in different ways by octopamine. The contra-laterally descending brain interneurons DBNc2-2 and DBNc1-2 each receives monosynaptic connections from campaniform sensillae located in the pedicel of the antennal base, and usually evoke a single spike in each interneuron in response to lightly touching the antennae. After bath application of the tissue permeable octopaminergic receptor agonist chlordimeform (CDM), DBNc1-2 responds with several spikes, whereas the response in DBNc2-2 is either blocked or remains unaffected. A further, as yet not fully characterised descending interneuron seems only to respond to antennal stimulation in the presence of CDM. Octopamine must act directly on the central synaptic connection with the interneurons, since nerve recordings from antennal afferents revealed no effect after CDM treatment. Stains of single campaniform sensillae on the pedicel revealed that their terminal processes are closely associated with the presumptive spike initiating zone of DBNc2-2 and DBNc1-2 in the brain. Immunocytochemistry revealed numerous octopaminergic terminals adjacent to this site. The markedly different anatomies of the interneurons suggests different roles in controlling turning reactions. We are currently investigating whether octopaminergic modulation underlies the decision of male crickets to approach or avoid conspecifics on antennal contact.

**Neuromodulation**

Keywords :insect; mechanosensory interneurons; octopamine

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-67**
**Presentation Time: 16:00 to 17:00**

## OCTOPAMINE IN THE OCTOPUS BRAIN: MAPPING A 'NEGLECTED' NEUROMODULATOR

**Giovanna Ponte[1]; Graziano Fiorito[2]**

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Octopamine (OA), a monoamine found in plants, invertebrates and vertebrates, was originally identified in 1948, in the salivary glands of the cephalopod mollusc Octopus vulgaris. While it only occurs as a trace amine in vertebrates, OA is one of the most abundant biogenic amines occurring in the nervous system of invertebrates, and is considered to be the invertebrate counterpart of noradrenaline. OA and/or its receptor(s) have been identified in a large number of invertebrate species, and reported to play a role in several physiological and behavioral processes. Interestingly, while scientists largely explored the presence and role of OA in many taxa, the study of its role in octopus, where it was originally discovered, and in other cephalopods, has been neglected, so that a detailed account of its distribution in the central nervous system is missing.

Here we explored the octopus brain to understand the significance of the exceptionally elevated concentrations of octopamine found in this cephalopod. We characterized, for the first time, octopaminergic neuronal populations in the brain lobes of O. vulgaris by immunofluorescence labeling. A mapping of OA in octopus brain areas is presented in relation with other modulators, and a functional hypothesis about the role of OA for visual and chemo-tactile sensory-motor processing is also provided.

### Neuromodulation

Keywords :neuromodulator; octopus vulgaris;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-68**
**Presentation Time: 15:00 to 16:00**

## CONTINUOUS LATERAL OSCILLATIONS AS A CORE MECHANISM FOR TAXIS IN DROSOPHILA LARVAE

**Antoine Wystrach[1,2]; Konstantinos Lagogiannis[1]; Barbara Webb[1]**

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The larvae of Drosophila Melanogaster spontaneously crawl towards or away from odours. This taxis behaviour is thought to consist of several distinct control mechanisms that trigger specific actions, sometimes characterised as decision-making. The present work supports an alternative hypothesis: that taxis results from direct ongoing sensory modulation of continuous lateral oscillations of the anterior body. An analysis of larvae crawling shows a rythmical, continuous lateral oscillation of the anterior body which encompasses all head sweeps, small or large, without breaking the oscillatory rhythm. We demonstrate that an abstract model agent based on this principle, operating in closed loop with the sensory environment, reproduces a surprising number of phenomena observed in larvae. Crucially, it does not require the `steering signal' to be lateralised; instead the closed loop imposes the appropriate relations of sensory input to motor output. Moreover, this mechanism enables all sensory modalities guiding taxis, innate or learnt, to converge on a single motor control substrate. This provides a simple and robust solution to integrate multiple information sources.

**Orientation & Navigation**

Keywords :taxis; sensory integration; drosophila larva

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-69**
**Presentation Time: 16:00 to 17:00**

## COMPARING THE LEARNING FLIGHTS OF BUMBLEBEE WORKERS (BOMBUS TERRESTRIS) LEAVING A FEEDING SITE WITH THOSE WHEN LEAVING THE NEST

**Elisa Frasnelli**[1]

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Wasps and bees perform learning flights on leaving significant places like their nest and feeding sites during which they acquire information about the visual characteristics of these sites that can help guide the insects' returns. Because bumblebees, Bombus terrestris, nest in the ground and will collect nectar from low plants, it is possible to compare the learning flights evoked by the two goals in circumstances in which the visual surroundings of each goal are very similar. We have recorded the learning flights of individual bees as they learnt both goals set 5m apart. The locations of the inconspicuous nest-hole and feeder were each marked by the same set of landmarks, three black cylinders and a flat purple ring. Flights were recorded with two video-cameras, one above each goal. Preliminary analysis reveals some structural similarities between flight manoeuvres at the two goals, but flights at the feeder are conspicuously shorter than those at the nest and the bees spend significantly less time close to the nest. In unrewarded tests bees located the feeder and the nest more accurately when the purple ring was present than when it was removed, showing that they learned features on the ground. In accord with the extra time invested when leaving the nest, bees were more persistent in searching for the nest than for the feeder. These differences may well be related to the permanence and uniqueness of a bee's nest compared with the more transient nature of flowers and their wider availability.

### Orientation & Navigation

Keywords :bees; learning; navigation

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-70**
**Presentation Time: 17:00 to 18:00**

## PROCESSING OF POLARIZED AND UNPOLARIZED LIGHT CUES IN THE CENTRAL COMPLEX OF THE DESERT LOCUST

**Uta Pegel[1]; Keram Pfeiffer[1]; Uwe Homberg[1]**

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Like other migratory insects, the desert locust likely uses a sky compass mechanism for spatial orientation. In the sky, several cues including direct sunlight, the polarization pattern of the sky and the chromatic and intensity gradient can be exploited for compass orientation. Previous work showed that the central complex in the locust brain holds a polarotopic internal representation of celestial E-vectors and may therefore act as an internal sky compass (Heinze and Homberg 2007, Science 315:995). To explore whether other celestial cues contribute to this internal compass, we examined whether polarization-sensitive (POL) neurons of the central complex receive additional input from the chromatic gradient of the sky. The intensity gradient of long wavelengths (green light) and the uniform distribution of short wavelengths (UV-light) across the sky lead to a chromatic gradient with highest intensity difference between long and short wavelengths near the sun and smallest difference in the antisolar hemisphere (Coemans et al. 1994, Vision Res 34:1461). We tested the responses of central-complex neurons to zenithal polarized light and a green and UV-light spot rotating at an elevation of 45° around the head of the animal. All POL-neurons were sensitive to the azimuth of the rotating unpolarized stimuli and therefore integrate polarized and unpolarized light information.

In many neurons the azimuthal tunings to both light spots were in the same position or close to each other, so that the locust might use the sun for orientation as the brightest spot in the sky and not the chromatic gradient.

**Orientation & Navigation**

Keywords :desert locust; polarization vision; color vision

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-71**
**Presentation Time: 18:00 to 19:00**

## EFFECTS OF SUB-LETHAL DOSES OF GLYPHOSATE ON THE NAVIGATION OF APIS MELLIFERA

**Maria Sol Balbuena[1]; Randolf Menzel[2]; Walter Farina[1]**

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Glyphosate (GLY) is a broad spectrum herbicide used for weed control. Although there are findings that show a negative impact of GLY on snails, crustaceans and amphibians, few studies have investigated its sub-lethal effects in non-target organisms such as the honeybee Apis mellifera, the main pollen vector in commercial crops. To evaluate whether sub-lethal concentrations of GLY (2.5, 5 and 10 mg/L) affects the homeward flight path of honeybees, we performed a catch-and-release experiment in which bees flying to the hive were displaced during foraging trips once or twice. Their homeward trajectories were tracked using harmonic radar technology. We found that honeybees fed with solution containing 10 mg/L GLY spent more time performing homeward flights than control bees (0 mg/L GLY) or bees treated with lower concentrations. They also performed more indirect homing flights. Moreover, the proportion of direct homeward flights performed after a second release from the same site increased in control bees but not in treated bees. These results suggest that, in honeybees, exposure to levels of GLY commonly found in agricultural settings impairs the cognitive capacities needed to retrieve and integrate spatial information for a successful return to the hive. Therefore, honeybee navigation is affected by ingesting traces of the most widely used herbicide worldwide, with potential long-term negative consequences for colony foraging success.

### Orientation & Navigation

Keywords :apis mellifera, glyphosate, navigation, harmonic radar tracking; ;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-72**
**Presentation Time: 15:00 to 16:00**

## SPECTRAL INFORMATION AS AN ORIENTATION CUE IN DUNG BEETLES

**Basil El Jundi[1]; James Foster[1]; Marcus Byrne[2]; Emily Baird[1]; Marie Dacke[1,2]**

Lund University,Lund,Sweden[1]; University of Witwatersrand,Johannesburg,South Africa[2]

During the day, a non-uniform distribution of long and short wavelength light generates a color gradient across the sky. This gradient could be used as a compass cue, particularly by animals such as dung beetles that rely primarily on celestial cues for orientation.

Here, we tested if dung beetles can use spectral cues for orientation by presenting them with monochromatic (green and UV) light spots in an indoor arena. Beetles kept their original bearing when presented with a single light cue, green or UV, or when presented with both light cues set 180° apart. When either the UV or the green light was turned off after the beetles had set their bearing in the presence of both cues, they were still able to maintain their original bearing to the remaining light. However, if the beetles were presented with two identical green light spots set 180° apart, their ability to maintain their original bearing was impaired. In summary, our data show that ball-rolling beetles could potentially use the celestial chromatic gradient as a reference for orientation.

### Orientation & Navigation

Keywords :color; navigation; skylight cues

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-73**
**Presentation Time: 16:00 to 17:00**

## 3D GRID CELLS AND BORDER CELLS IN FLYING BATS

**Gily Ginosar[1]; Arseny Finkelstein[1]; Alon Rubin[1]; Liora Las[1]; Nachum Ulanovsky[1]**

Weizmann Institute of Science,Rehovot,Israel[1]

Grid cells exhibit spatially-periodic firing fields, and are thought to be important for navigation. When recorded in animals moving on a 2D plane, they discharge when the animal passes through the vertices of a hexagonal grid spanning the 2D environment. Despite extensive research on 2D grid cells, there is an ongoing debate about the function of these fascinating neurons – namely, whether they encode the position of the animal or the distance travelled. Additionally, many animals navigate through 3D space, but no studies to date have attempted to characterize the 3D volumetric firing of grid cells. Here, we conducted experiments in flying bats in order to elucidate the grid code in 3D – and found that our results provide also surprising insights into the debate on grid function in 2D.

We trained Egyptian fruit bats (Rousettus aegyptiacus) to fly in a large flight room, while we wirelessly recorded single-neuron activity in entorhinal cortex. Results revealed grid-like structures in the 3D firing-rate maps, with multiple firing-fields. The spacing between firing-fields was more variable than in perfect synthetic 3D grids, but was substantially less variable than for randomly-distributed fields – namely, 3D grid-cells seem to exhibit a fixed distance scale, without forming a global lattice. These preliminary data shed new light on the function of grid cells, because the global lattice arrangement is a key requirement for representing position using the widely-proposed modulo-code. Conversely, the fixed inter-field spacing observed in our data is suitable for the encoding of distance.

### Orientation & Navigation

Keywords :grid; bat; 3d

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-74**
**Presentation Time: 17:00 to 18:00**

## VECTORIAL REPRESENTATION OF SPATIAL GOALS IN THE BAT HIPPOCAMPUS

**Ayelet Sarel[1]; Arseny Finkelstein[1]; Liora Las[1]; Nachum Ulanovsky[1]**

Weizmann Institute of Science,Rehovot,Israel[1]

Navigation, the ability to reach a desired destination, requires knowledge of one’s own location, as well as the position and direction to the goal. GPS tracking of large-scale natural navigation of bats showed that they navigate in very straight flights towards multiple distant goals, such as fruit-trees and alternative caves. Despite decades of research on spatial neurons that encode the animal’s own position (place-cells and grid-cells), very little is known about how neural circuits represent the location or direction of goals – which is essential for goal-directed navigation. Here we investigated how goal-related information is represented in the brain, by training Egyptian fruit bats to fly towards landing platforms (defined as ‘goals’), while the activity of single neurons from hippocampal area CA1 was recorded. We found a subpopulation of hippocampal neurons that exhibited rather narrow angular tuning to the direction of the goal. The cells were tuned also to goals positioned behind curtains, suggesting that the goal-direction signal is memory-based rather than sensory-based. The ability to encode goals that are not immediately visible is essential for real-life navigation in the wild, where goals are often hidden out of sight. Additionally, we found hippocampal neurons that encoded the distance to the goal. Taken together, our preliminary results suggest the existence of goal-direction and goal-distance signals in bat hippocampus – a vectorial representation that could support goal-directed navigation. We speculate that this vectorial neural representation could be the mechanism underlying the ‘home vector’ phenomenon that was found in behavioral experiments in multiple animal species.

### Orientation & Navigation

Keywords :bat; hippocampus; goal

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-75**
**Presentation Time: 18:00 to 19:00**

## BILATERAL INTEGRATION OF PHEROMONAL INPUTS REGULATES THE PERCEPTION OF BODY AXIS IN DROSOPHILA.

**Ross Mckinney[1]; Yehuda Ben-Shahar[1]**

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The bilateral integration of sensory inputs is important for stimulus localization across many sensory modalities. In the chemosensory system, the bilateral integration of olfactory signals is essential for the ability of individuals to navigate towards or away from specific odor sources such as food, predators, and mates in both vertebrates and invertebrates. While there is much evidence for the requirement of bilateral inputs in directing behaviors, the neural circuits underlying the processing and integration of these inputs are largely unknown. Here we describe a sexually dimorphic neural circuit that plays a role in processing bilateral pheromonal inputs important for directing mating displays in male D. melanogaster. By using high resolution behavioral analyses and genetic manipulations of neural activity, we show that males display spatially stereotyped courtship behaviors that are (1) predictive of female body axis orientation and (2) dependent upon bilateral contact pheromonal inputs. Our work indicates that the bilateral integration of chemosensory inputs is essential for mating decisions in male flies, and points to putative contact pheromones that represent body axis information in insects.

### Orientation & Navigation

Keywords :chemosensation; behavior; mating

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-76**
**Presentation Time: 15:00 to 16:00**

## WEAK BROADBAND ELECTROMAGNETIC FIELDS ARE MORE DISRUPTIVE TO MAGNETIC COMPASS ORIENTATION IN A NIGHT-MIGRATORY SONGBIRD (ERITHACUS RUBECULA) THAN STRONG NARROW-BAND FIELDS

**Susanne Schwarze[1,2]; Nils-lasse Schneider[1,2]; Thomas Reichl[1,2]; David Dreyer[1,2]; Nele Lefeldt[1,2]; Svenja Engels[1,2]; Neville Baker[3]; P J Hore[3]; Henrik Mouritsen[1,2]**

Research Centre for Neurosensory Sciences, University of Oldenburg,Oldenburg,Germany[1]; Institut für Biolgie und Umweltwissenschaften, Carl von Ossietzky Universität Oldenburg,Oldenburg,Germany[2]; University of Oxford, Physical and Theoretical Chemistry Laboratory,Oxford,UK[3]

Magnetic compass orientation in night-migratory songbirds is embedded in the visual system and seems to be based on a light-dependent radical pair mechanism. Recent findings suggest that both broadband fields ranging from 2 kHz to 9 MHz and single-frequency oscillating electromagnetic fields at the so-called Larmor frequency can disrupt this mechanism. However, due to nuclear spin interferences, effects specific to the Larmor frequency are difficult to understand considering that the primary sensory molecule should be organic and probably a protein. Therefore, we tested the orientation capabilities of European robins in a completely electromagnetically silent environment, under the influence of four different single-frequency oscillating electromagnetic fields including the Larmor frequency, double the Larmor frequency, 1.315 MHz and 50 Hz with different intensities, or in the presence of broadband electromagnetic white noise ranging from ca. 2 kHz - ca. 9 MHz. The created time-dependent electromagnetic fields were aligned up-down, i.e. 23° to the 67° inclined field of Oldenburg. Our results indicated that the magnetic compass orientation of European robins could not be disrupted by any of the relative strong single-frequency oscillating electromagnetic fields, but that the weak broadband field very efficiently disrupted their orientation.

**Orientation & Navigation**

Keywords :time-dependen electromagnetic fields; radical pair mechanism; bird orientation

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-77**
**Presentation Time: 16:00 to 17:00**

## PRECISE TARGET-DISTANCE CODING DURING CORTICAL SUPPRESSION IN ECHOLOCATING BATS

**Jerome Beetz[1]; Julio Hechavarría[1]; Manfred Koessl[1]**

Goethe-University,Frankfurt,Germany[1]

In the auditory system detailed temporal processing is crucial. Deficits in temporal processing, especially at cortical level, might result in language disorders like "word deafness". It has been shown that during repetitive sound stimulation suppression reduces temporal tracking capacity of cortical neurons. During echolocation, bats emit sequences of short and repetitive ultrasonic calls and have to orientate with the help of the echoes arising from call reflections from surrounding objects. The bat should be able to track echo events on a millisecond time scale and overcome auditory temporal suppression. The present study investigates the dynamics of target-distance processing of time-sensitive auditory cortex neurons during stimulation with natural echolocation sequences. The results show that cortical target-distance coding neurons actually profit from suppression. Neuronal activity in response to natural echolocation streams of repetitive pulse-echo elements and to individual pulse-echo elements presented randomly and outside the temporal context of the natural sequence demonstrate that cortical suppression results in sharper temporal tuning. This should produce improvement of spatial resolution during echolocation. Additionally, with echolocation streams consisting of multiple echoes coming from two objects along the same axis at different ranges we show that cortical suppression helps the neurons to be most responsive to the closest of the two objects. In conclusion we show that suppression induced by repetitive stimuli does not lead to general unresponsiveness or to deterioration of temporal neuronal tuning in neuronal networks dealing with target-distance. Suppression rather helps to obtain improved delay specificity and directs neuronal focus on close echo-producing objects.

### Orientation & Navigation

Keywords :echolocation; natural stimuli; auditory cortex

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-78**
**Presentation Time: 15:00 to 16:00**

## POLARIZED LIGHT AFFECTS LIGHT-DEPENDENT MAGNETIC COMPASS ORIENTATION IN BIRDS

**Rachel Muheim[1]; Sissel Sjöberg[1]; Atticus Pinzon-Rodriguez[1]**

Lund University,Lund,Sweden[1]

The light-dependent magnetic compass in birds is suggested to be based on a radical-pair mechanism taking place in the avian retina. So far, biophysical models have usually not taken into account that light enters the avian retina unidirectionally, through the cornea and the lens light, and that the activation of the cryptochromes, the putative magnetoreceptor molecules, is anisotropic, suggesting that the light-dependent magnetic compass is intrinsically polarization sensitive. We tested this putative interaction between the avian magnetic compass and polarized light by training zebra finches to magnetic and/or overhead polarized light cues in a 4-arm "plus" maze. The birds did not use overhead polarized light near the zenith for sky compass orientation. Instead, overhead polarized light changed how the birds perceive the magnetic field. Birds were well oriented when tested with the polarized light axis aligned parallel to the magnetic field, but they were disoriented, when the polarized light axis was aligned perpendicular to the magnetic field. Our findings reveal a fundamentally new property of the radical-pair-based magnetoreceptor with key implications for how birds and other animals perceive the Earth's magnetic field.

**Sensory: Magnetoreception**

Keywords :magnetic compass; polarized light; radical-pair process

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-79**
**Presentation Time: 17:00 to 18:00**

## PROESTROUS FEMALE RATS HAVE LOWER PREPULSE INHIBITION OF ACOUSTIC STARTLE REFLEX

**Marina Galleazzo Martins[1]; Carla De Moraes Machado[1]; Sérgio Augusto Rodrigues[2]; Camila Contin Diniz De Almeida-Francia[1]; José De Anchieta De Castro E Horta-Júnior[1]**

Institute of Biosciences - Univ Estadual Paulista,Botucatu,Brazil[1]; School of Agronomy - Univ Estadual Paulista,Botucatu,Brazil[2]

The acoustic startle reflex (ASR) is a fast and intense motor reaction in response to an unexpected and high-intensity sound stimulus triggered by brainstem nuclei, which is present in several species of mammals. The ASR has an adaptive value, since it is a response for a probable treat, protecting vital body parts. One of its modulations is prepulse inhibition (PPI), in which ASR amplitude is reduced by a previous low-intensity sound stimulus. In rodents, little is known about the influence of sex and estrous cycle on these behaviors. Our aim was to evaluate their influence in ASR and PPI. Twenty-eight female, in which estrous cycle was daily accompanied, and 10 male adult Wistar rats were studied for evaluation of ASR and PPI in repeated sessions, followed by immunohistochemistry for Fos protein to analyze the neuronal activity in nuclei related to PPI circuitry. Females were evaluated in each phase of the estrous cycle and its transitions. Neither gender nor estrous cycle modified the ASR amplitude. However, proestrous females had lower %PPI (32,52%) than diestrous females (56,05%) with prepulses >70 dB as well as more Fos-ir neurons and more neuronal density than diestrous ones in the VNTB, PPTg and CnF. These results suggest that sex and estrous cycle can surely modulate PPI. Thus, they must be considered when assessing ASR modulations in females alone and when comparing both sexes.

### Sensorimotor Integration

Keywords :startle; estrous cycle; fos protein

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-80**
**Presentation Time: 18:00 to 19:00**

## LOCUST FLIGHT MUSCLE ACTIVITY AND BODY ORIENTATION IN RESPONSE TO OBJECTS MOVING ALONG COMPLEX TRAJECTORIES

**Sinan Zhang[1]; John Gray[1]**

University of Saskatchewan,Saskatoon,Canada[1]

Locusts are ideal model systems to study complex behaviours, such as flight responses to objects approaching on a collision course. Thus far, flight muscle activity, wing kinematics and aerodynamic forces of locusts have been recorded during collision avoidance behaviour and measured from rigidly-tethered locusts flying in open-loop conditions. However, loosely-tethered flying locusts are capable of changing orientation in response to looming stimuli within a single wing beat, and generate avoidance responses within a single downstroke. To better understand neural control of flight steering, we placed a loosely-tethered flying locust inside an existing flight simulator, and presented visual stimuli of objects moving along complex trajectories. Preliminary analysis of video and EMG recordings suggests that locust initiate stereotyped avoidance behaviours during objects approach. Continued analysis will explore putative relationships between flight muscle activity and body orientation in response to complex object motion. This is the first study of loosely-tethered locusts responding to various visual stimuli, and will provide valuable information for the future construction of a closed-loop recording system.

### Sensorimotor Integration

Keywords :locusta migratoria; flight; collision avoidance

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-81**
**Presentation Time: 15:00 to 16:00**

## DESCENDING CONTROL OF VISUALLY-EVOKED LANDING IN DROSOPHILA

**Jan M. Ache[1]; Shigehiro Namiki[1]; Allen Lee[1]; Kristin Branson[1]; Gwyneth M. Card[1]**

HHMI Janelia Research Campus,Ashburn,USA[1]

Flies spend their time not just flying around, but also on the ground, where important life events, such as feeding or mating, occur. Deciding when and where to land is therefore crucial for a fly's survival. We set out to study the neural control of landing in Drosophila, as a paradigm for descending motor control and action-selection in a genetic model system. Through an extensive optogenetic activation screen, we discovered two bilateral pairs of descending interneurons (DNs 106 and 44), whose activation drives simultaneous extension of all six legs. These leg extensions mimicked those observed during the 'landing response' that flying flies perform in response to an approaching object. To unravel how DNs 44 and 106 control visually-evoked leg movements, we recorded their activity via whole-cell patch-clamp in awake, behaving flies, while tracking leg movements using computer vision strategies. We found that both DNs were multimodal, responding to both visual and mechanosensory stimuli. In line with the idea that DNs 44 and 106 specifically control leg movements during flight, visual responses were heavily state-dependent, and high spike rates were only reached in flight. The timing and magnitude of the responses of all four DNs was correlated with leg movements across a wide range of visual stimuli. However, driving any individual DN to spike at high frequencies was not sufficient to cause leg motion. This suggests that landing is controlled by the combined activity of a small population of DNs, which encode visual features in a context-dependent manner.

### Sensorimotor Integration

Keywords :descending neurons; electrophysiology; drosophila

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-82**
**Presentation Time: 16:00 to 17:00**

## CONSERVED MECHANOSENSORY-MOTOR CIRCUITS IN INSECT ANTENNAE.

**Harshada Sant[1,2]; Sanjay Sane[1]**

National Centre for Biological Sciences,Bangalore,Inda[1]; Manipal University,Manipal,India[2]

In addition to being the primary olfactory organs, insect antennae also serve several critical mechanosensory roles in all insects. The variety of insect antennal morphologies reflects the diversity of antennal mechanosensory functions, ranging from tactile sensation to audition and flight control. Nearly all insects position their antennae at the onset of flight, and then maintain and modulate this position during flight. The ubiquity of this so-called "antennal positioning response" in insects suggests the hypothesis that neural circuitry underlying this behavior is conserved across a broad range of insect species. To address this hypothesis, it is essential to probe the antennal mechanosensory and motor circuits using a comparative approach. To investigate this question, we characterized the architecture and neural targets of mechanosensory neurons which underlie the hair plates (or Böhm's bristles), known to mediate antennal positioning in moths, located on scape and pedicel of the antennae. In addition, we also surveyed the Johnston's organs, located between the pedicel and flagellum of the antenna. We chose phylogenetically distinct insect orders, including moths (Lepidoptera), honey bees (Hymenoptera) and crickets (Order Orthoptera), all of which use their antennae in distinct ways. Our data shows that despite their ecologically, morphologically and behaviorally diverse roles, the axonal projection patterns of Böhm's bristles and their motor neuronal targets within the Antennal Mechanosensory and Motor Centre (AMMC) remain essentially similar, suggesting that the neural architecture of the "antennal positioning behavior" is conserved and may thus be an essential feature in flying insects.

### Sensorimotor Integration

Keywords :sensory systems; evolution; hair plates, johnston's organs

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-83**
**Presentation Time: 17:00 to 18:00**

## THE SITE OF ECTOPIC SPIKE INITIATION FACILITATE SIGNAL INTEGRATION IN A SENSORY NEURON

**Carola Staedele Dos[1]; Wolfang Stein[1]**

Illinois State University,Normal,USA[1]

Long distance communication in the nervous system requires the propagation of action potentials along axons. The capacity of axons to contribute to signal integration and shaping neuronal output has long been underestimated. For instance, action potentials can be initiated in the axon trunk, far away from the soma and the axon hillock. Such ectopic action potentials bypass dendritic signal integration and have been shown to be functionally relevant in both vertebrate and invertebrate neurons. However, very little is known why ectopic spikes are initiated where they are and what controls their frequency. Here we study ectopic spiking in the anterior gastric receptor neuron (AGR), an experimentally advantageous single-cell muscle tendon organ in the stomatogastric nervous system of Cancer borealis. By using a combination of electrophysiology and optical imaging we found that AGR's spontaneous ectopic spike activity was consistently initiated at a predetermined location, in close vicinity to the neuropil region and thus potential synaptic partners. We show for the first time that ectopic spike frequency is under neuronal control: it was modulated locally by the gastric mill (GM) motor neurons, enabling a modulation of sensory activity by the motor system. This sensorimotor interaction was state-dependent because axon modulation with the biogenic amine octopamine abolished signal integration by dislocating the spike initiation zone. Our data thus indicate that site where spikes are initiated can be controlled by the motor system and that neuromodulation allows the dynamic enabling and disabling of sensorimotor interactions.

### Sensorimotor Integration

Keywords :ectopic action potential; cancer borealis; octopamine

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-84**
**Presentation Time: 18:00 to 19:00**

## ECHOLOCATION STRATEGY OF THE FRUIT-EATING BAT ARTIBEUS JAMAICENSIS (CHIROPTERA: PHYLLOSTOMIDAE) FOR CAPTURING TYMPANATE MOTHS

**Dennis Francos[1]; Yohami Fernández[1]; Ariadna Cobo[1]; Emanuel Mora[1]**

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Recent studies of acoustic sensory perception in moths have tried to place the insect in naturalistic behavioral and ecological contexts. The acoustic stimulation of the moth tympanic organ with natural signals is one of the accepted approaches to study the bat-moth acoustic interaction. So far, the auditory response of the A1 receptor cell to the bat calls of species adapted to feed/echolocate on fruits and flowers has not been studied. In this paper a three-dimensional positioning method that make use of a microphone array has been employed to determine the location of the fruit-eating bat Artibeus jamaicensis while capturing moths in the wild. This enabled the calculation of emission intensities at 10 cm from the mouth of the bat, what was achieved after considering the perceived intensity at microphones, and geometric and atmospheric attenuations. Thus, we were able to obtain several audio files reproducing the spectro-temporal characteristics of the echolocation calls in A. jamaicensis while capturing the wax moth Galleria mellonella. This work shows for the first time the echolocation behavior of a fruit-eating bat while foraging on insects in the wild. In addition, the audio files obtained were used for acoustic stimulation of the tympanic organ of the sympatric moth Empyreuma pugione. The study of the peripheral auditory processing in this moth suggested possible advantages in the echolocation strategy that would enable fruit-bats to succeed in capturing insects.

**Sensory: Audition**

Keywords :echolocation strategies; trophic niche; moth hearing

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-85**
**Presentation Time: 15:00 to 16:00**

## HORIZONTAL SOUND LOCALIZATION PERFORMANCE BY A GLEANING BAT, ANTROZOUS PALLIDUS

**Dustin Brewton[1]; Khaleel Razak[1]**

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The auditory cortex is necessary for sound localization. Recent studies in the pallid bat have generated testable hypotheses about bi-coordinate spatial representation in a mammalian auditory cortex. The noise-selective region of the pallid bat auditory cortex, putatively involved in localizing prey-generated noise, is organized into two binaural clusters based on interaural level difference (ILD) selectivity. Cells within the peaked cluster respond best to midline stimuli generating ILD ~ 0 dB. Cells within the binaurally inhibited (EI) cluster respond best to contralateral stimuli. To determine contributions of these regions to behavior, the first step is to characterize the horizontal sound localization ability of the pallid bat. Bats were trained to localize noise stimuli for a food reward on an 'approach to stimulus' task. The effect of sound duration, bandwidth (12 kHz low-pass or broadband), and location on performance was measured. A correct response equals a performance score of 1, a miss by one speaker (18o error) = 0.8, missing by 2 speakers = 0.6, etc. Results indicate that performance score co-varies with duration and location of the broadband stimulus ($p<0.001$). There is also a significant decline in performance when localizing low-pass stimuli vs. broadband noise stimuli ($p<0.001$).These results indicate a threshold bandwidth and duration is necessary for accurate localization in the pallid bat. The neurophysiological basis of these thresholds will be examined in the EI and peaked clusters.These experiments contribute to the development of the pallid bat prey-hunting behavior as a neuroethological model to understand sound localization mechanisms.

**Sensory: Audition**

Keywords :sound localization; auditory cortex; bat

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-86**
**Presentation Time: 16:00 to 17:00**

## SEX-SPECIFIC MECHANISMS OF HEARING IN MOSQUITOES

**Joerg T Albert[1]; Matthew P Topping[1]**

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The sense of hearing plays a crucial role in mosquito reproductive behavior, where males use the faint female flight tones to detect, and locate, a mating partner. To see if this sexually dimorphic auditory behavior associates with sex-specific hearing we analyzed auditory function across three disease-transmitting mosquito species. The antennal sound receivers of all mosquitoes displayed power gain, i.e. they actively amplified sound-evoked oscillations. Mechanical amplification was transduction-dependent, with males injecting more energy than females. Analyzing the nonlinear compliances, which result from the direct gating of mechanosensory ion channels we discovered a male-specific population of exquisitely sensitive auditory transducers. Global blocks of action potential signaling (via tetrodotoxin), resulted in large amplitude self-sustained sound receiver oscillations only in males, but not in females, suggesting the existence of a male-specific pathway for auditory gain control, potentially mimicking the efferent gain control mechanism of the mammalian cochlea.

**Sensory: Audition**

Keywords :mosquito hearing; acoustic communication; auditory transduction & amplification

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-87**
**Presentation Time: 17:00 to 18:00**

## CHANGES IN EGR-1 EXPRESSION IN AUDITORY NUCLEI OF MALE FROGS PLEURODEMA. THAUL DEPEND ON PLASMA TESTOSTERONE LEVELS.

**Maricel Quispe[1]**

Changes in the activity of sensory systems mediated by sexual steroidal hormones have been extensively studied using EGR-1 (ZENK) expression in different groups of vertebrates. In anurans, changes in the activity of cells of the midbrain auditory center, the torus semicircularis (TS) using EGR-1 mRNA have been reported for female frogs. High levels of this indicator occur in the TS of females treated with estradiol and stimulated with conspecific vocalizations. We studied the modulation effect of testosterone on the expression of EGR-1 protein in TS neurons in males of Pleurodema thaul. We found that testosterone-implanted males stimulated with a conspecific chorus had larger numbers of EGR-1 positive cells in the laminar nucleus of the TS relative to implanted subjects exposed to white noise, a biologically irrelevant sound. No such differences occurred in animals that did not received testosterone implants. Furthermore, no comparable differences in the principal nucleus occurred among animals receiving different treatments. These results suggest that testosterone levels have an important role on male frog brain activation during the breeding season and on the selective processing of biologically relevant signals. FONDECYT grant 1140014 and CONICYT grant 24100205.

**Sensory: Audition**

Keywords :egr-1; torus semicircularis; testosterone

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-88**
**Presentation Time: 18:00 to 19:00**

## HOW AND WHY DO CATERPILLARS HEAR?

**Jayne Yack[1]; Chantel Taylor[1]**

Carleton University,Ottawa,Canada[1]

Many species of larval Lepidoptera have been observed to respond to sounds, but there has been limited formal study of this phenomenon. Our study focuses on the behavioural responses to sound and identification of sensory organs in late instar larvae of Monarch butterflies (Danaus plexippus). Using high-speed videography caterpillars were shown to respond to sounds by freezing, contracting their bodies, and flicking their thorax vertically. Behavioural responses occur at latencies between 50 and 800 ms to sound frequencies ranging between 50 and 900 Hz, with a best frequency of 150 Hz. Sensory receptors were identified as pairs of elongated (~400 microns) trichoid sensillae located on the prothorax and last abdominal segments. The most important of these include an upper and lower pair on each side of the prothorax. Ablations of these setae in individuals previously demonstrated to respond to sound resulted in all individuals losing their ability to detect the sound, while (non-ablated) sham controls responded in 95% of post-operation trials. We suggest that the unique orientations and lengths of different pairs of setae contribute to increasing the caterpillar's receptive field. A survey of other lepidopteran species tested shows that caterpillar 'hearing' is widespread the phylogeny. Behavioural responses to sounds are discussed in terms of their importance in the insect's defense against natural predators and parasitoids.

**Sensory: Audition**

Keywords :caterpillar; sensory; near field sound

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-89**
**Presentation Time: 15:00 to 16:00**

## AN EFFERENT AUDITORY SYSTEM INNERVATING THE MOSQUITO JOHNSTON'S ORGAN

**Marta Andrés[1]; Marvin Seifert[1]; Martin Göpfert[1]**

University of Göttingen,Göttingen,Germany[1]

Mosquitoes are extremely sensitive to sound thanks to the outstanding properties of their chordotonal hearing organ, the Johnston's Organ (JO). Hearing plays an essential role in the mosquito life cycle since it mediates partner recognition. Male mosquitoes detect co-specific females by hearing their wingbeats and exhibit frequency selectivity and input amplification of the sound stimuli. These non-linear mechanisms resemble the cochlear amplifier that is finely modulated by efferent fibers to adapt the auditory response to the physiological requirements of the organism. However, insect chordotonal organs have been traditionally thought to lack efferent input. Here, we find evidence of an extensive efferent innervation of the mosquito JO. To our knowledge, it is the first time that such an efferent system is described for any insect chordotonal organ. Two types of efferent terminals are found releasing different neurotransmitters, and suggesting a complex modulation of the auditory input. Type I terminals are octopaminergic and innervate the auditory neurons. Injected octopamine affects JO auditory sensitivity and frequency tuning. By contrast, type II terminals are GABAergic and innervate the afferent auditory nerve. Blocking GABAergic transmission yields to changes in sound-evoked electrical responses of the JO. Deciphering the mechanisms mediating mosquito audition will reveal us the functioning of an extremely sensitive sound detector and potentially point at targets to disrupt the mating behavior, a still unexplored approach to control mosquito populations.

**Sensory: Audition**

Keywords :audition; mosquito; efferent

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-90**
**Presentation Time: 16:00 to 17:00**

## EFFECT OF ECHO FLOW INFORMATION ON FLIGHT AND ECHOLOCATION BEHAVIOR IN THE BIG BROWN BAT

**Michaela Warnecke[1]; Wu-Jung Lee[1,2]; Cynthia Moss[1]**

Johns Hopkins University,Baltimore,United States[1]; University of Washington,Seattle,United States[2]

To navigate in cluttered environments, not only is it important for animals to estimate their relative distance to obstacles, but also the speed at which they approach them. Such action planning is especially challenging for flying and swimming species that navigate in three dimensions. Previous research has shown that visual patterns influence the navigation paths of honeybees (Srinivasan et al., 1996, The Journal of Experimental Biology, 199(1)), budgerigars (Bhagavatula et al. 2011, PLoS computational biology, 10(3)), and zebra fish (Scholtyssek et al. 2014, Biology letters, 10(5)), suggesting that these species make use of optic flow patterns to guide their movements. Most research on the effect of sensory flow patterns on animal trajectories, however, has been conducted in species using vision as a primary sense for navigation. Here we report a study of acoustically guided navigation in the echolocating big brown bat. The bats flew into a corridor built from a series of poles with 2.5 cm diameter. The spacing between poles was adjusted to create different echo flow patterns from the two walls of the corridor. The flight trajectories and head aims of the bats navigating the corridor were recorded by high-speed IR motion-capture cameras. The bats' echolocation behavior was recorded with 4 ultrasound microphones, digitized and analyzed off-line. With different spacing of the poles on the left and right corridor walls, both the bats' head aim and flight trajectory steered away from the acoustically more reverberant wall. We hypothesize that the bats adapt their behavior to balance the echo flow pattern as they navigated the corridor.

**Sensory: Audition**

Keywords :bat echolocation; echo clutter; flight behavior

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-91**
**Presentation Time: 17:00 to 18:00**

## THE AQUATIC TYMPANIC EAR: CONVERGENT ADAPTATIONS FOR UNDERWATER HEARING IN THREE TETRAPODS

**Jakob Christensen-Dalsgaard[1]; Magnus Wahlberg[1]; Ole NÆSBYE Larsen[1]**

University of Southern Denmark,Odense,Denmark[1]

All groups of tetrapods have members that adopt aquatic lifestyles with physiological adaptations also of their auditory system. Auditory sensitivity is affected by the different characteristic impedances in air and water caused by the differences in density and sound speed. Water is a high pressure, low particle motion medium, and the consequence is that an efficient underwater ear is sensitive to sound pressure. It is often stated that underwater hearing can work efficiently without a middle ear apparatus by bone conduction, since sound is transmitted from water to inner ear tissue with little loss. However, the sensitivity of such an ear is limited by the very low particle motion in water. We report on underwater hearing in tetrapods ranging from totally aquatic (the clawed frog Xenopus laevis) and mostly aquatic (the red-eared slider Trachemys scripta) to mostly terrestrial (the cormorant Phalacrocorax carbo sinensis) studied by laser vibrometry and auditory evoked responses. All have tympanic middle ears with an air-filled middle ear cavity. The eardrum vibration peak frequency is correlated with the resonance frequency of the middle ear cavity air volume and the eardrum is modified (cartilaginous or partly cartilaginous). In all three species, the lowest threshold to underwater sound is at this peak frequency and is around 80 dB re 1 μPa. The sensitivity to sound pressure is slightly lower in water than in air, making underwater hearing much more efficient in terms of sound energy. Consequently, the slightly modified tympanic ears of these species are efficient aquatic sound receivers.

### Sensory: Audition

Keywords :middle ear; frog; bird

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-92**
**Presentation Time: 18:00 to 19:00**

## VOCAL INTERACTIONS IN FREELY MOVING ZEBRA FINCHES (TAENIOPYGIA GUTTATA): CONTEXT DEPENDENT CHANGES AND A LOOK INTO THE BRAINS' SECONDARY AUDITORY AREAS.

**Mauricio Nicolas Adreani[1]; Manfred Gahr[1]; Andries Ter Maat[1]**

Max Plank Institute for Ornithology,Seewiesen,Germany[1]

Calls, which are generally unlearned vocalizations, are the most frequent component of birds' repertoires. However, when compared with song, studies of calling behaviour are relatively seldom. Recent technological advances (e.g. telemetric backpack microphones) that allow for individual recordings of interacting birds opened up a new field of research. Recently, it has been shown that in zebra finches, the usage of unlearned calls changes with the breeding cycle. We aim to study the neurophysiological mechanisms behind these changes. It is well known that in mammals' auditory perception changes during the life cycle. To test whether something similar could occur in birds, we designed an experiment with two consecutive conditions: in freely behaving zebra finches we recorded neurophysiological responses and vocal activity continuously before and after the breeding onset. Individuals were equipped with telemetric microphones, and the pair carried electrophysiology transmitters that registered the electrical activity in the caudomedial nidopallium (NCM), an auditory area that contains a great number of sex-related hormone receptors. Night playbacks of different call types took place daily and the local field responses (LFPs) were analyzed. At the behavioural level, we found that vocal activity of the birds changed drastically as well as the composition of the repertoire. Interestingly, the strength of the interactions between birds varied in diverse ways depending on the call type and the social status. When analyzing the LFPs, in NCM, we found a power peak in the 30-50 Hz band and the spectral entropy of these bands changed after the breeding onset.

**Sensory: Audition**

Keywords :context dependant plasticity; vocal communication; songbirds

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-93**
**Presentation Time: 15:00 to 16:00**

## SOUND SPECIFIC RIGHT-LEFT ASYMMETRY IN THE CORTICAL PROCESSING OF COMMUNICATION CALLS BEFORE AND AFTER CORTICAL SILENCING WITH MUSCIMOL

**Markus Schaefer[1]; Julio C. Hechavarría[1]; Manfred Kössl[1]**

Communication sounds of mammals, although playing an important role for social interactions, are still not completely understood regarding their cortical processing. A number of studies have shown that the left brain hemisphere of humans is specialized for speech processing, whereas the right hemisphere is specialized in the processing of prosody and music. Whether the processing lateralization described in humans is a generalized feature across mammals remains unclear. In this study we try to shed light on the processing mechanisms that allows the gerbil's (Meriones unguiculatus) brain to decode information from communication calls. Our approach was to compare the pure-tone and communication-call elicited cortical activity of both hemispheres. Cortical activity was measured with a 16-channels vertical multielectrode array before and after cortical silencing with the GABA-receptor agonist Muscimol. By using a current source density analysis that is based on the second spatial derivative of the local field potentials along the radial depth, we spatially and temporally localized the functionally weighted synaptic activity across the cortical columns. The sound elicited current-source-density patterns differed between sound types and hemispheres, thus suggesting that sound specific activity patterns mediate the processing of specific sound types in both hemispheres. Current-source-density patterns elicited by different sound types included mid (> 50 ms) and long latency (> 250 ms) synaptic depolarizations whose origin is likely not intracortical since they remain there after cortical silencing with Muscimol. We argue that the mid- and long latency inputs to the cortical column could be of importance for a hemispheric-specific processing of sounds that differ in their spectro-temporal design.

**Sensory: Audition**

Keywords :neuropharmacology; primary auditory cortex; intracortical network processing

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-94**
**Presentation Time: 16:00 to 17:00**

## AN ELECTRIC FISH POTASSIUM CHANNEL SPECIALIZED FOR ULTRA-BRIEF DISCHARGES: SEQUENCE EVOLUTION AND BIOPHYSICS.

**Harold Zakon[1]; Sophie Sdao[2]; Fernando Fernandez[3]; Alfredo Ghezzi[1]; Jason Gallant[2]**

The University of Texas,Austin,United States[1]; Michigan State University,East Lansing,USA[2]; University of Puerto Rico,Cayey,Puerto Rico[3]

Electric fish sense the environment and communicate with electric organ discharges (EODs). The African mormyroidae comprise one wave-type (Gymnarchus niloticus) and 200+ pulse-type species. Most pulse-type species generate brief (hundreds of microseconds) EODs. A voltage-gated potassium channel (Kv1.7) of mammalian muscle is duplicated in teleosts. In Brienomyrus brachyistius, a mormyrid with an ultra-brief pulse, Kv1.7b is in muscle and Kv1.7a in the EO. Vivo-morpholino knock-down of Kv1.7a from the B. brachyistius EO attenuated the EOD compared with controls demonstrating the role of Kv1.7 in EOD generation. We compared sequences of these two channels from mormyroids and other teleosts. Mormyroid Kv1.7b is similar across teleosts. Kv1.7a of G. niloticus, whose wave-type EOD is a series of regular 1 msec pulses, resembles the kv1.7a of non-electric teleosts. Kv1.7a of pulse mormyroids has amino acid substitutions in conserved, functionally critical regions of this channel (the voltage sensor and regions of the channel that interact with the voltage-sensor). Gymnarchus Kv1.7a expressed in Xenopus oocytes activates at moderately depolarized voltages ($V1/2=-20mV$) with a moderate activation time constant (~2.4msec); Kv1.7a from B. brachyistius, activates at more hyperpolarized voltages ($V1/2=-42.0mV$) with a rapid activation time constant (~1.4msec) (values between species are significantly different, $p<0.002$). Rapid activation of Kv1.7a at a hyperpolarized membrane potential would shorten EOD pulses.

### Sensory: Electrosensory

Keywords :electric organ; electric fish; potassium channel

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-95**
**Presentation Time: 17:00 to 18:00**

## NEURONAL TUNING OF THE GYMNOTIFORM ELECTROSENSORY LATERAL LINE LOBE TO NATURAL COMMUNICATION SIGNALS

**Volker Hofmann[1]; Michael Metzen[1]; Maurice Chacron[1]**

McGill University,Montreal,Canada[1]

Gymnotiform weakly electric fish emit constant frequency, sinusoidal electric currents (electric organ discharge EOD) to the surrounding water. The EODs of two fish being in vicinity to each other interact, which causes a sinusoidal amplitude modulation of the compound waveform (beat). This can be used for social communication: by transiently increasing its EOD frequency a fish can cause a distortion of the beat, which constitutes a communication signal (chirp). The identity of these signals is determined by the magnitude (DF) and the duration (DT) of the EOD frequency excursion and varying these parameters gives rise to a variety of chirp waveforms. The tuning of behavioral responses to different chirp waveforms is narrow which shows that the animals are able to decompose the variety of naturally occurring waveforms and determine the identity of a chirp. We here endeavor to find a neuronal correlate of this behavioral ability in the electrosensory pathway of the weakly electric gymnotid Apteronotus leptorhynchus. As electrosensory afferents will faithfully encode the different compound waveforms, we start with a systematic characterization of the neuronal tuning properties to the chirp parameters in pyramidal cells of the electrosensory lateral line lobe (ELL). While the tuning of the ELL population matches this found in behavior, it is generally broader. This suggest that further refinement can be expected in downstream nuclei, such as the torus semicircularis (TS), which will be targeted in subsequent recordings.

**Sensory: Electrosensory**

Keywords :electrocommunication; sensory encoding; signal detection

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-96**
**Presentation Time: 18:00 to 19:00**

## SK CHANNELS UNDERLIE EFFICIENT PARALLEL PROCESSING AND PERCEPTION OF NATURAL SENSORY STIMULI IN THE ELECTROSENSORY SYSTEM

**Chengjie Huang[1]; Zhubo Zhang[1]; Maurice Chacron[1]**

McGill University,Montreal,Canada[1]

Understanding how neurons in the brain encode and process stimuli encountered by an animal in its environment is essential to elucidating how behavioural mechanisms operate.Natural sensory stimuli are known to follow a decaying power-law yet contain numerous redundancies,and therefore must be processed efficiently within the given constraints of neurons in the brain.Efficient coding theory states that the nervous system must adapt its neural processing and behavioural strategies to match the natural scene statistics.How efficient processing of the natural stimulus features occurs,and the consequential perception and behavior are poorly understood in general.One prominent hypothesis is that incoming sensory information can be segregated and efficiently processed via different "streams,"otherwise known as parallel processing.Here we used the weakly electric fish Apteronotus leptorhynchus, to demonstrate that parallel processing occurs in the three segments of the hindbrain structure electrosensory lateral line lobe (ELL) to efficiently encode second-order stimulus attributes.Using a combination of electrophysiology and pharmacology,we found that the lateral (LS) and centrolateral segments (CLS) temporally decorrelate stimulus features to give rise to power-law adaptation enabled by the high density of small-conductance calcium activated potassium (SK) channels.On the contrary,we found that the centromedial segment (CMS) which contains little to none SK channels,serves as a bandpass filter to preserve stimulus features.Together,these results demonstrate a general novel mechanism of SK channels underlying optimal parallel processing of second-order natural sensory input,which is likely to be shared across sensory systems and species.

**Sensory: Electrosensory**

Keywords :sk channels; parallel coding; envelopes

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-97**
**Presentation Time: 15:00 to 16:00**

## SENSORY-EVOKED SEROTONIN DYNAMICS AND ITS RELATION TO ONGOING COMMUNICATION BEHAVIOR

**Haleh Fotowat[1]; Erik Harvey-Girard[1]; Joseph F Cheer[2]; Rüdiger Krahe[3]; Leonard Maler[1]**

University of Ottawa,Ottawa,Canada[1]; University of Maryland,Baltimore,USA[2]; McGill iversity,Montréal,Canada[3]

The brain serotonergic (5-hydroxytryptamine; 5-HT) system affects targets throughout the central nervous system and is highly conserved across vertebrates. 5-HT affects the response properties of neurons in sensory cortices of various vertebrate species, but its mechanisms of action under behaviorally relevant conditions remain poorly understood. We used fast-scan cyclic voltammetry in the electrosensory system of weakly electric fish Apteronotus leptorhynchus to study sensory-evoked dynamics of 5-HT release in response to naturalistic communication signals. We found that the presence of a conspecific could give rise to 5-HT release specifically in the electrosensory lobe (ELL) map that is specialized for processing electrocommunication signals (lateral segment: LS). The release was variable across fish and in response to conspecifics of different size and sex, suggesting dependence of the response on an individual's past experience. Intense auditory stimuli did not evoke a response, suggesting specificity for the electrosensory modality. Interestingly, 5-HT responses were particularly suppressed in the trials where the fish generated a behavioral response to signals of same-sex conspecifics (chirps). Serotonin release in sensory regions is therefore under the influence of an animal's own behavior and may enhance discrimination of communication signals in a context-dependent manner.

**Sensory: Electrosensory**

Keywords :fast-scan cyclic voltammetry; serotonin; weakly electric fish

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-98**
**Presentation Time: 16:00 to 17:00**

## PHASE-LOCKING TO HIGH-FREQUENCY STIMULI IN THE WEAKLY ELECTRIC FISH APTERONOTUS LEPTORHYNCHUS.

**Jan Grewe[1]; Carolin Sachgau[2]; Jan Benda[1]; Fabian Sinz[3,4]**

University of Tuebingen,Tuebingen,Germany[1]; University of Ottawa,Ottawa,Canada[2]; Bernstein Center for Computational Neuroscience,Tübingen,Germany[3]; Baylor College of Medicine,Houston,USA[4]

A species-specific segregation of communication channels is commonly observed when several species share the same habitat and use the same sensory modality to communicate or navigate. For instance, the auditory sensory periphery is often tuned to the carrier frequency of the sounds produced by the same individual or other individuals of the same species. Similarly, the electroreceptors in the active electrosensory system of the weakly electric fish Apteronotus leptorhynchus show a tuning to the carrier frequency of the own electric field used for navigation and communication. Since fish of the same species tend to exhibit similar frequencies it became an accepted view that the tuning properties establish a “private” species-specific channel for communication and sensation. However, field data show that different species of weakly electric fish occupy the same habitat and our recent outdoor recordings demonstrate active interactions between individuals of species with very different electric field frequencies. In vivo recordings from receptor afferents as well as from pyramidal neurons in the electrosensory lateral line lobe in the hindbrain show phase locking of spike times to signals a few hundred Hertz away from the individual's own field frequency. These findings are incompatible with the idea of a private coding channel. High-frequency phase-locking in pyramidal neurons underlines the behavioral relevance and further suggests a precisely organized wiring pattern of the afferent input.

**Sensory: Electrosensory**

Keywords :weakly electric fish; electrophysiology; phase-locking

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-99**
**Presentation Time: 17:00 to 18:00**

## PULSE DISCRIMINATION FROM TWO FREELY SWIMMING GYMNOTUS SP.

**Rafael Tuma Guariento[1]; Paulo Matias[1]; Jan Frans Willem Slaets[1]; Lirio Onofre Baptista Ds Almeida[1]; Reynaldo Daniel Pinto[1]**

São Carlos Institute of Physics - University of São Paulo,São Carlos,Brazil[1]

Weakly field electric fishes have electric organs capable of generating an electric field that surrounds their bodies, and which is detected by specialized cells on their skin. Distortions of this field allow electric fishes to locate and identify both objects (electrolocation), and other electric fishes. In the latter case, electrocommunication occurs via a modulation of the electric organ's firing rate. More specifically, pulse-type electric fishes emit a temporally located electric signal, with a stereotypical waveform. In principle, it is possible to detect the spike train generated by a freely swimming fish simply by inserting a pair of electrodes in the aquarium and amplifying the recorded signals differentially. However, to study the communication between conspecifics, it is necessary to evaluate which fish fired each spike, in situations in which there may be overlap between the signals of different fishes. This is a non-trivial problem when both fishes are swimming freely in the aquarium, changing their relative position to the electrodes and interacting mechanically, for instance with reciprocal pursuits and bites.

In this work, we have developed a machine-learning based algorithm, with a user-friendly graphical interface, capable of discriminating the pulses and exporting a file with the time instant of each pulse.

**Sensory: Electrosensory**

Keywords :electric fish; machine learning; support vector machine

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-100**
**Presentation Time: 18:00 to 19:00**

## NEURAL CODING OF ELECTRIC IMAGES IN PULSE GYMNOTIFORMES.

**Alejo Rodriguez-Cattaneo[1]; Pedro Aguilera[1]; Carolina Pereira[1]; Angel Caputi[1]**

IIBCE,Montevideo,Uruguay[1]

Here we investigate the neural encoding of the electric images at the slow electrosensory pathway of Gymnotus omarorum combining measuremet and modelling of object generated electric images with extracellular recordings of primary afferents and electrosensory lobe neurons in acutely descerebrated freely discharging preparations and electrosensory lobe neurons and field potentials in the freely exploring animal. Despite the anatomical similarities between pulse and wave gymnotids, the early encoding of electric images is different. We confirmed that receptor and ELL neurons responses are patterned. We found that this pattern is modified not only by amplitude but also by time waveform of the local EOD. Patterning of the activity of the ELL neurons and their modulation by objects can be explained taking into account the afferents' firing patterns and the local (ELL intrinsic) and recurrent (ELL- praeminentialis) circuits. Supported by ANII, PEDECIBA and UDELAR-CAP.

**Sensory: Electrosensory**

Keywords :; ;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-101**
**Presentation Time: 15:00 to 16:00**

## DISTRIBUTION OF VOLTAGE-GATED SODIUM CHANNELS AND SODIUM-POTASSIUM ATPASES ALONG THE ELECTRIC ORGAN OF THE WEAKLY ELECTRIC FISH BRACHYHYPOPOMUS GAUDERIO.

**Vielka Salazar[1]; Caitlin Bennett[1]; Jessica Prendergast[1]**

Cape Breton University,Sydney,Canada[1]

The weakly electric fish Brachyhypopomus gauderio generate electric organ discharges (EODs), via their electric organ (EO), for electrocommunication and electrolocation. When measured at a distance of approximately 10 cm away from the fish, the remote EOD pattern of B. gauderio is a biphasic waveform. Yet, local recordings (measured within millimeters) have revealed that the remote biphasic signal is actually a composite of slightly different waveforms produced by different parts of the EO along the rostrocaudal axis. In this study, we characterized morphological differences using histochemically-stained sections of consecutive 0.5 cm segments to visualize changes in the electric organ's cells, the electrocytes. We also labeled voltage-gated sodium channels (VGSCs) and sodium-potassium ATPases within cell membranes of the electrocytes to map their distribution along the EO's rostrocaudal axis. Overall, the length, width, and space between rows of electrocytes, and stalk length and width were greater in the male's rostral and mid EO, with little sexual dimorphism seen in the caudal EO. VGSCs and ATPases were more abundant in the anterior membrane of electrocytes in the rostral and mid EO, and equally abundant in both anterior and posterior membranes of electrocytes in the caudal EO. These results help us to better understand the role of EO morphology and membrane physiology on signal plasticity in the context of different social states.

**Sensory: Electrosensory**

Keywords :electric organ; voltage-gated sodium channel; sodium-potassium atpase

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-102**
**Presentation Time: 16:00 to 17:00**

## SURFACE WAVE PERCEPTION IN CROCODILES

**Nadja Grap[1]; Horst Bleckmann[1]**

Institute of Zoology,Bonn,Germany[1]

Crocodiles are able to hunt in complete darkness without the need of acoustic cues. Instead they use their Integumentary sensory organs (ISOs) to detect water surface waves elicited by prey, predators or conspecifics. The ISOs cover the jaws, particularly surrounding the teeth. The aim of our study was to determine how sensitive crocodiles (Crocodylus niloticus, Caiman crocodilus) respond to single-frequency water surface waves, whether they can discriminate between different wave stimuli, and to which precision they determine the direction and distance to a wave source. Using operant conditioning, crocodiles were trained to respond to surface waves, produced by blowing air onto the water surface, with an orienting movement. Within the test range (15 Hz to 80 Hz), threshold values decreased with increasing wave frequency (12.8 µm at 15 Hz and 0.5 µm at 80 Hz peak-to-peak water displacement). Frequency discrimination limens were 0.04 at 40 Hz and 0.1 at 15 Hz. Frequency changes (e.g. from 40 to 38.5 Hz) within a wave train were also recognized. Nile crocodiles determined the direction and – roughly – the distance to a surface wave source even in the presence of an interfering surface wave stimulus.

**Sensory: Mechanosensation**

Keywords :crocodile; water surface waves; integumentary sensory organs

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-103**
**Presentation Time: 17:00 to 18:00**

## COMPARISON OF CERCAL SYSTEM WIND-SENSITIVE FILIFORM PRIMARY AFFERENT RESPONSES IN COCKROACHES PERIPLANETA AMERICANA AND BLABERUS CRANIIFER.

**Jeffrey Triblehorn**[1]

College of Charleston,Charleston,USA[1]

The wind-sensitive insect cercal sensory system is involved in important behaviors including predator detection and initiating terrestrial escape responses. However, not all insects possessing a cercal system exhibit this behavior. In cockroaches, wind evokes strong terrestrial escape responses in Periplaneta americana, but only weak escape responses in Blaberus craniifer. These behavioral differences correlate with differences the cercal system and sensory processing of wind information. We examined afferent responses in these two species using 250 ms wind puffs with velocities between 0-250 cm/s. Extracellular recordings of the filiform afferent population activity taken from the cercal nerve showed that that B. craniifer responses were similar to or greater than P. americana responses even though B. craniifer possessed smaller cerci with less filiform hair receptors than P. americana. Furthermore, the greater filiform afferent responses in B. craniifer included a larger amplitude second positive peak compared to P. americana. To investigate the species differences in the afferent population responses, we recorded intracellularly from individual afferents. In P. americana, three types of afferent activity were recorded: 1) spike counts increasing rapidly with stimulus velocity and plateauing with a short latency (12-15 ms) that did not vary with stimulus velocity; 2) spike counts increasing gradually as stimulus velocity increased with longer latency (25-75 ms) that decreased with stimulus velocity; 3) low spike counts that did not vary with stimulus velocity with the longest latencies (40-100 ms) that decreased with stimulus velocity. P. americana responses will be compared to individual B. craniifer afferent responses.

**Sensory: Mechanosensation**

Keywords :blatteria; insect; predator-prey

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-104**
**Presentation Time: 15:00 to 16:00**

## NON-VISUAL FUNCTIONS OF VISUAL OPSINS

**Diego Giraldo[1]; Damiano Zanini[1]; Marta Andrés[1]; Bart R. H. Geurten[1]; Martin C. Göpfert[1]**

Georg-August Universität Göttingen,Göttingen,Germany[1]

Evidence is accumulating that opsins can sense more than light. In Drosophila, opsins were recently implicated in larval temperature preference behaviours and in hearing in adult flies. Here, we report that Drosophila larvae also require visual opsins for locomotion, and show that the proprioceptors that control locomotion do express opsins. Opsin mutant larvae had reduced muscle contraction amplitude and reduced locomotion speeds. When we genetically rescued the function of the respective opsin gene, normal locomotion was restored. Opsin-dependent locomotion defects associated with altered temperature preference behaviours and closely resembled the locomotion deficits of mutants whose chordotonal neurons are impaired. Promoter-fusions revealed that opsins are expressed in the serially arranged, proprioceptive chordotonal neurons in the larval body wall. Opsin expression was confirmed with antibodies, and chordotonal neurons seemed to be the only neurons that express opsins outside the larval eye. This suggests that larval locomotion and temperature preferences might converge on chordotonal neurons. It also strongly supports the idea that light-independent opsin functions evolutionarily predated their use as photoreceptor proteins.

**Sensory: Mechanosensation**

Keywords :opsin; chordotonal organs; proprioception

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-105**
**Presentation Time: 16:00 to 17:00**

## INVESTIGATION OF THE MOLECULAR MECHANISMS RESPONSIBLE FOR MAGNETIC TRANSDUCTION IN THE NEMATODE C. ELEGANS


**Andres Vidal- Gadea[1]**

Illinois State University,Normal,USA[1]



The magnetic field of the earth provides many organisms with sufficient information to successfully navigate through their environments. While evidence suggests the widespread use of this sensory modality across many taxa, it remains an understudied sensory modality. Previous research by our lab demonstrated that C. elegans uses the earth’s magnetic field to engage in vertical soil migrations. Magnetosensation in C. elegans takes place through the AFD neurons, the first magnetosensory neurons described in any animal. How these cells integrate magnetic information about their environment is not known, nor are the proteins necessary and sufficient for magnetic field detection and orientation. We show that orientation to magnetic fields relies on the number and integrity of the sensory villi at the tip of the AFD neuron. Present work in our lab focuses on identifying the molecular transduction machinery responsible for this sensory modality in C. elegans and will potentially shed light on how magnetic transduction takes place in other taxa


**Sensory: Magnetoreception**


Keywords :nematode; magnetosensory neuron;

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-106**
**Presentation Time: 15:00 to 16:00**

## COLD-AVOIDANCE BEHAVIOR AND THERMORECEPTOR ACTIVITY IN DROSOPHILA

**Gonzalo Budelli[1]; Paul Garrity[1]**

Brandeis University,Waltham,USA[1]

Thermosensation is essential for animals to avoid extreme temperatures and to seek optimal temperatures for growth and reproduction. In small insects, thermosensory systems must drive particularly robust behavioral responses because their body temperature rapidly equilibrates to the environmental temperature. In Drosophila, two systems for sensing moderately warm temperatures have been described, one internal (inside the head) and one peripheral (in the arista), and the molecular identities of the thermoreceptors for these systems are known, with TrpA1 acting internally and Gr28b peripherally (Hamada et al, 2008, Nature 454, 217-220; Ni et al., 2013, Nature 500, 580-584). In addition, cool-responsive neurons have been identified in the arista and sacculus, and three TRP channels (Brivido1, Brivido2 and Brivido3), implicated in cold detection (Gallio et al. (2011) 144:614-624). Consistent with this previous report Brivido mutants fail to avoid cold and our data indicate that cool- and warmth-responsive thermoreceptors exhibit distinct patterns of temperature-dependent spiking. Our preliminary analyses also suggest that the electrophysiological responses of cool-responsive thermoreceptors in the arista depend on members of the Ionotropic Receptor family of sensory receptors. Mutant flies of these Ionotropic Receptors also fail to avoid cold. Analysis of the behavior and physiological responsiveness of wild type and mutant thermoreceptors will be presented.

**Sensory: Olfaction and Taste**

Keywords :thermosensation; ionotropic receptors; cold avoidance

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-107**
**Presentation Time: 16:00 to 17:00**

## ODOR INTENSITY AND GAIN CONTROL IN THE HONEY BEE OLFACTORY SYSTEM

**Emiliano Marachlian[1,3]; Ayelen Nally[2]; Ramon Huerta[4]; Fernando Locatelli[2,3]**

Departmento de Fisica, FCEyN, Universidad de Buenos Aires,Buenos Aires,Argentina[1]; Departamento de Fisiología, Biología Molecular y Celular, FCEyN, Universidad de Buenos Aires,Buenos Aires,Argentina[2]; IFIByNE-CONICET,Buenos Aires,Argentina[3]; Bicircuits Institute, UCSD,San Diego,United States[4]

Animals rely on chemical cues to extract ecologically relevant information from the environment. This information is primarily encoded by the olfactory sensory neurons. Each specific odor recruits a particular combination of receptors that provides the input for its internal representation. In natural conditions, odors are normally present at different concentrations and each concentration can produce different activity patterns in terms of intensity of activation and combination of receptors. A problem is how the animals recognize the same odor across different concentrations in spite of the different input patterns. We work on the hypothesis that local inhibition at processing of the olfactory information in the antennal lobe provides the gain control that contributes to stabilize odor identity across intensities. We use honey bees to study odor generalization across intensities and to understand the neural computations that underlie generalization. In behavioral experiments we describe odor generalization across intensities. Using calcium imaging we measured the neural representations of high and low odor concentrations in the projection neurons at the antennal lobe output. Using different GABA blockers we describe the contribution of the local inhibitory network in stabilizing odor patterns across intensities. We found that GABA-A and GABA-B components contribute differentially in terms of the functional range of odor intensity and in the temporal profile of the activation elicited by odors. The results are formalized in a computational model of the antennal lobe that provides detail of the inhibitory network.

**Sensory: Olfaction and Taste**

Keywords :olfaction; insects; coding

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-108**
**Presentation Time: 17:00 to 18:00**

## TEMPORAL OR SPATIAL ODOR-CODING DURING NESTMATE RECOGNITION IN ANTS?

**Stefanie Neupert[1]; Christoph Kleineidam[1]**

University of Konstanz,Konstanz,Germany[1]

The ability to discriminate between members from the own colony (nestmates) and members of a foreign colony (non-nestmates) is crucial for colony cohesion and resource protection.
In ants, nestmate recognition is based on complex mixtures of cuticular hydrocarbons (CHC) on the body surface. Colony odors of conspecific colonies only differ in the ratios of CHCs. Given the complexity and similarity of the colonies' recognition cues, ants are amazingly fast and precise in this discrimination task. Similarly to any other odor, colony odors are represented in the antennal lobe (AL) in a spatio-temporal activation pattern of glomeruli. It is well documented that different spatial representations correlate to odor quality. Surprisingly, we found that the spatial activation patterns in response to colony odors are very similar but also highly variable when nestmate odors are presented. As a consequence, from spatial activation pattern alone it is impossible to infer what colony odor was presented. Thus, nestmate recognition challenges our current view on odor coding. The high variability in nestmate odor representation may reflect plasticity that tunes the olfactory system to reliably identify nestmates. However, this does not explain how nestmate odors are distinguished first hand. In order to address this, we investigate another (temporal) aspect of odor representation, namely the onset and sequence of activation. To this aim, we assess the activity of glomeruli using line scans during functional imaging that allow much higher sampling rates than capturing frames, and allow analyzing the significance of temporal coding in the olfactory system.

**Sensory: Olfaction and Taste**

Keywords :nestmate recognition; odor discrimination; antennal lobe

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-109**
**Presentation Time: 18:00 to 19:00**

## HERBIVOROUS AND NON-HERBIVOROUS DROSOPHILIDS DIFFER IN BEHAVIORAL AND ANTENNAL RESPONSES TO LEAF VOLATILES

**Benjamin Goldman-Huertas[1]; Noah Whiteman[1,2]**

The University of Arizona,Tucson,United States[1]; University of California, Berkeley,Berkeley,USA[2]

Scaptomyza flava and its relatives are an emerging system for exploring the genomic, physiological and behavioral basis of plant-herbivore interactions and the evolution of herbivory. These flies are compelling in that they are a recently evolved group of leaf-mining herbivores that are closely related to the model organism Drosophila melanogaster. S. flava feeds obligately on living mustard plants (Brassicaceae), including the model organism Arabidopsis thaliana. Herbivorous Scaptomyza evolved from yeast-feeding ancestors, the most common dietary niche of Drosophila. Recent work has shown that the odorant receptor (OR) repertoire of Scaptomyza flava includes multiple losses of homologs of both yeast volatile receptors and ORs involved in oviposition choice. These losses are associated with a lack of behavioral and antennal responses to yeast volatiles. However, how Scaptomyza has evolved to perceive and choose intact leaves is unknown. We present coupled gas chromatography electroantennographic detection (GC-EAD) recordings of species of herbivorous and non-herbivorous Scaptomyza and Drosophila responding to leaf volatiles of the host-plant Turritis glabra (Brassicaceae) and show herbivorous S. flava responds to different green leaf volatiles compared to non-herbivorous relatives. S. flava and it's relatives also showed differential responses to host-leaf volatiles in four-field olfactometer assays. In addition, OR homologs known to detect green leaf volatiles with signatures of episodic positive selection via branch-site tests were cloned and introduced from these species into the D. melanogaster empty neuron fly line.

**Sensory: Olfaction and Taste**

Keywords :herbivory; electroantennography; scaptomyza

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-110**
**Presentation Time: 15:00 to 16:00**

## THE NPY SIGNALING PATHWAY MODULATES FOOD INTAKE UNDER STARVATION CONDITIONS IN ADULT WORKER HONEY BEES

**Rodrigo Velarde[1]; David Hale[2]; Susan Fahrbach[2]; Martin Giurfa[3]; Maria Gabriela De Brito Sanchez[3]**

Faculty of Exact and Natural Sciences, University of Buenos Aires,Buenos Aires,Argentina[1]; Wake Forest University,Winston-Salem,USA[2]; CNRS-University Paul Sabatier Toulouse III,TOULOUSE,France[3]

Neuropeptide Y (NPY) signaling regulates food searching and food intake across animals. Insect genomes contain two homologues of NPY, neuropeptide F (npf) and short neuropeptide F (sNPF), and a single NPF receptor (snpfR). In Drosophila larvae upregulation of these genes by starvation increases the likelihood to feed on noxious foods. In honey bees, the pathways that regulate the rejection or ingestion of noxious foods are currently unknown. We tested whether starvation increased the propensity of adult worker bees to ingest noxious foods as a result of increased NPY signaling. In honey bee colonies, nurse bees are characterized as nutritionally enriched relative to foragers. After starvation, the propensity to ingest noxious foods increased in nurses and foragers. We measured the mRNA levels of NPY-like pathway genes following starvation. While only a slight increase in the expression levels of NPY-like prepropeptide mRNAs was observed, the level of the sNPF receptor (snpfR) mRNA was significantly upregulated. To determine the functional role of snpfR upregulation by starvation we reduced the mRNA levels of snpfR by RNAi in starved bees. Down regulation of snpfR decreased the propensity to feed either on non-toxic or toxic foods, suggesting an altered perception of the satiation state. We discuss our results in light of an emerging pattern of functional divergence rather than conservation in the NPY-like pathway. Such divergence may reflect the diversity of feeding-related behaviors across insects around the unifying element of this signaling pathway for responses to food-related stimuli.

### Sensory: Olfaction and Taste

Keywords :neuropeptide y; honey bee; feeding

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-111**
**Presentation Time: 16:00 to 17:00**

## VISUAL ACUITY IN APOID BEES

**Elisa Rigosi[1]; Steven D. Wiederman[1]; Julia Schuckel[2,3]; David C. O'carroll[3]**

The University of Adelaide,Adelaide,Australia[1]; Smithsonian Tropical Research Institute,Panama City,Panama[2]; Lund University,Lund,Sweden[3]

Apoidea are a group with diverse social structures and behaviour. In addition to their importance as pollinators, social behaviour in several species has made them popular models for understanding visual processing. Visual acuity contributes to success in locating and tracking resources, as well as avoiding predators. But while the optics are well studied in several species, reliable physiological recordings are scarce from light adapted photoreceptors. We assessed photoreceptor acuity from the following Apoidea: Apis mellifera, Bombus terrestris, Anthidium manicatum, Amegilla murrayensis. We used intracellular recordings and presented dark moving stimuli on a high luminance LCD screen, allowing quantification of receptor noise, light adapted acceptance angle (Drh), and the smallest moving feature that receptors can encode. On average, A. mellifera foragers show frontal DrhX: 2° and DrhY: 2.1°, while B. terrestris DrhX: 1.6° and DrhY: 1.7°. These are 25% and 40% smaller than previously reported, and allow detection of moving features below 0.5°. In all species acuity decreases away from the frontal eye region. A. manicatum males and Amegilla are solitary bees that perform conspecific tracking. Both show correspondingly impressive acuity with DrhX: 1.1° and DrhY: 1.2° in Amegilla and a minimum detectable moving object of 0.3° - similar to limits in drone honey bees, despite mean facet diameters 0.78x smaller.

**Sensory: Vision**

Keywords :bees; visual acuity; insect eyes

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-112**
**Presentation Time: 17:00 to 18:00**

## SINGLE OBJECT RESOLUTION IN BUDGERIGARS (MELOPSITTACUS UNDULATUS)

**Sandra Chaib[1]; Olle Lind[1]; Almut Kelber[1]**

Lund University,Lund,Sweden[1]

Avian visual acuity is traditionally measured as the ability of the eye to resolve high contrast striped gratings. Behavioural experiments testing grating acuity generally agree quite well with the anatomical measurements of ganglion cell density, indicating that sampling density of the retina is the limiting factor of spatial acuity. However, in an ecological context it can also be relevant to know how small single objects an eye can resolve. For example, in what distance is a foraging bird able to spot an insect on the ground or detect a flying bird of prey against the sky? The budgerigar (Melopsittacus undulatus) has been used extensively as a model organism in the study of avian vision. Their contrast sensitivity and visual acuity for striped gratings has been determined in behavioural experiments (Lind & Kelber, 2011 J Vis 11(7)) and the latter also anatomically by retinal ganglion cell density (Mitkus et al, 2014, J Comp Physiol A 200). Now we have also examined the limit for visual resolution of single objects in budgerigars. Using a two-choice behavioural procedure we trained birds to distinguish circular dark objects of different sizes. We used objects of different size and contrast to the background as well as objects with sharp or blurred edges to see how this influenced the perception of the birds. Preliminary results indicate that budgerigars' ability to resolve single round objects is well below that for striped gratings.

### Sensory: Vision

Keywords :spatial visual acuity; birds; psychometrics

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-113**
**Presentation Time: 18:00 to 19:00**

## HOVERFLY RESPONSES TO IMAGES WITH NATURAL AND ARTIFICIAL SPATIAL STATISTICS: BEHAVIORAL AND NEURAL MECHANISMS

**Karin Nordstrom[2]; Olga Dyakova[1]; Josefin Dahlbom[1]**

Uppsala University,Uppsala,Sweden[1]; Flinders University,Adelaide,Australia[2]

Animal sensory systems are optimally adapted to those features typically encountered in natural surrounds, thus allowing neurons with limited bandwidth to encode challengingly large input ranges. The natural input that biological visual systems encounter is not random, but contain statistics that are remarkably constrained in both space and time. Photographs of natural scenes can be statistically analyzed using the Fourier transform that describes the image as a complex-valued composition of spatial frequencies with different orientation. It has long been known that peripheral visual systems in vertebrates and insects have evolved to respond efficiently to their typical spatial statistics. The vertebrate visual cortex is also tuned to natural spatial statistics, but less is known about coding in the insect brain. To redress this we have recorded intracellularly from a higher-order visual neuron in the hoverfly. We show that the cSIFE neuron, which is inhibited by stationary images, is maximally inhibited when the slope of the rotationally averaged amplitude spectrum is close to the mean in natural scenes. We show that the spatial statistics have behavioral relevance using in two ways: 1) In the lab, tethered hoverflies show strongest optomotor response to images with naturalistic image statistics, and 2) In the field hoverfly behavior is affected by the spatial statistics of the location. Our data thus show that the insect nervous system and its behavioral output are tuned to the amplitude spectra of natural scenes, similar to what has been found in the vertebrate visual cortex and human psychophysics.

**Sensory: Vision**

Keywords :natural scenes; electrophysiology; quantitative behavior

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-114**
**Presentation Time: 15:00 to 16:00**

## COLOUR CONSTANCY AND RELATIVE COLOUR VISION IN CHICKEN

**Peter Olsson[1]; David Wilby[2]; Almut Kelber[1]**

Lund University,Lund,Sweden[1]; Bristol University,Bristol,United Kingdom[2]

Object colours are defined by their spectral reflectance and the spectral composition of the illumination. The illumination changes over the day and in different environments such as below water and in the forest. This is a potential problem as the spectral information reaching the eyes from the same object can be confused in different environments. Colour constancy is a phenomenon where colour perception remains constant, regardless of illumination. Colour constancy has been found in non-human animals, both vertebrates and invertebrates, but has not been tested in birds, nor has there been an attempt to quantify how good colour constancy is in any non-human animal. We trained chickens to peck at a trained colour stimulus for food, and tested how well they could discriminate that colour in different illuminations. We found that chickens indeed showed colour constancy and that they remained colour constant in larger illumination shifts when tested with larger colour differences, when they were familiar with the colours and with longer adaptation time. In a second experiment we found that when chickens could use relative colour, e.g. always choosing the 'redder' stimulus, to find a trained colour stimulus, colour discrimination was possible in even larger illumination changes. Our methods can be used in other animals to quantify and compare colour constancy between species.

### Sensory: Vision

Keywords :colour vision; animal behaviour; visual modelling

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-115**
**Presentation Time: 16:00 to 17:00**

## CONTEXT-DEPENDENT POPULATION CODING IN AN INSECT VISUAL MOTION DETECTION SYSTEM

**Jack Gray[1]; Paul Dick[1]**

University of Saskatchewan,Saskatoon,Canada[1]

Two well-studied neurons in the locust visual system, the Lobula Giant Movement Detector (LGMD) and its postsynaptic partner, the Descending Contralateral Movement Detector (DCMD) respond robustly to complex visual motion and have been implicated in controlling flight steering. However, little is known about responses of other motion sensitive neurons in this system. We used multichannel electrodes to record activity from the ventral cervical connective while randomly presenting a range of visual stimuli, including looming, receding, translation, and trajectory transitions. Spike sorting revealed individual units that could be segregated into categories based on their response profiles and we found evidence of multiple neuronal units with responses to visual motion that are both novel and unique. In addition to DCMD responses, we observed units that responded to general object motion or primarily to looming, translational or compound trajectories. Principle component and dynamic factor analysis revealed population vectors that define context-dependent categorical responses to aspects of object motion. These findings suggest that visually-evoked behaviours in the locust are controlled by an ensemble of visual neurons, rather than one principal pathway.

**Sensory: Vision**

Keywords :locust; vision; population coding

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-116**
**Presentation Time: 17:00 to 18:00**

## VISION IS AN IMPORTANT SENSE FOR THE CORAL EATING CROWN-OF-THORNS STARFISH.

**Ronald Petie[1]; Anders Garm[1]; Michael Hall[2]**

University of Copenhagen,Copenhagen,Denmark[1]; Australian Instititute of Marine Science, Townsville,Australia[2]

The crown-of-thorns starfish is one of the major causes of coral reef decline. Proper management of starfish populations depends on our understanding of the biology of the animal, where the sensory biology is an important part for the adult starfish. For a long time, starfish in general have been considered to navigate solely by olfaction. Here we present evidence of the importance of vision for the crown-of-thorns starfish. Our behavioural studies in the wild showed that the crown-of-thorns starfish can not find coral reefs when blinded or when the reefs are shielded from view. We also present evidence for the presence of true spatial vision, through a series of behavioural studies in the laboratory. In addition, the physiology of the eyes represents a well tuned matched filter for seeing coral reefs. The eyes of the crown-of-thorns starfish are most sensitive to blue light and are the slowest of any animal studied thus far. They view a narrow visual streak around the horizon with low resolution spatial vision. Together, this enables the crown-of-thorns starfish to see large, inanimate objects on the horizon against a blue background best. Coral reefs are a perfect match! Our findings provide a first indication that vision might be much more important in starfish in general, than previously appreciated. In addition, it opens up new opportunities for outbreak management in the form of traps based upon their sensory biology.

**Sensory: Vision**

Keywords :crown-of-thorns starfish; vision; eyes

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-117**
**Presentation Time: 18:00 to 19:00**

## POLARIZATION VISION IN CRABS: A TWO-CHANNEL DETECTION SYSTEM?

**Mélanie Basnak[1]; Martín Berón De Aatrada[1]**

Laboratorio de Neurobiología de la Memoria, Facultad de Ciencias Exactas y Naturales, UBA. IFIBYNE-CONICET,Capital Federal,Argentina[1]

Polarization vision is used by many different species in vital tasks, such as orientation, navigation, and contrast enhancement. Neohelice granulata, like other crabs, lives in an environment rich in polarization information. A prior experiment showed that a looming stimulus with the same intensity and spectral light composition that the background, but a 90º degree difference in the angle of polarization of light evoked the animal's escape response. This suggests that this species is able to detect moving stimuli using only polarization cues. Our goal now was to assess if Neohelice possesses differential sensitivity to stimuli polarized with different angles. To achieve this, we presented looming stimuli in a modified LCD screen, placed to one side of a rotating sphere where the animals could walk freely. The monitor was mounted on a rotating device. The stimuli held a constant 90º polarization contrast with the background. Thus, by rotating the ensemble, the two main polarization vectors entered the crab's eye with different angles. We quantified the escape response and found it to be greater for those stimuli for which the two E-vectors' angles were vertical and horizontal. This result suggests that Neohelice's photoreceptors have better sensitivity for vertically and horizontally polarized light. This interpretation is consistent with anatomical studies that evidence an orthogonal pattern of the photoreceptor's microvilli in the eyes of decapods. We are now conducting electrophysiological recordings from Neohelice's photoreceptors to characterize their polarization sensitivity, an issue we expect to discuss with visitors at the current poster presentation.

**Sensory: Vision**

Keywords :arthropods; polarization vision; photoreceptors

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-118**
**Presentation Time: 15:00 to 16:00**

## HIGHLY DIRECTION-SELECTIVE VISUAL NEURONS IN THE CRAB NEOHELICE GRANULATA

**Florencia Scarano[1,2]; Julieta Sztarker[1,2]; Daniel Tomsic[1,2]**

University of Buenos Aires,Buenos Aires,Argentina[1]; CONICET,Buenos Aires,Argentina[2]

One of the earliest and most important processing steps in any visual system is the ability to determine the direction in which objects, such as prey or predators, are moving. In visual animals, this is accomplished by direction-sensitive neurons (DSN).

However, the mechanism by which neurons become direction-selective and how directional information encoded by DSN guides behavior are complex, unsolved problems that call for new experimental models. To avoid predator attacks crabs employ two systems simultaneously: an open-loop mechanism directs the crab's translatory movements directly away from the stimulus, and a rotational mechanism using continuous feedback turns the crab so that the stimulus is kept at 90º of the body axis. The tracking of moving objects by the lateral visual field suggests a continuous visuomotor transformation based on the direction of the moving object. By performing in vivo intracellular recording and staining, we identified DSN from the lobula (3rd optic neuropil) of the crab. Morphologically, these neurons show broad arborizations in the lobula and lobula plate. They only respond to objects moving along the azimuthal axis with depolarization and with action potentials trains in response to objects moving in the preferred direction. They also exhibit pronounced sustained hyperpolarization in response to objects moving in the null direction. From the 15 recorded neurons, 8 presented a preference for objects moving in the anteroposterior direction, whereas the other 7 preferred the opposite direction. Most of these cells have their receptive fields centered on the lateral pole. Based on these results, we propose a possible role of these DSN in the crab's object tracking behavior.

**Sensory: Vision**

Keywords :direction sensitive neurons (dsn); object tracking behavior; receptive field

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-119**
**Presentation Time: 16:00 to 17:00**

## WHAT FRACTION OF NEURONS IS ACTIVE WHEN ONE VIEWS NATURAL SCENES? : RESPONSE SPARSENESS IN MACAQUE CORTICAL AREAS V1 AND V4 ESTIMATED BY 2-PHOTON CALCIUM IMAGING

**Ichiro Fujita[1,4]; Takanori Fukazawa[1]; Shinji Nishimoto[1,2]; Koji Ikezoe[1,2,3]**

Osaka University Graduate School of Frontier Biosciences,Suita,Japan[1]; National Institute of Information and Communications Technology,Suita,Japan[2]; University of Yamanashi,Chuo,Japan[3]; Center for Information and Neural Networks,Suita,Japan[4]

Sensory events evoke responses in a population of neurons across brain areas. Barlow (1972) proposed that as we ascend in the hierarchy of the mammalian visual pathway, “a relatively small population of neurons are active, and each says a lot when it is active”. We tested this hypothesis by estimating the response sparseness in the primary (V1) and mid-tier (V4) visual cortex of cynomorgus monkeys. While we presented videos of natural scenes, we monitored calcium responses from a large number of layer II/III neurons by using 2-photon imaging techniques. From the response matrix of video frames vs. neuron identities we computed lifetime sparseness (LS) and population sparseness (PS). LS indicates what fraction of video frames elicits responses in a given neuron, and PS indicates what fraction of neurons in an imaged area responds to a given video frame. Both varies from 0 (equal responses to many stimuli or among neurons) to 1 (strong responses to limited stimuli or in particular neurons). We found no difference in PS between V1 and V4 (median, V1: 0.31, V4: 0.33; $p = 0.97$; Wilcoxon rank-sum test), suggesting that the fraction of active neurons remains constant for areas at different stages. LS was higher in V1 than V4 (V1: 0.49, V4: 0.39; $p = 0.032$), indicating that V1 neurons responded more selectively to particular frames than V4 neurons.

**Sensory: Vision**

Keywords :2-photon imaging; sparseness; visual cortex

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-120**
**Presentation Time: 17:00 to 18:00**

## ON THE ROLE OF VISION AND GRAVITY IN HEAD-BODY COORDINATION OF FREELY WALKING BLOWFLIES

**José Monteagudo[1,2]; Jens Lindemann[1,2]; Martin Egelhaaf[1,2]**

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Most animals try to keep their visual systems horizontal during locomotion show compensatory head movements to achieve this. In walking animals the orientation of the body is constrained through its direct leg-based contact with the often uneven walking substrate, making head-body coordination very important. Gravity and vision are likely to be the most important cues for most animals to determine the orientation of their surroundings and thus of their visual systems. We investigated how these cues are employed by walking blowflies, which - despite being known mostly for their acrobatic flight behavior - frequently explore their environment by walking. We recorded freely walking animals and reconstructed the orientation of head and body while approaching an object in a cylindrical arena. In our experimental analysis, gravitational and visual cues available to the animal were brought systematically into conflict with each other. We discovered that walking blowflies employ both visual and gravitational cues to orient their head and thus their visual system. When both cues are brought into conflict blowflies reach a compromise between the orientations reported by the different cues, weighing them differently depending on their availability. The presence of visual cues reduce head rotations compensating for gravity, if they are aligned with the orientation of the ground, or enhance them, if they are congruent with the direction of gravity.

**Sensory: Vision**

Keywords :insect vision; head-body coordination; multisensory integration

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-121**
**Presentation Time: 18:00 to 19:00**

## INVESTIGATING THE NEURAL CORRELATES OF MATE PREFERENCE IN HELICONIUS BUTTERFLIES

**Nathan Buerkle[1]; Erica Westerman[1]; Marcus Kronforst[1]; Stephanie Palmer[1]**

University of Chicago,Chicago,USA[1]

Wing color based mate choice in an adaptive radiation of Heliconius butterflies presents an excellent system for studying how nervous systems evolve to produce novel behaviors. Here, we focus on a small clade of butterflies comprising Heliconius cydno galanthus, H.c. alithea, and H. pachinus, where white vs. yellow wing coloration is known to be a Mendelian trait. Prior behavioral work shows that males preferentially court females of the same color, while male hybrids show no color preference. We hypothesized that this difference in preference can be attributed to differences in screening pigments expressed in the eye that filter light and alter the observed spectral tuning of photoreceptors. To test this hypothesis, we examined the genetic basis for mate choice preference using a genome wide association test (GWAS), compared screening pigments using a combination of epifluorescence microscopy and histology, and compared photoreceptor spectral tuning using intracellular recordings. Our preliminary results suggest that eye organization does not differ between color morphs. Rather, differences in mate preference likely emerge within central brain circuits.

**Sensory: Vision**

Keywords :butterflies; color vision; mate choice

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-122**
**Presentation Time: 15:00 to 16:00**

## A POLARIZED VIEW OF THE WORLD: MORE THAN PUSHING DUNG BACKWARDS UP-HILL OR OTHERWISE


**Justin Marshall[1]; Yakir Gagnon[1]; Sonke Johnson[2]; Thomas Cronin[3]; Nick Roberts[4]; Viktor Gruev[5]; Sam Powell[5]; Martin How[4]**

University of Queensland,Brisbane,Australia[1]; Duke University,Durham,USA[2]; University of Maryland Baltimore County,Baltimore,USA[3]; University of Bristol,Bristol,UK[4]; Washington University,Missouri,USA[5]



The functions of polarization vision in terrestrial species include navigating to and from food sources, a variety of polaro-taxes, dung-ball rolling and possible mate choice in butterflies. Its purpose in marine animals is less well understood, may also include navigational tasks but recent evidence suggests also includes polarization signaling. Mate choice or territorial conflict seems to drive the evolution of this communication strategy. As with colour, as soon as a signal exists, potential strategies of camouflage as well as conspicuousness must be considered. A long-held hypothesis is that polarization vision in water is used to break the mirror camouflage of silvery fish. However, direct in situ evidence that silvery fish are more visible to polarization vision than they are to radiance vision is poor or lacking. Here we use in situ polarization imagery to quantify the visibility of 15 species of fish when viewed by polarization-sensitive and polarization-insensitive visual systems. We find that at distances over 5m, the visibility of these animals is poorer for polarization vision than for radiance vision. At shorter range, the physical properties of silvery fish skin creates contrast between fish and their backgrounds in degree of polarisation. Silvery fish may therefore be more conspicuous to predators equipped with polarization vision and polarocrypsis in this context does not exist.


**Sensory: Vision**


Keywords :polarisation vision; communication; sensory neurobiology

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-123**
**Presentation Time: 16:00 to 17:00**

## CAN YOU SEE IT? GOLDFISH STARTLE TO POLARIZED LIGHT STIMULI

**Violeta Medan[1]; Martín Berón De Astrada[1]; Santiago Otero Coronel[1,2]**

FCEN-UBA and IFIByNE-CONICET,Buenos Aires,Argentina[1]; FMED-UBA,Buenos Aires,Argentina[2]

Aquatic environments are rich in polarized light patterns, creating a background polarization field against which objects diffusing or differentially reflecting polarized light can be viewed. To animals with a visual system sensitive to polarized light such as goldfish, Carassius auratus, these cues could provide valuable information about its environment and be used for navigation and object detection. To test to which extent polarization sensitivity its behaviorally functional for goldfish, we recorded their startle response (C-start) probability in response to an expanding disc (loom) where the background was linearly polarized and the loom was elliptically polarized. Goldfish startled to a polarized loom although with a smaller probability (35% startled, N=14) and longer latency (mean ± SD: 60±12 ms after end of loom) than when confronted with a black-over-white control loom (100% startled, 79 ± 33 ms before end of loom, N=14). Different neural processing and/or lower saliency of polarized looms could be responsible for the lower probability and longer response latency. Using non-polarized looms we tested if decreasing the contrast ratio (saliency) between the stimulus and the background reduced the response probability and increased latency of the response. Results show that progressively smaller contrast ratios have a smaller response probability (KW-ANOVA, $p<0.001$). Although latency to respond increases as the contrast ratio diminishes, it never reaches the values observed with polarized looms. We speculate that the neural circuits implied in processing visible and polarized stimuli might differ resulting in longer latency to respond to polarized stimuli.

**Sensory: Vision**

Keywords :polarized vision; starle response; goldfish

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-124**
**Presentation Time: 17:00 to 18:00**

## COLOUR PREFERENCES OF THE FIREBUG (PYRRHOCORIS APTERUS)

**Linnea Van Griethuijsen[1]; Ibrahim Hashim[1]; Nadja Verspagen[1]; Kayla Kolff[1]; Sebastian Rock[1]; Sophie Manuel[1]**

Maastricht University,Maastricht,Netherlands[1]

Pyrrhocoris apterus, commonly known as the red firebug, is known to aggregate in groups. Because firebugs have a conspicuous red and black pattern on their elytra, we wanted to know if the colour red could potentially play a role in forming aggregations. More specifically, we tested if P. apterus can distinguish red from blue and green and if it has a preference for one colour over another. We presented these colours in front of firebugs attached to a y-maze globe. Three test conditions were offered: red-green, red-blue and blue-green. Colours were presented as printed paper surfaces, with the division between the colours directly in front of the firebug. Colours were selected in such a way that they would appear the same tint of grey when printed grey scale. For each firebug walking on the Y-maze globe, up to 10 decisions at the Y-fork were recorded. We found a preference for red over green (Chi square, $n = 29$, chi square = 56,8 $p < 0.01$, 63 turns to green and 227 turns towards red), indicating that P. apterus can distinguish red from green and has a preference for red over green. No preferences were found when testing the other colour combinations. Because of our experimental design, this may also mean that P. apterus cannot distinguish between red / blue and blue/ green.

### Sensory: Vision

Keywords :firebug; coulour preference; y-maze globe

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-125**
**Presentation Time: 18:00 to 19:00**

## SEEING WITHOUT EYES: VISUAL PERFORMANCE AND MULTIMODAL RESPONSE IN THE PURPLE SEA URCHIN: STRONGYLOCENTROTUS PURPURATUS

**John D. Kirwan[1]; Samuel Walmsley[1]; Michael J. Bok[1]; Jochen Smolka[1]; Dan-Eric Nilsson[1]**

Lund University,Lund,Sweden[1]

Vision and photoreception evolve as a consequence of selection on visual tasks and low-resolution vision has appeared repeatedly in several phyla. Sea urchins (Echinoidea) have no eyes but nonetheless some species have a relatively fast, visual response, mediated by a diffuse photoreceptor system covering the body. Urchins can respond with negative or positive phototaxis, which may implicate a role in shelter seeking or predator avoidance. Estimates of the spatial resolution of these animals have previously been made in several urchin species. Here, we make estimates of visual performance for the model system Strongylocentrotus purpuratus, using dark stimuli rendered from a difference of Gaussians (in order to be isoluminant, consistent and imperceptible to non-resolving photoreception) to quantify the angular resolution of vision. We quantify the contrast sensitivity of the phototactic response by modulating the irradiance. We also investigate the influence of a multimodal response including olfactory stimuli. Treatments are applied in which the seawater has been exposed to an echinivorous predator or crushed urchins to determine if this influences the behavioural response to dark stimuli. By characterising the performance attributes of understudied eye types and linking visual function to the sensory tasks, we can better understand the evolutionary pressures which produce divergent structures and classes of eyes.

**Sensory: Vision**

Keywords :echinodermata; acuity; extraocular

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-126**
**Presentation Time: 15:00 to 16:00**

## COMPARATIVE VISUAL ECOLOGY OF THREE CORAL REEF FISH PREDATORS

**Genevieve A. C. Phillips[1]; Karen L. Carleton[2]; Shelby E. Temple[3]; Karen L. Cheney[4]; N. Justin Marshall[1]**

Queensland Brain Institute, The University of Queensland,Brisbane,Australia[1]; Department of Biology, University of Maryland,College Park,USA[2]; School of Biological Sciences, University of Bristol,Bristol,UK[3]; School of Biological Sciences, The University of Queensland,Brisbane,Australia[4]

Understanding how coral reef fish view their environment is central to learning more about their behavioural ecology. Visual information is important in predation, so understanding how the visual systems of predators are tuned to their environment is key to understanding predator-prey interactions. In this study we investigated the visual systems of three ecologically and phylogenetically distinct coral reef fish predators: coral trout, Plectropomus leopardus (Serranidae); slingjaw wrasse, Epibulus insidiator (Labridae) and raggy scorpionfish, Scorpaenopsis venosa (Scorpaenidae). We then related their visual systems to their predatory ecology using a multidisciplinary approach. Anatomical studies of the eye and retina, microspectrophotometry (MSP) measurements from individual photoreceptors, and relative opsin expression levels (RNA-seq) were used to compare the visual systems of the three predators. Information on the ecology of the predators, and how they attack their prey was then correlated with our findings. In general, while the three predators have similar photoreceptors, they show markedly different photoreceptor distribution across the retina, with regions of highest density correlating with the most relevant viewpoint for accurate prey discrimination against the background. MSP recordings revealed at least three, and up to five spectrally-distinct cone photoreceptors, with similar numbers of opsin classes expressed within the retina. The results of our study support the theory that visual systems are highly correlated with the behavioural ecology of animals: all three predators' visual systems reflect their foraging strategies.

**Sensory: Vision**

Keywords :visual ecology; predator-prey relationships; coral reef fish

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-127**
**Presentation Time: 16:00 to 17:00**

## PREDATOR DETECTION BY PRIMATES: EVALUATING THE ROLE OF COLOR VISION, BACKGROUND SCENARIO, AND DETECTION DISTANCE

**Daniel Pessoa[1]; Pedro De Moraes[2]; Maria Helena Spyrides[1]**

Federal University of Rio Grande do Norte,Natal,Brazil[1]; University of Brasilia,Brasilia,Brazil[2]

Predation risk is a major ecological factor driving primate evolution; however, its relevance to color vision evolution and polymorphism maintenance has been underexplored. The relation between primate visual phenotype and predator detection has only recently been assessed, and a number of other factors may, nevertheless, influence how predators are detected by their prey, such as the background scenario and the detection distance. In our study, we aimed to evaluate how these variables affect predator detection. We prepared and edited photographs of taxidermized carnivore mammals, in different background scenarios (open grassland, closed canopy forest and savannah), with two different dimensions (2 and 5 cm) to simulate short and long detection distances. Forty humans (20 dichromats and 20 trichromats) participated in the experiment. On a touchscreen monitor, an image depicting a predator was randomly presented together with three other photographs containing only the background vegetation. Trichromats presented significantly lower latency and higher detection accuracy in all conditions tested. These results suggest that trichromacy may be even more advantageous than thought previously, since it facilitates the detection of predators with diverse skin coloration in environments with different backgrounds, and at longer distances.

**Sensory: Vision**

Keywords :visual polymorphism; color-blindness; carnivore mammals

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-128**
**Presentation Time: 17:00 to 18:00**

## COLOUR OPPONENCY IN A TETRACHROMATIC BUTTERFLY

**Finlay Stewart[1]; Michiyo Kinoshita[1]; Kentaro Arikawa[1]**

Sokendai (The Graduate University for Advanced Studies),Hayama,Japan[1]

The swallowtail butterfly Papilio xuthus has an elaborate retina containing eight spectrally distinct classes of photoreceptors. Based on wavelength discrimination experiments, its colour vision is thought to be tetrachromatic. Presumably this information is encoded as three colour-opponent channels and one achromatic one, but how these putative opponent channels are organised in Papilio – or any other tetrachromatic invertebrate – is unknown. The present study seeks to resolve this issue behaviourally, utilizing colour contrast. This refers to the phenomenon whereby the perception of an object's colour is affected by that of its background. Papilio's colour vision exhibits this property, but a detailed account of which colours induce which others is lacking. We use a novel tetrachromatic DLP projector system to display stimuli containing violet, blue, green, and red components on the floor of an arena in an automated, closed-loop manner. We train butterflies to feed from a bright "white" (R+G+B+V) circle appearing against a dimly coloured or black (control) background. We subsequently present them with whitish circles of various tints and record from which ones they attempt to feed, in order to ascertain the opponent colour to the background during training. Preliminary results suggest that no trivial scheme can account for their selections: the animals do not simply choose the brightest target, nor the tint corresponding to their trained background colour, nor the one containing all components except that colour.

**Sensory: Vision**

Keywords :opponency; colour; contrast

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-129**
**Presentation Time: 18:00 to 19:00**

## DYNAMIC SQUID IRIDESCENCE PROVIDES POLARIZED SIGNALS DETECTABLE BY CONSPECIFICS.

**Trevor Wardill[1,2]; Shelby Temple[3]; Paloma Gonzalez-bellido[1,2]; Timothy York[4]; Viktor Gruev[4]; Nicholas Roberts[3]; Roger Hanlon[2]**

University of Cambridge,Cambridge,UK[1]; Marine Biological Laboratory,Woods Hole,USA[2]; University of Bristol,Bristol,UK[3]; Washington University,St. Louis,USA[4]

Cephalopods have incredibly adaptable skin, capable of presenting vibrant colour patterns enabling dynamic signalling or camouflage. Their patterns are created with pigmented chromatophores and iridocytes that use structural colouration. However cephalopods are colour blind but can see polarized light, so we set out to quantify in detail the polarization of this iridescent reflected light and squids' behavioural responses to it. We collected polarization videos of stimulated squid iridophores using a division-of-focal-plane camera. Iridophores when unstimulated reflect light that is 12% polarized which increases when stimulated by 5±2% and the angle of polarization changed by 11±4 degrees. Chromatophores, which overlay iridophores, effectively masked the maximally stimulated iridophore polarization signatures when expanded. To determine if these changes could be detected by conspecifics, we quantified the behavioural responses of animals to a polarization contrast-only stimulus using a customized LCD monitor. Squids responded robustly to looming stimuli that differed by 15-17° polarization, when polarization was >10%. Remarkably, some continued to respond at 10% even when the stimulus differed by as little as 3°. Our quantitative evidence indicate that squids have the necessary sensory and motor abilities to perform intraspecific communication through neurally controlled polarized skin reflections. However, how squid perceive information contained in different visual dimensions (polarization, colour and brightness) and whether polarization acts as a signal amplifier in the low-contrast environments of turbid or poorly illuminated waters remain for future investigation.

**Sensory: Vision**

Keywords :cephalopod; polarization vision; intraspecific signalling

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-130**
**Presentation Time: 15:00 to 16:00**

## A RECORD BREAKING EYE: HOW THE VISUAL SYSTEM OF THE TINY ROBBER FLY HOLCOCEPHALA FUSCA OUTPERFORMS DRAGONFLIES

**Paloma T. Gonzalez-bellido[1,2]; Samuel T. Fabian[1]; Ann C. Pettigrew[1]; Karin Nordström[3]; Trevor J. Wardill[1,2]**

University of Cambridge,Cambridge,UK[1]; Marine Biological Laboratory,Woods Hole,USA[2]; Flinders University,Adelaide,Australia[3]

Humans employ saccades to quickly place the object of interest in their fovea. Such action serves two purposes: to view the target with the highest resolution and to allow triangulation of its position. Mantises also exploit foveation and stereo vision to decide if a prey is within striking distance of their raptorial appendages, but the role and cues provided by such fast head movements in insects that detect and attack much more distant targets remain a source of controversy. Reports on dragonfly behaviour support the presence of neural mechanisms for calculating target distance and size, but classic models postulate that the inter-eye distance is not sufficient to provide stereopsis through the behavioural range. In addition, since motion parallax does not provide accurate distance cues for a moving target, it cannot explain the behaviour. To solve this conundrum we have investigated target detection in the robber fly Holcocephala fusca, a tiny dipteran with an extreme eye shape. We show how such a tiny eye achieves a level of visual resolution that rivals the best and largest insect eyes (i.e. those of dragonflies) and the crucial purpose that this level of spatial resolution, together with pre-pursuit head movements, serve in the decision to take-off after a prey. Because our study was carried out in the wild, with completely unconstrained and unmanipulated animals, our results are a robust reflection of their natural performance level and behaviour. To our knowledge this is the first ever study of this type in a dipteran species.

**Sensory: Vision**

Keywords :fovea; predation; saccade

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-131**
**Presentation Time: 16:00 to 17:00**

## VISUAL INTENSITY THRESHOLD IN BATS USING PSYCHOPHYSICS

**Clément Cechetto[1]; Lasse Jakobsen[1]; Annemarie Surlykke[1]; Eric Warrant[2]**

University of southern Denmark,Odense,Denmark[1]; University of Lund,Lund,Sweden[2]

Most bats use echolocation to hunt and navigate, emitting ultrasonic calls and localizing objects in their surroundings from the returning echoes. Due to the effectiveness in terms of perceptual detail that is available to bats through echolocation, their use of vision has been understudied. All bats possess eyes, which presumably are of adaptive value since the eyes and visual processing areas of the brain, which are energetically expensive, have degenerated in other vertebrate species (e.g. Astyanax mexicanus). A few species of echolocating bats seem to be able to use vision in dim light as a navigational cue or even, in rare cases, as a hunting cue. This study aims to investigate how well bats can see in order to understand how they integrate information from both the visual and auditory pathways. We investigated visual intensity thresholds in two species of vespertilionid bats (Myotis daubentonii and Nyctalus noctula) using a psychophysiological paradigm. Initial results show that these bats are able to see green lights (~540 nm) at intensities as low as those on a moonless starlit night (i.e. 0.003 lux). This wavelength of green light is close to the peak absorption wavelength of the rod photoreceptors. Our results indicate that vision is likely important for bats and ecologically relevant since their eyes are functional when they are active. Further experiments will reveal if this sensitivity holds for the full colour spectrum.

### Sensory: Vision

Keywords :bats; multimodal integration; vision

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-132**
**Presentation Time: 17:00 to 18:00**

## TARGET INTERCEPTION BY A PREDATORY FLY

**Samuel T. Fabian[1]; Trevor J. Wardill[1]; Ann C. Pettigrew[1]; Graham K. Taylor[2]; Karin Nordström[3]; Paloma T. Gonzalez-Bellido[1]**

Cambridge University,Cambridge,United Kingdom[1]; Oxford University,Oxford,UK[2]; Flinders University,Adelaide,Australia[3]

Holcocephala fusca, a small robber fly (Asilidae), preys on smaller insects by sallying from a fixed perch and plucking them from the air. During the attack, this predator contrasts the silhouette of the target against the sky, reacting to velocity changes or perturbations to the prey's flightpath. To investigate this behaviour further, we presented beads with varying speeds and accelerations and reconstructed the 3D predatory flights by Holocephala (data obtained in the field). We show that Holocephala does not fly directly towards the target (a simple pursuit strategy), but steers to intercept it. Moreover, while airborne, Holocephala can switch strategies to shadowing the target or to quitting the assault altogether. Interestingly, the lines joining Holocephala and bead (line of sight) are quasi-parallel throughout most of the trajectories, indicating that a type of proportional navigation rule may underlie this behaviour. Although different versions of proportional navigation explain the behaviour of bats, tiger beetles and humans when chasing moving targets, its applicability in flying insects is currently debated. To test if proportional navigation can predict the predatory flightpath of H. fusca, we applied a Proportional Navigation model to over one hundred trajectories. The output of the model mimics many of the tested flight paths with reasonable accuracy, especially for direct assaults, further supporting the notion that some type of proportional navigation may be at play. However, not every flight is completely described by the model, and we are currently investigating additional variables or mechanical limitations that may explain the deviations.

### Sensory: Vision

Keywords :predation; interception; flight

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-133**
**Presentation Time: 18:00 to 19:00**

## HEAD-BODY-COORDINATION IN DROSOPHILA MELANOGASTER

**Kristina Corthals[1]; Martin C. Göpfert[1]; Bart R. H. Geurten[1]**

Georg-August-Universität Göttingen,Göttingen,Germany[1]

Due to the small stereobasis and interocular overlap, most insects lack stereoscopic vision. Therefore, other cues for distance estimation become prevalent as for example the retinal image shift by self-motion. During translational movements, close objects will travel faster across the retina than distant ones, whereas during rotational movement all objects move with the same speed. Therefore, only translational movements provide distance information. Insects overcome this problem by using a saccadic strategy, which consists of very short and fast rotations, called saccades that disrupt long translational movements. This strategy has been found in different insects. Here, we show that walking Drosophila melanogaster perform body saccades without the typical head saccades described for other insects?. This was also paired with the absence of haltere movement during walking, which seems to coordinate head movement in other insects. Modeling of the visual field of Drosophila revealed that head movements affect the retinal input only marginally.

**Sensory: Vision**

Keywords :saccades; optic flow; head-body-coordination

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-134**
**Presentation Time: 15:00 to 16:00**

## STOP! FREEZING TIME… CAN A BEHAVIORAL OUTPUT BECOME AN ALARM CUE?

**Andreia Cruz[1]; Marta Moita[1]**

Champalimaud Foundation,Lisbon,Portugal[1]

It has been previously shown that rats with prior experience with shock respond to the display of freezing by con-specifics, i.e. show observational freezing, but naïve ones do not. We hypothesized that freezing becomes an alarm cue during exposure to shock, as rats associate their own freezing responses with shock. Exposure to shock may also contribute to observational freezing through stress-induced sensitization. To address this issue, we compared exposure to shock that lead to the expression of freezing, with shock in the absence of freezing. We found that exposure to shock without the expression of freezing did not lead to observational freezing, supporting our hypothesis that the animal has to associate it's own fear responses with shock. To rule out a contribution from stress-induced sensitization, we compared corticosterone levels after the different shock exposures and found no differences in the strength of the stress response. Still, stress could facilitate observational freezing. Hence, we subjected rats to a forced swim session, which induced a very strong stress response. However, these animals, did not display observational freezing. To further elucidate whether observational freezing requires animals to experience freezing in association with shock, we are currently testing ways to induce freezing artificially in the absence of an aversive state, through the use of optogentics. Artificially induced freezing paired with shock should lead to observational freezing, but alone it should be ineffective.

### Social Behavior

Keywords :freezing; circuit; amygdala

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-135**
**Presentation Time: 16:00 to 17:00**

## NEURAL AND PHYSIOLOGICAL MECHANISMS OF PARENTAL CARE IN A BIPARENTAL POISON FROG

**Eva Fischer**[1]

Harvard University,Cambridge,USA[1]

Parental care behavior is a critical evolutionary innovation, allowing exploitation of novel habitats, influencing fitness and survival of parents and offspring, and serving as an evolutionary precursor to the emergence of social behavior. Diverse parental care strategies have evolved across animal taxa, yet the mechanisms underlying parental behaviors and their evolution remain poorly understood. We take advantage of the diversity of parental care strategies exhibited by closely related species of South American poison frogs to identify neural and physiological mechanisms mediating parental care across species. Poison frogs show remarkable diversity in parental care strategies, including male uniparental care, female uniparental care, and biparental care. Parental care in poison frogs involves defense, hydration, and cleaning of embryos during development, transportation of tadpoles to pools of water, and tadpole care until metamorphosis. In the present study, we examined hormone and brain transcriptomic signatures associated with different care stages in the biparental poison frog species Ranitomeya imitator. We characterized hormone levels and whole-brain gene expression in both males and females during non-reproductive periods, egg care, tadpole transport, and tadpole care. Understanding the mechanisms mediating parental care across diverse species will ultimately contribute to our understanding of the maintenance and evolution alternative parental care strategies.

### Social Behavior

Keywords :poison frog; parental behavior; transcriptomics

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-136**
**Presentation Time: 17:00 to 18:00**

## NEURAL BASIS OF THE VARIABILITY IN PARENTAL OR INFANTICIDAL BEHAVIORAL RESPONSES TO PUPS IN INEXPERIENCED MICE (C57BL/6)

**Marcela Alsina-Llanes[1]; Daniel Olazabal[1]**

Facultad de Medicina,montevideo,Uruguay[1]

There is significant variability in the immediate behavioral response exhibited by inexperienced mice when they are exposed to pups for the first time: parental, no parental or infanticidal. We determined the brain areas that expressed c-Fos when females and males were exposed to pups for the first time (15 min) and displayed full parental behavior (FPB), partial parental behavior (PPB), no parental behavior (NPB), or Infanticidal behavior (IB). Females without exposure to pups (CTL) and males exposed to wire-mesh balls (CTO) were used as control groups. The different subregions of the medial preoptic area (MPOA), ventromedial hypothalamic nucleus (VMH), cortical amygdala (AMC) and medial (AMM) were analyzed. No significant differences in any of the subregions of the MPOA were found, suggesting that different expression of c-Fos in this area is not associated to parental behavior (PB) during the first 15 min. The females that displayed PPB showed higher levels of c-Fos in the AMM compared to CTL ($F = 1.4$, $p <0.05$), suggesting that this area could participate in the transition to FPB. The vlMPOA showed higher levels of c-Fos ($t = 2.4$, $p <0.05$) in infanticidal male compared to CTO, suggesting their involvement in IB and/or inhibition of PB. This work shows the areas immediately or transiently recruited and/or engaged when the animals are exposed to pups for the first time and display different behaviors.

### Social Behavior

Keywords :maternal behavior; infanticidal behavior; inexperienced mice

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-137**
**Presentation Time: 18:00 to 19:00**

## THE CROWDER, THE BETTER: WOOD TERMITE PREFERENCE FOR INFESTED RATHER THAN TO UNINFESTED WOOD

**Conrado Rosi-Denadai[1]; Lirio Cosme Junior[1]; Raul Guedes[1]**

Universidade Federal de Viçosa,Viçosa,Brazil[1]

Cryptotermes is the most widespread genus of drywood termites in the world. Despite its broad presence, Cryptotermes exhibits feeding preferences between different types of wood. Curiously, vibrational cues play an important role on the evaluation of food resource quality by termites. Therefore, this preliminary study aimed to answer three questions: 1) what are the spectral and temporal characteristics of vibrational cues produced by foraging Cryptotermes brevis?; 2) Do these cues correlate with colonization density?; and 3) Do C. brevis foragers prefer infested to non-infested wood? Vibrational cues from ten termite colonies with population sizes ranging from 5 to 25 individuals were recorded with a laser vibrometer. A total of thirty vibrational cues were characterized and the number of vibrational cues registered for an average period of one second was regressed against population size. Finally, a preference experiment was performed in which termites chose between an infested and a non-infested piece of Pinus wood. As results, the foraging cues have an average duration of 0.022s (SD=0.014s; N=30), a dominant frequency of 444Hz (SD=178; N=30) and one harmonic at 778Hz (SD=253; N=29). The regression analysis indicated a curve with a peak rate of vibrational cues at size equal to 15 termites ($F=14.4$; $p=0.002$; $R^2=0.78$). Termites strongly prefer infested to non-infested wood ($X^2=14.7$; $p=0.0001$; $N=22$). These results will allow further research on how termites use vibration to discriminate different types of wood.

### Social Behavior

Keywords :vibrational cues; foraging behaviour; food preference

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-138**
**Presentation Time: 15:00 to 16:00**

## NEURAL BASIS OF MATERNAL AND PATERNAL CARE IN POISON FROGS

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Switching from aggression or apathy towards infants to the intense bond that most human parents experience requires a transformative shift in the brain that is orchestrated by changing hormone levels. However, we understand very little about how the brain facilitates care for offspring, especially in males, where paternal care is coupled with maternal involvement in most species. Poison frogs show highly diverse parental care strategies, from biparental monogamous species to uniparental male or female with no pair bonding. This variability in parental behavior allows the neural basis of parental care to be teased apart from partner affiliation in a comparative framework. We compared the hormonal and neural changes across various parental stages in two species of poison frogs with contrasting reproductive strategies, one with uniparental male care (Dendrobates tinctorius) and another with female-biased care (Oophaga pumilio). We quantified changes in hormone levels and found that cortisol increases with tadpole transport. We also quantified neural induction across different behavioral states and identified brain regions associated with the care of tadpoles. Finally, we used RNA sequencing to examine the patterns of gene expression involved with different parental care strategies and found many differentially expressed genes between parental and non-parental stages. Of special interest is the neuropeptide galanin, which is upregulated with paternal care in poison frogs, similar to the onset of paternal care in rodents. Together, this work highlights differences in neuroendocrine mechanisms between distinct parental care systems and suggests there are conserved mechanisms that promote parental care in frogs and mammals.

### Social Behavior

Keywords :parental care; poison frog; neuroendocrinology

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-139**
**Presentation Time: 16:00 to 17:00**

## NMDA RECEPTOR MEMBRANE EXPRESSION DURING LONG-TERM MEMORY CONSOLIDATION IN THE CENTRAL NERVOUS SYSTEM OF THE CRAB NEOHELICE GRANULATA

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Alterations in the strength of synaptic connections between neurons are key to the formation of a memory trace. These alterations may be driven by the molecular composition
of synaptic membranes. NMDAR-dependent changes in strength of glutamatergic synapses are thought to underlie some forms of learning and memory both in vertebrates and invertebrates. In this study we find changes in surface expression of the NMDAR during the consolidation phase of the contextual learning of the crab Neohelice granulata. Our results show that the surface expression of the NR1 subunit of the receptor changes after training without affecting its general expression. Immediately after training, the surface expression of the NMDAR NR1 subunit is decreased, followed by an upregulation 3 hours post-training, returning to naïve and control levels 24 hours after the end of training.

The changes in NMDAR surface expression observed in the central brain, are not seen in the thoracic ganglion. To evaluate if the surface expression of the NMDAR NR1 subunit is affected by neuronal activity, we used bicuculline injections, that produced an increment in the central brain of the crab 3 hours after administration of the drug. A cocktail of MK-801 and CNQX evaluated at same time point showed no change. These results suggest that the changes in NR1 in the brain could be part of an event of metaplasticity that first, during the downregulation, is helping in the stability of the trace and later at 3 hours post-training changes the threshold of synapse activation.

### Synaptic Plasticity

Keywords :nmdar; crab; consolidation

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-140**
**Presentation Time: 17:00 to 18:00**

## EXPERIENCE DEPENDENT CHANGES IN ODOR SIGNALING IN THE HONEY BEE BRAIN

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Odor experience modifies circuits in the insect antennal lobe (AL). During appetitive olfactory learning, octopamine (OA) acts in the AL via one of its receptors AmOA1, which is primarily expressed on inhibitory (GABAergic) neurons. We have reported variation in expression of AmOA1 in the AL in forager bees of unknown age or experience. We proposed that differences in olfactory experience lead to individual differences in the physiological processing of an odor and the way the brain expresses AmOA1. To test this hypothesis, we controlled the age and olfactory experience of bees from a single matriline. We set up young, newly emerged bees in queen-right colonies and maintained them in different conditions. One colony was allowed to forage openly and experience natural associations of reward with floral odors. Two other colonies were maintained in tents and experienced association of a single monomolecular odor with reinforcement. We sampled known aged bees from each colony and used calcium imaging and immunostaining to establish how experience affects the AL. Gross glomerular activation patterns elicited by the different odors were conserved across bees from different treatments. However, glomerular response profiles were more consistent across bees with limited olfactory experience than across bees that had been openly foraging. Glomeruli showing more consistent responses were the glomeruli that are recruited by the odor to which the bees had been continuously exposed. Furthermore, AmOA1 staining was more uniform among individuals with limited experience. These results show that consistent experience drives modifications of the AL network within individual bees.

### Synaptic Plasticity

Keywords :antennal lobe plasticity; olfactory experience; octopamine

**Poster Session II, April 2, 15:00 - 19:00 h.**
**Poster Number: II-141**
**Presentation Time: 15:00 to 16:00**

## REGULATION OF NEUROLIGINS AND NEUROXIN 1 IN THE ADULT HONEYBEE BRAIN ACCORDING TO EARLY OLFACTORY EXPERIENCES

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Neurexins and neuroligins are highly conserved adhesive proteins found on synaptic membranes. These proteins produce a trans-synaptic bridge that facilitates maturation and specification of synapses. In the Drosophila larvae, Neurexin 1 is required for synapse formation and associative learning; while in the honeybee, increased levels of Neurexins and Neuroligins have been reported in the adult brain after olfactory learning. Since the interaction between these proteins guides synapse formation, we investigated whether these connected proteins are differentially regulated in the mature adult honeybee brain according to early-time, specific odor-rewarded inputs. We evaluated gene expression levels of these synaptic anchors proteins in bees of 17 days of age that had undergone associative odor training at different periods of early adulthood. Bees had been fed with scented food (sucrose solution scented with 1-Hexanol) only during the period of either 1-4 or 5-8 or 9-12 days of age and compared with a control group (always odorless food; n=9, pools of 10 brains each). At 17 days of age, bees were anesthetized and their brains dissected and put in liquid nitrogen. Then TRIZOL extraction of mRNA was performed and qRT-PCR was performed to assess expression levels of Nlg2-5 and Nrx1. Results show that events of associative learning occurred during 5-8 days of age can boost the expression levels of Nrx1 and Nlg2. Therefore, early olfactory experiences improved their synapse formation.

### Synaptic Plasticity

Keywords :qrt-pcr; synaptic plasticity; gene expression

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