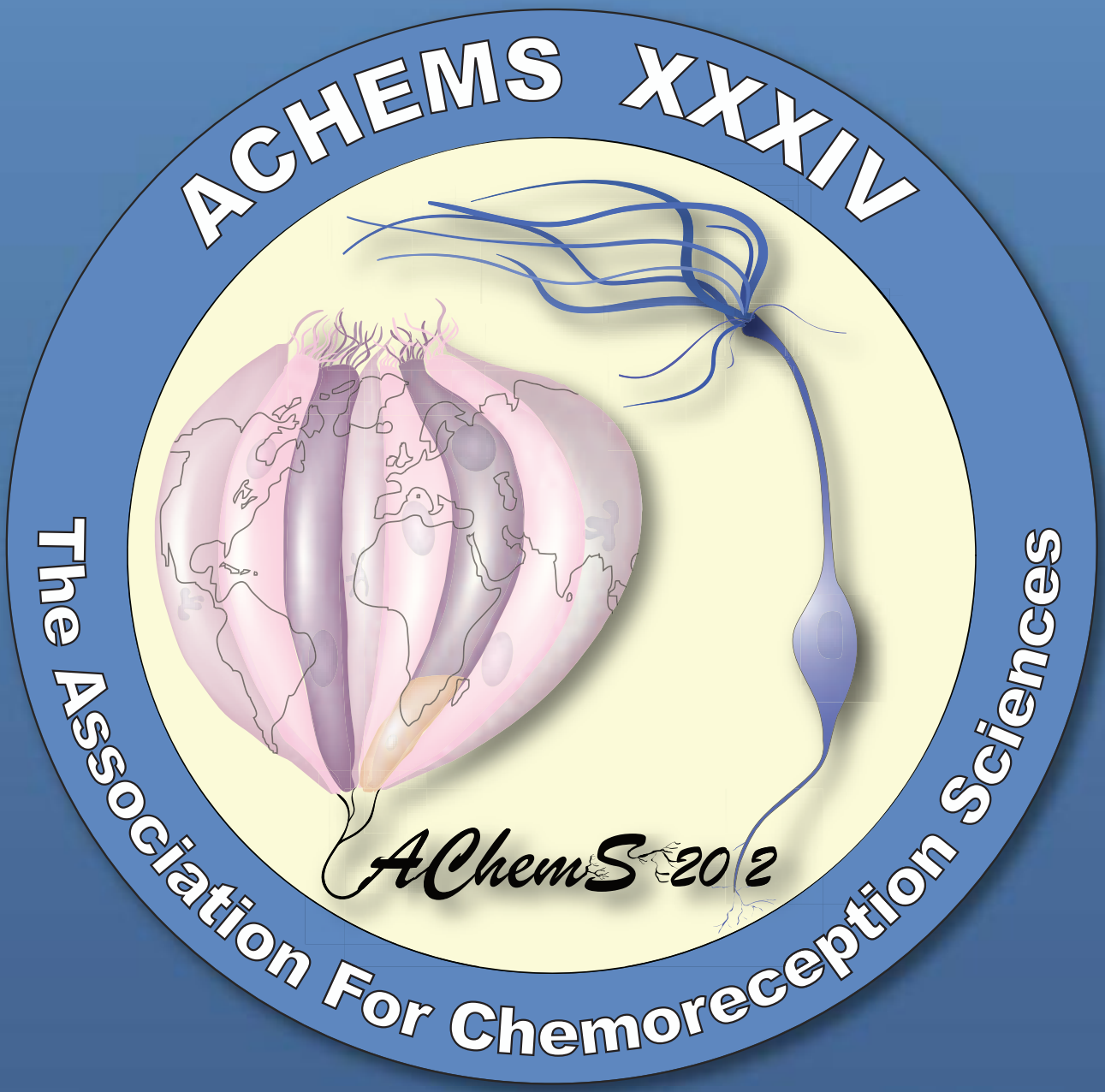

ACHEMS
2012 Annual Meeting

ABSTRACTS

Huntington Beach, California
April 25-28, 2012

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Association for Chemoreception Sciences

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Thursday, April 26
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Friday, April 27
8:00 a.m. – 12:00 p.m. | 7:00 p.m. – 11:00 p.m.

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34th Annual Givaudan Lectureship — Givaudan Corporation
David Anderson, PhD, California Institute of Technology

18th Annual Ajinomoto Award to Promising Young Researcher in the Field of Gustation
Ichiro Matsumoto, PhD, Monell Chemical Senses Center

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Yuzo Ninomiya, PhD, Kyushu University

21st Annual Moskowitz Jacobs Award for Research in Psychophysics of Human Taste and Smell
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The Polak awards are funded by the Elsje Werner-Polak Memorial Fund in memory of our niece gassed by the Nazis in 1944 at age 7: Ghislaine Polak and the late Ernest Polak

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Ning Cheng, NIH/NINDS
Timothy Connelly, University of Pennyslvania School of Medicine
David Gire, University of Colorado, Rocky Mountain Taste and Smell Center
Dyan MacWilliam, University of California Riverside
Jeremy McIntyre, University of Michigan
Anan Moran, Volen Center for Complex Systems

We are pleased to announce that four 2012 Polak Junior Scientists Travel Fund Awards were given for this year's Meeting.

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MEETING EVALUATION

The meeting evaluation is available online. Please visit www.achems.org to give us your feedback on the meeting. Your input helps AChemS' leadership continue to offer quality annual meetings and member services.

#1 GIVAUDAN LECTURE: NEURAL CONTROL OF AGGRESSION IN DROSOPHILA

Neural Control of Aggression in Drosophila

David J. Anderson[1], Eric Hoopfer[1, 2], Gerald M. Rubin[2], Xiaoqing Han[1], Liming Wang[1]
[1]Division of Biology, California Institute of Technology and Howard Hughes Medical Institute Pasadena, CA, USA, [2]Janelia Farm Research Campus, Howard Hughes Medical Institute Ashburn, VA, USA

Aggression between conspecific males is a social behavior that is under pheromonal control. How these pheromones are interpreted by the brain, and their role in regulating aggression, remains poorly understood. Pheromones that can promote aggression have been identified in both insects and mammals, but there are relatively few systems in which the corresponding receptors have been identified, and where genetic experiments to test their behavioral relevance are possible. *Drosophila melanogaster* presents a powerful system in which to investigate these issues. I will describe experiments that have led to the identification of aggression pheromones in this species, and insights into the chemosensory "logic" by which this innate behavior is controlled. Systematic genetic screens to identify the neural circuits that control aggressive behavior will also be discussed. Acknowledgements: Howard Hughes Medical Institute

#3 SYMPOSIUM: THE FLAVOR OF THINGS TO COME: EXPECTATION & THE PROCESSING OF CHEMOSENSORY INFORMATION

Context-dependent patterns of neural activity in the human olfactory system

Noam Sobel[1], Anat Arzi[1], Anton Plotkin[1], Sagit Shushan[1], Tali Weiss[1]
[1]Weizmann Institute of Science/Neurobiology Rehovot, Israel

Smelling the same odorant can be accompanied by a significantly different percept as a function of context and expectation. Where in the brain does this modulation occur, and what are the neurochemical underpinnings of this process, remains unknown. Here I will review data from our and other labs that have used functional neuroimaging to uncover context-dependent patterns of activity in both primary and secondary olfactory cortex. Moreover, I will present pilot data that examines whether expectation modulates patterns of neural activity at the earliest stage of the olfactory process, namely in the olfactory epithelium. Acknowledgements: ERC Ideas 800250

#4 SYMPOSIUM: THE FLAVOR OF THINGS TO COME: EXPECTATION & THE PROCESSING OF CHEMOSENSORY INFORMATION

Rate and sniff-based odor coding in piriform cortex are differentially modulated by behavioral context

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[1]Department of Cell and Developmental Biology, Rocky Mountain Taste and Smell Center and Neuroscience Program, School of Medicine University of Colorado Aurora, CO, USA, [2]Department of Physiology and Biophysics, Rocky Mountain Taste and Smell Center and Neuroscience Program, School of Medicine University of Colorado Aurora, CO, USA

We made extracellular recordings from the anterior piriform cortex of mice trained to perform two olfactory tasks, one in which any odor signaled the presence of a water reward (passive sensory task), and one in which one odor (cumin aldehyde or room air) was unrewarded (S-) and all other odors were rewarded (S+, active sensory go/no-go task). We found that the rate of firing of both single and multi-units recorded in the anterior piriform (integrated over 2 seconds during odor exposure) did not often signal the identity of the odors during the passive task (only 5% of 70 single units and 1% of 176 multi units responded divergently to odors). During the active task, however, piriform rate responses often indicated the category of an odor, with 32% of units showing a divergent response to S+ vs. S- odors (22% of 126 single units and 39% of 191 multi units), while still containing little information as to the odor identity (5% of 320 units). When spike-timing was considered relative to each sniff, however, this pattern changed, with odor identity being coded by a number of cells (11% of single units and 28% of multi-units) in the active task, as well as in the passive task (13% of single units, 24% of multi-units coding odor identity). Eliminating sniff-phase information by randomizing spike times relative to sniffing nearly entirely eliminated odor identity information, while categorical distinctions in the active task remained intact. Taken together, our results suggest that multiplexed coding occurs in the piriform cortex, with behaviorally relevant categorical information largely transmitted through firing rate, while odor identity is mostly coded in a sniff-phase dependent manner. Acknowledgements: NIH DC00566 (DR), DC04657(DR) and DC011980(DG)

#5 SYMPOSIUM: THE FLAVOR OF THINGS TO COME: EXPECTATION & THE PROCESSING OF CHEMOSENSORY INFORMATION

Top-down modulation of central taste and flavor

Dana M Small[1,2]
[1]The John B Pierce Laboratory New Haven, CT, USA, [2]Yale University New Haven, CT, USA

Perceptual experiences result when physiochemical stimuli are transduced into nerve impulses and then elaborated and integrated in the central nervous system to inform ongoing behavior. A critical part of optimizing behavior is the formulation of predictions and the development of beliefs and expectations about the nature of stimuli and the outcome of behaviors. These beliefs and expectations have a profound influence on perception and thus behavior. This presentation will review recent work from our lab in which we use functional magnetic resonance imaging to explore the influence of beliefs and expectations on central response to taste

and flavor. We show that unexpected oral stimulation results in suppression of visual cortex and up-regulation of sensory, attention and reward regions and we demonstrate that labels about the nutritional value of the flavors being consumed impact hypothalamic responses and perceived pleasantness. We also find that the magnitudes of such effects are often influenced by individual factors such as body mass index and sensitivity to reward. Taken together the findings underscore the principle that sensation involves neural circuits beyond those specialized for sensory representation. What is ultimately perceived results from elaborate network interactions guided by behavioral optimization rather than a veridical representation of the world.
Acknowledgements: NIDCD R01DC6706 PepsiCo

#6 SYMPOSIUM: THE FLAVOR OF THINGS TO COME: EXPECTATION & THE PROCESSING OF CHEMOSENSORY INFORMATION

Effects of cue-triggered expectation on cortical processing of taste

Alfredo Fontanini
Department of Neurobiology and Behavior, SUNY Stony Brook Stony Brook, NY, USA

Food does not appear in one's mouth unexpectedly. Tasting is typically the outcome of a behavioral sequence promoted by anticipatory cues. The sight of a dish, its odor or the sound of a drink being poured are all signals that trigger expectations about the availability of a gustatory stimulus. As a result gustatory information is often perceived against the background of prior expectations. Expectation influences neural activity in two ways: it alters the background state of cortical networks and modulates responses to sensory stimulation. I will present evidence for a link between these two phenomena. Results from a combination of electrophysiological, behavioral and pharmacological techniques will be featured. I will discuss evidence showing how anticipatory cues can activate the gustatory cortex (GC) in behaving rodents. Recordings from rats trained to perform a one-cue self-administration paradigm or a two-cues auditory go/no-go task will be shown. These data will provide evidence for a functional role of cue-induced anticipatory activity in GC. Additionally, responses to cued self-deliveries of tastants will be compared with those evoked by unexpected or erroneously-expected stimuli. Differences in the coding will be described and related to priming activity triggered by anticipatory cues. A functional link between anticipatory activity and changes in taste processing will be presented. Finally, data will be shown on how the effects of expectation in GC depend on top-down inputs from the basolateral amygdala. Results from multiple experimental approaches will be used to unveil the circuits mediating the effects of amygdala's inputs. Altogether our data will provide a new model explaining how changes in the state of cortical circuits can shape the processing of expected and unexpected stimuli. Acknowledgements: This work was supported by National Institute of Deafness and Other Communication Disorders Grants R01-DC010389 and R03-DC008885

#9 PRESIDENTIAL SYMPOSIUM: NEURAL EPIGENETICS & OLFACTION

Dnmt3a-dependent Non-promoter DNA Methylation Facilitates Transcription of Neurogenic Genes

Hao Wu[1], Volkan Coskun[2], Jifang Tao[2], Wei Xie[3], Weihong Ge[1], Kazuaki Yoshikawa[4], En Li[5], Yi Zhang[6], Yi Eve Sun[1,2]
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DNA methylation at proximal promoters facilitates lineage restriction by silencing cell-type specific genes. However, euchromatic DNA methylation frequently occurs in regions outside promoters. The functions of such non-proximal promoter DNA methylation are unclear. Here we show that the de novo DNA methyltransferase Dnmt3a is expressed in postnatal neural stem cells (NSCs) and is required for neurogenesis. Genome-wide analysis of postnatal NSCs indicates that Dnmt3a occupies and methylates intergenic regions and gene bodies flanking proximal promoters of a large cohort of transcriptionally permissive genes, many of which encode regulators of neurogenesis. Surprisingly, Dnmt3a-dependent non-proximal promoter methylation promotes expression of these neurogenic genes by functionally antagonizing Polycomb repression. Thus, non-promoter DNA methylation by Dnmt3a may be utilized for maintaining active chromatin states of genes critical for development.

#10 PRESIDENTIAL SYMPOSIUM: NEURAL EPIGENETICS & OLFACTION

Mechanisms of Odorant Receptor Gene Silencing

John Ngai
Dept of MCB and Helen Wills Neuroscience Institute, University of California Berkeley, CA, USA

In the vertebrate olfactory system, individual olfactory sensory neurons typically express just one odorant receptor (OR) gene from a large repertoire that ranges from 50~150 genes in fish to >1000 genes in rodents. The highly regulated expression of OR genes according to the "one receptor, one neuron" rule defines the functional identity of the sensory neuron by determining the odorants to which the cell responds. ORs also play a role in the precise targeting of the olfactory sensory neurons' axons in the olfactory bulb, which underlies the anatomical basis of the olfactory sensory map. How is the expression of one OR gene established and maintained in each neuron? Previous studies have shown that individual sensory neurons can in rare instances sequentially express multiple OR genes, with such gene switching events occurring more frequently when the initial OR gene expressed by the cell is a pseudogene. These observations support a model in which a functional OR, once selected, silences the expression of all other OR genes in the genome. In this manner, OR gene silencing prevents gene switching and ensures the stable expression of a single OR in each olfactory sensory neuron.

The intracellular signaling mechanisms mediating OR-dependent gene silencing remain largely unknown, however. In this presentation I will discuss recent experiments focusing on the genetic and epigenetic mechanisms subserving OR gene silencing. Acknowledgements: This work was supported by a grant from the NIDCD (R01 DC02253).

#11 PRESIDENTIAL SYMPOSIUM: NEURAL EPIGENETICS & OLFACTION

Epigenetic Regulation of Olfactory Receptor Expression

Stavros Lomvardas
UCSF/Anatomy San Francisco, CA, USA

Olfactory receptor gene choice, the process of the stochastic activation of one out of a thousand alleles is poorly understood. Our data are consistent with an epigenetic control of olfactory receptor expression. Our experiments suggest that that in the mouse olfactory epithelium, olfactory receptor (OR) genes are marked, in a highly dynamic fashion, with the molecular landmarks of constitutive heterochromatin. The cell-type and differentiation dependent deposition of H3K9me3 and H4K20me3 along the OR clusters is, reversed during the process of OR choice for monogenic and mono-allelic expression. Our findings provide genetic and biochemical evidence that demethylation of the silenced OR alleles is necessary for olfactory receptor activation and for the subsequent terminal differentiation of the olfactory neuron. Moreover, we provide evidence for a spatial regulatory layer in OR choice. Using a complex DNA FISH probe and super-resolution imaging technologies we demonstrate that the active OR allele is spatially separated from the aggregated silenced ORs. Genetic manipulation of the spatial segregation of active and inactive alleles results in dramatic changes in olfactory receptor expression and violation of the "one receptor per neuron rule". Acknowledgements: R03 DC010273 Epigenetic Regulation of Olfactory Receptor Expression

#12 PRESIDENTIAL SYMPOSIUM: NEURAL EPIGENETICS & OLFACTION

Coding olfaction

Peter Mombaerts
Max Planck Institute of Biophysics Frankfurt, Germany

Each olfactory sensory neuron (OSN) in mouse chooses one of 1,200 odorant receptor (OR) genes for expression. OR genes are chosen for expression by greatly varying numbers of OSNs. The mechanisms that regulate the probability of OR gene choice remain unclear. Here, we have applied the NanoString platform of fluorescent barcodes and digital readout to measure RNA levels of 577 OR genes in a single reaction, with probes designed against coding sequences. In an inbred mouse strain with a targeted deletion in the P element, we find that this element regulates OR gene choice differentially across its cluster of 24 OR genes. Importantly, the fold changes of NanoString counts in ΔP or ΔH mice are in very close agreement with the fold changes of cell counts, determined by in situ hybridization. Thus, the P and H elements regulate the probability of OR gene choice, not OR transcript level per OSN.

#13 PRESIDENTIAL SYMPOSIUM: NEURAL EPIGENETICS & OLFACTION

Epigenetic Gene Regulation in Neurodegeneration and Repair

Johannes Gräff, Li-Huei Tsai
Picower Institute for Learning and Memory, Department of Brain and Cognitive Sciences, Howard Hughes Medical Institute, Massachusetts Institute of Technology Cambridge, MA, USA

Chromatin modifications, particularly histone-tail acetylation, have recently been implicated in memory formation. Increases in histone-tail acetylation that are induced by inhibitors of histone deacetylases (HDACis) facilitate learning and memory in wildtype mice as well as in mouse models of Alzheimer's-like neurodegeneration. Moreover, increases in histone acetylation by HDACi treatment induce dendritic sprouting and increase synapse numbers. Long-lasting remodeling of neural circuits, therefore, may underlie the beneficial effects of HDACis on cognition. Through a combination of genetic and pharmacological approaches, we have identified histone deacetylase 2 (HDAC2) to be a major HDAC involved in regulating the expression of genes essential for synaptic plasticity and memory formation. HDAC2-deficient mice exhibit facilitated long-term potentiation (LTP), whereas HDAC2 overexpressing mice exhibit impaired learning and hippocampal LTP. Moreover, HDAC2-deficient mice are refractory to the beneficial effects of HDACis in enhancing cognition. Recently, we found that HDAC2 is dysregulated in mouse models of Alzheimer's disease as well as in Alzheimer's disease human postmortem brains. We propose a model whereby HDAC2 dysregulation causes an epigenetic blockade of gene expression that contributes to cognitive impairment in neurodegenerative diseases such as Alzheimer's. These observations suggest that targeting chromatin remodeling may serve as a new avenue for treating cognitive decline caused by neurodegeneration.

#13.5 PLATFORM PRESENTATIONS: OLFACTION

Baleen Whales and Tubenose Seabirds — A Colossal Chemosensory Convergence?

Julie C. Hagelin[1], Janice M. Straley[2], Lindsey B. Nielson[3], Andy Szabo[4]
[1]University of Alaska Fairbanks, Institute of Arctic Biology Fairbanks, AK, USA, [2]University of Alaska Southeast Sitka, AK, USA, [3]College of the Atlantic Bar Harbor, ME, USA, [4]University of Alaska Southeast Juneau, AK, USA

How filter-feeding baleen whales locate ephemeral swarms of zooplankton prey remains a biological mystery. Though it is widely believed that all whales cannot smell, evidence points to the contrary, including indigenous knowledge, anatomical and genetic data. Baleen whales face a foraging "problem" that is similar to tubenose seabirds (e.g. petrels, shearwaters). Below we address the parallels and present initial data for whales. Classic seabird studies revealed that tubenoses use olfactory-mediated foraging, in which they oriented into the wind upon approaching experimental "plumes" of food scent. More recent work has discovered avian attraction to dimethyl sulfide (DMS), a reliable indicator of zooplankton prey. We observed humpback whales (*Megaptera novaeangliae*) in southeast Alaska for evidence of behaviors consistent with the use of odor cues. Our data suggest that whales orient into the wind ($n = 231$, $df = 1$, $X^2=54.6$, $P < 0.0001$). This suggests that humpbacks are well positioned to perceive volatile

chemical stimuli. We plan experimental tests of DMS. We hypothesize that whales, like seabirds, converged upon olfaction and use DMS to locate dense swarms of patchy zooplankton prey. Other patterns support this notion. Within whales, baleen species that specialize on zooplankton (Suborder Mysticeti) have more notable olfactory systems than toothed whales (Odonticeti). A similar diet-based dichotomy occurs in seabirds between tubenoses (Order Procellariiformes) and Charadriiformes. Applying general principles of avian chemosensory behavior may help us gain new insight into the feeding biology of whales. The approach promises to yield information about an entirely overlooked mode of perception in whale biology applicable to other key behaviors, such as migration and social interactions. Acknowledgements: Alaska Whale Foundation, Juneau Lighthouse Association

#14 **PLATFORM PRESENTATIONS: OLFACTION**

Chemosensory Functions for Degenerin/Epithelial Sodium Channels

Yehuda Ben-Shahar, Xiaoling Gu
Washington University in St. Louis/ Biology St. Louis, MO, USA

Asthma represents a major but poorly understood health concern. In asthmatic individuals, noninfectious stimuli such as cold air or strong odors can often induce and exacerbate disease conditions, but the cellular and molecular mechanisms underlying these pathologies are unknown. We have identified a rare population of cells in the human airway epithelium that show the morphology of immune-related dendritic cells but express members of the human olfactory receptor family. Based on these findings, we tested the novel hypothesis that direct activation of olfactory sensory pathways in specialized non-neuronal olfactory sensory cells ($_{olf}$DCs) mediates asthma-related hyperreactivity via immune-independent pathways. We further hypothesize that the sensory activation of $_{olf}$DCs leads to hyperreactivity via a local release of 5-HT, which mediates airway constriction. We discovered that $_{olf}$DCs incidence was associated with airway disease states in both COPD vs. normal humans as well as in primate models of asthma. Furthermore, preliminary data suggest that stimulating primary human airway cultures with strong odors can lead to release of 5-HT, which may provide a mechanistic explanation for odor sensitivities in individuals suffering from airway diseases.

#15 **PLATFORM PRESENTATIONS: OLFACTION**

Computational Assessments of Olfactory Receptor Odorant Interactions

Chiquito J Crasto, Peter C Lai
University of Alabama at Birmingham, Department of Genetics Birmingham, AL, USA

Computational methods have allowed a glimpse into the mechanisms of the first step leading to olfaction. Odor molecules follow a path from outside the nostrils through the mucus membrane, bind, interact with and excite the olfactory receptor, thereby facilitating a signal transduction process that leads to our sense of smell. We have performed rigorous computational assessments of several experimentally (functionally) well characterized olfactory receptors: rat OR I7, mouse ORs S79 and S86 (part of a comprehensive combinatorial functional analysis), human ORs 17-209 (OR1G1) and the "functional pseudogene17-210 (OR1E3P). Our computational methodology includes: creating the protein model, computationally binding an odorant (experimentally shown to bind the receptor) into the OR model binding region, simulating an aqueous environment and a lipid bilayer representing the plasma membrane, and performing long-duration molecular dynamics simulation studies of the odorant behavior in the OR binding pocket. Our results have, all firsts for the field, allowed us to view in real time entry and exit paths from and to the binding region of the OR. We have also observed how specific residues contribute to odorant binding—a combination of van der Waals and electrostatic interactions—over the course of a simulation. We have observed the involvement of specific amino acid residues from the inter-helical loops, an advancement over traditional static docking methods. We have been able to show a strong correlation between excitation of an OR by an odorant and preferential binding between two binding regions of an OR. It has long been surmised that OR excitation proceeds from a structural change following OR-binding. We have been able to pinpoint this structural excitation in the OR. Acknowledgements: NIH (NIDCD) (1R21DC011068-01)

#16 **PLATFORM PRESENTATIONS: OLFACTION**

Fasting induced-changes in the spatiotemporal representation of odors in the main olfactory bulb

Mounir Bendahmane[1,2], Claire Martin[1], Monique Caillol[2], Christine Baly[2], Hirac Gurden[1]
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Odors are major indicators of food palatability and essential for food detection and feeding behavior. However, the nutritional impact on the representation of odors in the olfactory system is elusive. Therefore we studied the effects of fasting on the spatiotemporal activity in the main Olfactory Bulb (OB), a structure supporting the first step of odor coding in the brain. We tested odor responses of the OB in 17 hours-fasted rats compared to ad libitum-fed rats. We used two olfactory stimuli: the first one (almond aroma odor) is associated to food since it is incorporated to a homemade cake that rats are used to eat and are excited about; the second is the pure odorant hexanal which is neutral. We probed both types of coding (spatial and temporal) at

both levels where they occur (glomerular layer and deeper layers respectively) in anesthetized rats. Finally, we used different concentrations of each stimulus to check for changes in odor threshold. Using intrinsic optical signals imaging and local field potential recordings, we observed that odor maps and changes in oscillatory patterns of activity in the OB are present for both types of stimuli at low concentrations (0.1% hexanal or 2% almond aroma) in the majority of fasted rats (8 / 9 animals tested) but only in a small fraction of fed animals (3 / 9 animals tested). For higher odor concentrations (0.5% hexanal or 5% almond aroma), most fed animals responded (7 / 9 animals tested). We conclude that fasting deeply impacts the overall odor detection threshold in the OB. Acknowledgements: Agence Nationale de la Recherche ANR-09-JCJC-0117-01

#17 **PLATFORM PRESENTATIONS: OLFACTION**

Functional glomerular organization in the mouse accessory olfactory bulb

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The mouse accessory olfactory system (AOS) processes sensory information about nonvolatile chemical cues, including urinary sulfated steroids. The first neural circuit in the AOS pathway, the accessory olfactory bulb (AOB) receives peripheral input from vomeronasal sensory neurons (VSNs) via thousands of synaptic pooling structures called glomeruli. In the main olfactory system, imaging techniques have allowed direct observation of glomerular activity patterns in response to odors. The complex organization of glomeruli in the AOB has thus far prevented similar approaches. We applied a new high-speed volumetric imaging technique, objective-coupled planar illumination (OCPI) microscopy, to image presynaptic Ca^{2+} in *ex vivo* preparations taken from mice expressing the genetically-encoded calcium indicator *GCaMP2* in VSNs. This approach produced reliable volumetric activity images across multiple randomized trials. We analyzed activity patterns to a panel of sulfated steroids in order to associate each active glomerulus with a known functional class of VSNs. We then analyzed glomerulus positions from each VSN class for evidence of chemical-topographical organization, or "chemotopy". We found that absolute glomerulus position gave little information about chemical receptive field. However, we found that certain VSN classes maintained close relative glomerulus positions. When we analyzed the relationship between chemical receptive fields and relative glomerulus position, we found no positive link between them. In fact, the classes with the most closely associated glomeruli had the most dissimilar receptive fields. We conclude that AOB glomerular organization is non-chemotopic, and suggest that the tightly associated glomerular modules represent fundamental processing units in the AOS. Acknowledgements: NIH 1F32DC009352 (JPM) NIH 1K99DC011780 (JPM) NIH 5R01DC010381 (TEH) NIH 5R01NS068409 (TEH)

#18 **PLATFORM PRESENTATIONS: OLFACTION**

Chemosensory interactions in rat olfactory cortex

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Interactions between the gustatory and olfactory systems are responsible for perception of flavor, which is central to the ability to learn food preferences and aversions. While many examples of behavioral correlates of taste-smell integration exist, the physiological basis for such interactions remains largely unknown. Based directly on recent behavioral work, the present research focuses on multimodal influences on neuronal activity in rat olfactory cortex. Electrophysiological recordings were made from gustatory and/or posterior piriform cortex (1.4 mm posterior to Bregma, 5.5 mm lateral, >5.5 mm ventral) of awake Long-Evans rats, using implanted arrays of up to 16 moveable microelectrodes. We recorded LFP and spiking activity while rats were presented with taste and odor stimuli. Tastes were delivered through intra-oral cannulae; odors were actively sampled using a nose poke. Simultaneous monitoring of respiratory activity through intra-nasal cannulae allowed us to determine the exact timing of olfactory stimulation. The results show that ~50% of PPC neurons respond to taste stimuli. Control experiments in which we inactivated primary gustatory and olfactory sensory epithelia confirmed stimulus-specificity of taste responses. We further confirmed that recordings were made from olfactory cortex using known anatomical and functional hallmarks, such as responsiveness to odor stimuli, and modulation of olfactory, but not gustatory responses by the respiratory signal. Our data demonstrate that PPC is a multimodal area, receiving both olfactory and gustatory input. This finding strengthens the idea that crossmodal interactions play an integral role in chemosensory processing, and may be responsible for guiding adaptive behaviors related to food preference.

#19 **PLATFORM PRESENTATIONS: OLFACTION**

Lateral entorhinal cortex top-down modulation of odor coding in the piriform cortex

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The lateral entorhinal cortex (LEC) is the gateway for olfactory input to the hippocampus. Layer II/III LEC neurons receive direct input from both the olfactory bulb and piriform cortex, and in turn project to the hippocampal dentate gyrus and CA3. However, the LEC also projects back to the piriform cortex (PCx) and olfactory bulb (Insausti et al., 1997), and stimulation of the LEC depresses olfactory bulb input to the piriform cortex (Mouly & Scala, 2006). Furthermore, local field potential analyses reveal that in odor discrimination-trained animals the EC can signal the olfactory system prior to odor onset, potentially preparing the system for odor sampling (Kay et al., 1996; Martin et al., 2007). Given that activity in the LEC is shaped by input from the hippocampus, amygdala and cholinergic input from the medial septum, the present study examined how LEC top-down input modulates PCX odor coding in rats and mice. Single-unit and LFP recordings were

made from the olfactory bulb and anterior PCX before, during and after LEC stimulation (electrical or optogenetic) or LEC reversible lesions (muscimol infusions, 500µg). Both spontaneous and odor-evoked activity was quantified, including single-unit odor receptive field characteristics. In addition, in separate animals LEC single-unit odor receptive fields were characterized and compared with PCX. The results suggest that LEC single-units are more narrowly tuned than aPCX units. Furthermore, LEC activity suppresses PCX activity, and release from this inhibition can modify PCX single-unit odor receptive field characteristics. Given the known function of LEC in working memory and multisensory integration, these results suggest it may serve as a powerful top-down modulator of olfactory cortical function, odor perception and odor memory. Acknowledgements: NIDCD, DC03906 NIA, AG037693 NIMH, MH067763

#21 **SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE**

Taste Gene Polymorphism, Dietary Behaviors and Health

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Genetic variation in taste influences food sensations, driving food choices and possibly satiety responses, which ultimately impact body weight and health. Associations between bitter receptor SNPs and preference/intake for alcohol and vegetables, and related diseases, have been most studied. Yet, single polymorphism, diet and health relationships are observed inconsistently, suggesting this initial research was top-down and reductionist. Environmental factors affect receptor expression and functionality of the taste system beyond receptor-ligand binding. Are there polymorphisms related to this regulation? For example, we observed *TAS1R1*-intronic SNP effects on perceived intensity across prototypical tastants and irritants. The taste-diet-health relationship also is affected by multiple polymorphisms. We found that *TAS2R38* nontasters consumed vegetables more frequently than *TAS2R38* tasters; the effects were more pronounced when accounting for fungiform papillae number. Similarly, sAC gene effects on sucrose and quinine intensity were larger in propylthiouracil tasters than in nontasters. Inaccuracies in measuring dietary intake confound this research. Increased attention to assessing food preference may advance understanding of chemosensory influences on health. Preference is easy to measure and may capture what is habitually consumed. The full impact of chemosensory-related genes on diet for preventing chronic diseases such as obesity, diabetes and cancer will be realized through multidisciplinary collaborations and large, representative datasets with careful psychophysical, nutrition and genetic measures. These findings will inform interventions that promote food enjoyment, satisfaction and health; optimize food and pharmaceutical palatability; and identify novel behavioral and disease biomarkers. Acknowledgements: United States Department of Agriculture Hatch Project CONS00827 funds and the National Institutes of Health DC008613

#22 **SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE**

Experimental Models of Compensation Following Regional Oral Sensory Damage

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Four cranial nerves carry oral sensory cues, and mounting evidence indicates that these inputs interact centrally to sustain whole-mouth sensation following regional loss. Consistent with clinical observations, psychophysical data show that local oral sensory anesthesia leads to compensatory disinhibition at remaining oral loci. While several reports have found that chorda tympani (CT) block augments glossopharyngeal (IX) sensation, selective enhancement of trigeminal (V) sensation among supertasters of 6-n-propylthiouracil (PROP) suggests that oral disinhibition occurs in proportion to genetic taste status. Recent work supports this view, as unilateral CT block produces insufficient compensation in nontasters to maintain whole-mouth taste; effects on the posterior tongue include asymmetric taste loss and uniform oral burn loss, but contralateral trigeminal function is unaffected. Because oral sensation guides flavor perception and localization, the effects of regional oral anesthesia extend to retronasal olfaction (but not to orthonasal olfaction): Following CT block, retronasal localization shifts to intact regions of the mouth, retronasal intensity aligns closely with whole-mouth taste intensity, and individuals with low taste function (e.g., T2R38 nontaster haplotypes, pre-existing oral sensory damage) perceive the weakest retronasal cues. Taken together, these findings demonstrate robust individual differences in the impact of localized oral sensory loss on subsequent taste and flavor perception: Supertasters may experience whole-mouth constancy, while nontasters may consistently fail to achieve it. This variation may contribute to long-term dietary and behavioral health outcomes, and it may explain widespread inconsistency in the clinical literature regarding oral sensory dysfunction. Acknowledgements: NIH DC 00283

#23 **SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE**

Clinical Examples of Damage to Taste Nerves: Chorda Tympani and Glossopharyngeal Nerves

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Anesthesia studies show that taste and retronasal olfactory sensations (i.e., olfactory sensations evoked by foods in the mouth) are affected by central interactions among the neural inputs from the oral/nasal cavity. Previous work has established that inhibition produced at the central termination of the chorda tympani taste nerve normally inhibits areas receiving input from other cranial nerves. Thus reduced chorda tympani input (anesthesia, clinical damage) can result in intensification of some oral sensations. Anesthesia abolishes all input from the anesthetized nerve; clinical damage diminishes input but does not usually totally abolish it. Otitis media damages the chorda tympani nerve (CN VII); tonsillectomy damages the glossopharyngeal nerve (CN IX). Studies of these two pathologies permit comparisons of partial damage to the chorda tympani, the glossopharyngeal, or both

nerves. Results reveal that damage restricted to only one of these nerves leads to intensified sensations mediated by undamaged cranial nerves (increased whole mouth taste, oral touch (e.g., fats) and oral burn/pain (e.g., chilis). In addition, retronasal olfaction is intensified (possibly secondarily to whole mouth taste intensification). If both nerves are damaged, these intensifications do not occur; rather, oral sensations are reduced. Both otitis media and tonsillectomy have been associated with intensified preferences for high fat foods and weight gain in some individuals. Future research will reveal how these behavioral changes are linked to the sensory alterations produced by taste nerve damage. This may lead to the ability to identify those individuals with histories of otitis media or tonsillectomy that are at risk for weight gain. Acknowledgements: We thank NIDCD for support via grants DC000283 and DC8613.

#24 **SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE**

Taste Alterations in Inflammatory Disease Models

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Many diseases associated with inflammation can affect taste. For example, patients with oral and upper respiratory infections and those with autoimmune diseases may experience taste abnormalities of varying severity. Recent studies have shown that numerous genes involved in immune responses are highly expressed in taste buds. Yet, it remains largely unclear how immune responses, such as inflammation, affect the taste system. We recently demonstrated that in the lipopolysaccharide (LPS)-induced acute inflammation model in mice, taste progenitor cell proliferation and taste bud cell renewal were significantly inhibited. The average life span of taste bud cells was shortened by LPS treatments. Moreover, mice injected with LPS displayed a range of altered responses to taste compounds in behavioral tests. Inhibition of taste cell renewal was also observed in MRL/lpr mice, a model for autoimmune diseases with chronic inflammation. The taste buds of MRL/lpr mice were smaller than those of wild type congenic control (MRL/+/+) mice. Immunohistochemical analyses showed a significant reduction in the number of gustducin-positive taste receptor cells in diseased mice. Furthermore, MRL/lpr mice exhibited reduced responsiveness to bitter, sweet, and umami compounds in taste behavioral tests. Together, these studies in animal models suggest that inflammation, by affecting the renewal and turnover of taste cells, contributes to the development of taste disorders. Acknowledgements: Supported by NIH/NIDCD grants DC010012 and DC011735 and NSF grant DBJ-0216310.

#25 **SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE**

Neuroimaging of Chemosensory Dysfunction

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Neuroimaging is a powerful tool for investigating brain structure and function in health and disease. We have investigated the neural substrate of chemosensory dysfunction using EEG and both functional and structural MRI in populations of clinical interest, including persons at risk for Alzheimer's disease (AD) where olfactory impairment may signal incipient dementia. As interventions for AD become available, determining who is at risk and the effectiveness of interventions will be critical for initiating treatment before significant neurological compromise. This presentation will briefly summarize key findings and highlight new data from ERP and fMRI studies. FMRI was conducted at 3T on a GE scanner. Subjects performed sensory or memory tasks as brain activation was imaged. Scans were processed with AFNI software (Cox, 1996). Both whole brain activation and activation in regions of interest (ROIs) were analyzed. FMRI revealed intriguing differences between groups at risk for cognitive decline that suggested differences in activation in key ROIs and neural recruitment or compensation in other regions. Olfactory event-related potentials (OERP) were recorded with Neuroscan. OERPs demonstrated significant delays in brain response and differential topographical distribution of the amplitude of OERPs in persons at risk for decline, particularly in tasks that required both olfactory function and semantic memory. Understanding the relationship between olfactory function and the underlying substrate may facilitate identification of biomarkers and targets for intervention to prevent, delay or arrest disease progression in those at risk for developing Alzheimer's disease and in other clinical populations with chemosensory compromise. Acknowledgements: Supported by NIH grant #DC002064 from the National Institute on Deafness and Other Communication Disorders and #AG004085 from the National Institute on Aging to CM. Genotyping supported by P50AG005131 from the National Institute on Aging to the UCSD ADRC. We gratefully acknowledge MiRan Wang, Barbara Cerf-Ducastel, Rick Buxton and Tom Liu.

#26 SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE

Sensory Alterations in Early Parkinson's Disease

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Olfactory dysfunction is an early 'pre-clinical' sign of Parkinson's disease (PD). Other sensory disturbances, including alterations in taste and vision, have also been reported in early PD. In this presentation, an overview of the influences of PD on the function of olfaction and the other major senses is provided. Early results are presented from an ongoing study of the administration of a large battery of sensory tests to the same cohort of early stage PD patients while on and off of dopamine therapy. In addition to **SPECT imaging** of the dopamine transporter, the subjects of this study were administered the following sensory tests: **olfaction**: odor identification, detection, discrimination/memory, suprathreshold intensity and pleasantness, sniff magnitude, odor event-related potential; **taste**: whole-mouth taste identification; chemical and electrical regional chemosensory tests; **touch:** spatial and point tactile thresholds; **hearing**: pure-tone thresholds; filtered words test; auditory figure-ground test; competing words test; competing sentences test; hearing in noise (HINT) test; gaps in noise (GIN) test, auditory brainstem and cortical electrical responses; **vision:** visual acuity; contrast sensitivity; color vision testing; optical coherence tomography (OCT); pattern visual evoked potentials (PVEP); pattern electroretinography (PERG); **balance:** computerized dynamic posturography, oculomotor testing, and caloric studies. Preliminary findings suggest that olfaction and taste discriminate better between PD patients and controls than other sensory measures and discriminate as well or better than SPECT imaging of the dopamine transporter. Dopaminergic therapy appears to have little influence on any of the test measures. Acknowledgements: USAMRAA W81XWH-09-1-0467

#27 SYMPOSIUM: CHEMICAL SENSES IN HEALTH & DISEASE

Modulation Of Airway Defense Functions From Environmental Chemical Exposure

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The chemosensory systems in the nose and upper airways serve a critical protective role — not only to detect but also to trap, clear and detoxify many inhaled exogenous pollutants. However, the capacity of these defense mechanisms in the airways can be overwhelmed by significant acute or chronic exposures. Exposure-induced inflammation and morphological changes can lead to altered olfactory and nasal trigeminal sensitivity. Moreover, the interaction of such exposures with individual susceptibility factors, such as tobacco use, nasal metabolic capacity and pre-existing inflammatory disease can predispose individuals to additional damage to the airways. This talk will review clinical studies in pollutant-exposed populations, including those exposed on 9/11 and beyond at the World Trade Center, and discuss the implications for the observed changes and potential for recovery in chemosensory function. Acknowledgements: NIH-NIDCD P50 DC 006760

#28 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

Olfactory Behavior Correlates with APP-induced Circuit Disruption and Recovery

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Neural circuits are precisely organized; however, the relation between correct wiring and behavior is poorly understood. Knowledge of this association would be useful to assess functional recovery from disease. We recently established a reversible olfactory-based disease model in which OSNs can be rapidly induced to degenerate by overexpressing amyloid precursor protein (APP), which is critically involved in Alzheimer's disease. Using this model we found that OSNs undergo extensive apoptosis by 3-weeks of age and without the presence of extracellular amyloid deposits. Here we show that APP was also present in OSN axons, which showed strong caspase3 signal and reduced synaptic protein expression. We found that glomerular structure was severely distorted in mutant mice and that OSN axonal convergence was disrupted. Using SpH-imaging we further revealed that odor-induced activity was much diminished in the OB consistent with anatomical findings. We further show using behavioral assays that olfactory detection and discrimination was significantly impaired. Since OSNs are known to continuously regenerate we tested the capacity of the system for restoration following APP-induced disruption. We reveal that within 1 week after shutting-off APP expression, the glomerular circuitry was partially restored both in structure and function and that behavioral deficits were similarly reversed. Together, these data show a clear correlation between functional recovery and circuit organization, suggesting that while precise wiring may be necessary for optimal function, basic function can occur even if wiring is not completely correct. These findings further support a cell autonomous role for APP in inducing OSN degeneration, and present a model to study circuit disruption and repair within a precisely defined network. Acknowledgements: NIH intramural program 1ZIANS003002-09

#29 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

Therapeutic gene rescue of a mammalian ciliopathy induced anosmia

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Cilia on olfactory sensory neurons (OSNs) compartmentalize the signaling pathway components that are necessary for odor transduction. In humans, alterations in cilia formation and function clinically manifest as ciliopathies, a growing class of pleiotropic genetic disorders. Recent publications from several labs have now demonstrated anosmia as a phenotype associated with several ciliopathy disorders. Despite significant progress identifying the genes underlying ciliopathies, curative therapies are not yet available to patients. We demonstrate that mice with a hypomorphic mutation in the gene encoding the intraflagellar transport protein, IFT88 (ORPK, ift88^{Tg737Rpw}), lack olfactory cilia as determined by both immunohistochemical and scanning electron microscopy analysis. The loss of olfactory cilia in ORPK mice results in anosmia, as measured by electro-olfactogram (EOG) recordings and immunohistochemical analysis of expression S100a5 in the OE and tyrosine hydroxylase (TH) in the olfactory bulb. Expression of an ectopic IFT88:GFP fusion protein in OSNs by adenoviral infection shows that IFT88 enriched in the proximal regions of olfactory cilia in wildtype mice. Importantly, viral-mediated re-expression of IFT88 in mature OSNs of ORPK mice is sufficient to restore acetylated a-tubulin positive cilia structures. Using EOGs, staining for S100a5 and TH, we show that odorant induced activity is restored to infected OSNs. These studies represent the first in vivo therapeutic treatment to reestablish cilia in a mammalian ciliopathy, and show that gene therapy is a viable curative option for functional rescue of the complex cilia organelle in established differentiated cells. Acknowledgements: This work was support by NIH grants R01DC009606 (to J.R.M), T32DC00011 and 1F32DC011990 (to J.C.M), R01DC004553 and R01DC008295 (to R.R.R) and R01DK75996 (to B.K.Y)

#30 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

G-protein-coupled Odorant Receptors Underlie Mechanosensitivity in Olfactory Sensory Neurons

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Sensory receptors typically function in just a single stimulus modality. However, in the olfactory system, mechanical processes such as sniffing and respiration are known to affect odor perception, and we previously demonstrated that olfactory sensory neurons (OSNs) detect both chemical and mechanical stimuli. While the G-protein-coupled receptor cascade underlying odor detection is well established, the mechanical sensor and subsequent transduction cascade are elusive. Here we used patch-clamp recordings from the dendritic knobs of mouse OSNs that were genetically labeled for defined odorant receptors to examine olfactory mechanoreception. We found that knocking out key signaling proteins in odor transduction completely eliminated mechanical responses of OSNs to puffs of odor-free Ringer's solution. We also demonstrated that mechanosensitivity of OSNs is associated with certain odorant receptor types: OSNs that expressed SR1, M71, or I7 were mechanosensitive, while neurons labeled for mOR23 or mOR-EG were not. Interestingly, mechanosensitive OSNs expressing SR1, M71, and I7 had higher rates of basal firing in loose-patch recordings than OSNs expressing mOR23 or mOR-EG. Genetic ablation of SR1 reduced mechanosensitivity in OSNs, and disruption of I7 receptor-G protein coupling in I7(RDY) neurons eliminated both mechanosensitivity and basal firing. These results provide strong evidence that some odorant receptors (e.g. SR1 and I7) confer mechanosensitivity to their host OSNs. Our findings reveal an exceptional case in which G-protein coupled receptors serve as both chemical and mechanical sensors to carry odor and airflow information into the brain. Acknowledgements: Supported by R01 DC006213 from NIDCD, NIH.

#31 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

Precise optical control of olfactory sensory neuron input elucidates olfactory bulb circuit function in awake, freely moving mice

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Historically, olfaction has been a difficult sense to study in freely moving animals due to both the inherent imprecision present in odor plumes as well as difficulties in defining the spatial and temporal patterns of sensory neuron input to the olfactory bulb. Using a custom built array incorporating tetrodes and an optical fiber (see Dang, et al., this meeting) and transgenic mice expressing

humanized Channelrhodospin-2 (hChR2) in all olfactory sensory neurons (OSNs), we have developed a novel technique for precisely controlling both the spatial and temporal aspects of OSN input within the olfactory bulbs of freely moving mice. This technique involves optically stimulating OSN axon terminals and making tetrode recordings from mitral and tufted (MT) cells in the ventral aspect of the olfactory bulb. We show that by adjusting the power output of the LED coupled to the optical fiber, patterns of OSN activation with various spatial extents can be created in the olfactory bulb. Further, the patterns of OSN input can be adjusted such that the activity of the recorded MT cells contains information adequate to discriminate between the OSN input patterns. We demonstrate the use of this technique to examine the effect that ongoing bulbar activity has upon the ability of populations of simultaneously recorded MT cells to discriminate between spatial patterns of OSN input. We also report results from experiments in freely moving mice regarding the impact that behavioral state has upon MT responses to precisely controlled olfactory stimuli. Acknowledgements: NIDCD F32DC011980 (DG), R01DC009640 (TB), R21DC010911 (TB), the Whitehall Foundation and the Brain Research Foundation (TB), the Boettcher Foundation's Webb-Waring Biomedical Research Program (GF), NIDCD R01DC00566 (DR), P30DC04657 (DR).

#32 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

Neuronal population state dynamics changes in taste processing following emotional learning

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A bad experience with an unfamiliar dish can cause us to avoid that for a long time thereafter. Gustatory cortex (GC) plays a significant role in driving this effect of experience on behavior, but the manner in which GC ensemble taste processing is altered during this process is not fully understood. Here, we investigated this question, basing our work on recent studies showing that ensembles of GC neurons respond to taste delivery with coherent sequences of states, each uniquely defined in terms of the set of firing rates across the neuronal ensemble, that repeat reliably across trials, but with a variable time course. We recorded multiunit activity from the GC of rats, holding a subset of neurons across a conditioned taste aversion (CTA) and extinction protocol, whereby rats first learned to associate a taste (CS) with malaise (US) and then learned that the CS was again safe. The protocol was optimized to alter the emotional value of an initially palatable taste twice in quick succession, while leaving its sensory characteristics unchanged. Hidden Markov Model (HMM) analysis of the neuronal data then revealed the putative underlying state transition timings. These analyses demonstrated that following CTA GC ensembles jump into state sequences earlier, and progress through those state sequences more quickly (the durations of states became shorter) and sharply (transition times between states got shorter). Following extinction these changes were relaxed back towards pre-CTA values. Altogether our findings suggest that CTA somehow "primes" networks in GC to process tastes more quickly. Acknowledgements: This work is funded by R01 DC-6666 and the Swartz Foundation

#33 PLATFORM PRESENTATIONS — POLAK YOUNG INVESTIGATOR AWARD WINNERS

Volatile Inhibitors and Activators of the Carbon Dioxide-Sensitive Neuron as a New Generation of Mosquito Control Agents

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Carbon dioxide (CO_2) present in our exhaled breath is an important sensory cue for blood-feeding mosquitoes, causing activation of long-distance host-seeking and an increased responsiveness to human skin-odors. CO_2 is used as the primary lure in mosquito traps in the developed world, but generating CO_2 is expensive and impractical for use in developing countries where vector borne diseases cause millions of deaths each year. The identification of affordable and safe chemicals that can either activate or inhibit the CO_2 receptor neuron could enhance the control of disease transmitting mosquitoes. CO_2 is detected by 7-transmembrane receptors (Gr1,3) expressed by neurons in peg-sensilla of the mosquito maxillary palp. Using structural similarity measurements to known agonists and antagonists, we performed a novel chemical informatics screen of >400,000 chemicals to predict novel CO_2 receptor ligands. We selected 139 of these chemicals and tested them for activity using single sensillum recordings from the mosquito, *Aedes aegypti*. We found that over 20% of the predicted compounds increase activity of the CO_2 receptor neuron substantially. The strongest activators (>100 spikes/sec) were tested in both *Aedes* and *Culex quinquefasciatus*, and results indicate a conservation of response across species. We identified several compounds that decreased responsiveness to CO_2 when odor pulses were overlaid on a background of a longer CO_2 stimulus. The top two inhibitors decreased activity by 60 and 83%. Several of these newly identified activators and inhibitors are pleasant-smelling to humans and are already approved for use as flavor and fragrance agents. These odors are being tested in both laboratory and semi-field conditions for their potential use as agents in a new generation of mosquito control. Acknowledgements: RO1 grant from NIAID (NIH)

#35 WORKSHOP: RESEARCH CAREERS IN INDUSTRY

Round-table Q&A session with all the speakers and audience

Workshop attendees are eligible to attend the Social with workshop speakers and ChEMA members

#37 SYMPOSIUM: WIRING NEURAL CIRCUITS IN OLFACTORY SYSTEMS

Developmental Regulation of Neural Circuit Formation in the Mouse Olfactory System

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In the mouse olfactory system, much of axon wiring in neural map formation occurs autonomously by axon-axon interactions of olfactory sensory neurons (OSNs). Axonal projection along the dorsal-ventral (D-V) axis is regulated by positional information of OSNs within the olfactory epithelium (OE). Unlike the projection along the D-V axis, anterior-posterior (A-P) projection is instructed by OR molecules that regulate the expression levels of axon guidance molecules using cAMP as a second messenger. Many G-protein coupled receptors are known to have two conformations, active and inactive, and spontaneously transit between the two, generating the basal activity in the absence of agonists. We assume that the OR-derived basal activity participates in the olfactory map formation. Beta2-adrenergic receptor (beta2-AR) is known to share many functional similarities with OR molecules and substitute ORs for OR-instructed OSN projection. Taking advantage of these previous observations, we have analyzed axonal projection of OSNs instructed by the mutant-type beta2-AR with the altered levels of basal activity. We have found that the basal activity mutants of beta2-AR alter expression levels of axon guidance molecules, e.g., Nrp1 and Sema3A, and change glomerular locations along the A-P axis in the OB. After establishing the topographic map of glomeruli, the map needs to be properly connected with second-order neurons, mitral/tufted (M/T) cells. We have found that Sema3F, a repulsive ligand to Nrp2, which is secreted by early-arriving dorsal OSN axons, guides both late-arriving $Nrp2^+$ OSN axons and their partner $Nrp2^+$ M/T cells to the ventral region of the OB. This coordinated guidance is an important process for proper alignment and synapse formation of OSN axons and M/T cells during olfactory development. Acknowledgements: Specially promoted grant from the Japanese Government

#38 SYMPOSIUM: WIRING NEURAL CIRCUITS IN OLFACTORY SYSTEMS

Olfactory sensory axons target specific identified protoglomeruli in the zebrafish

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The zebrafish is an almost ideal system in which to study the initial targeting of olfactory sensory axons within the olfactory bulb. It is relatively simple, develops very quickly, and is accessible to observation and manipulation at all stages of development. Importantly, the initial targets of sensory axons in the olfactory bulb are distinct, individually identifiable protoglomeruli, making it possible to access the specificity of early targeting. We have mapped the projections of two broad classes of olfactory sensory neurons that target mutually exclusive protoglomeruli. OMP expressing sensory axons project to the Central Zone, Dorsal Zone, MG, and LG3 protoglomeruli. TRPC expressing axons project to the Olfactory Plexus, VP, LG1, LG2, and LG4 protoglomeruli. We have engineered transgenic fish lines in which the expression of a particular odorant receptor is linked to the expression of an axonal tracer. In the first line we produced, a minigene construct drives expression of the odorant receptor OR111-7 and a tracer. Depending on the developmental age, approximately 5-25 fluorescently labeled olfactory sensory neurons are observed in each olfactory pit. At 3 dpf, their axons project predominantly to the Central Zone protoglomerulus while a much smaller number of axons sometimes project to the LG1 protoglomerulus. The high specificity of this projection allows us to determine the contributions of candidate guidance cues on olfactory guidance in mutant embryos or with morpholino knockdown experiments. Using this approach, we have found that netrins 1a and 1b expressed at the ventral and midline margins of the bulb act as attractants that draw the axons of OR111-7 transgene expressing sensory neurons into the ventrally and medially positioned Central Zone protoglomerulus. Acknowledgements: This work was supported by 9RO1-DA025407 from NIDA

#39 SYMPOSIUM: WIRING NEURAL CIRCUITS IN OLFACTORY SYSTEMS

Representations of Olfactory Information in Mammalian Olfactory Cortex

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Sensory information is transmitted to the brain where it is processed to translate stimulus features into appropriate behavioral outputs. In the olfactory system, distributed neural activity in the nose is converted into a segregated glomerular map in the olfactory bulb. Here we describe the development and deployment of a neural tracing technique that enables us to ask how this ordered representation is transformed in higher centers in mouse olfactory cortex. We use this tracing strategy to characterize the neural circuits that convey information from defined glomeruli in the olfactory bulb to the piriform cortex and the cortical amygdala. We find that the spatial order apparent in the olfactory bulb is discarded in piriform cortex; axons from individual glomeruli project diffusely to the piriform cortex without apparent spatial preference. In contrast, within the cortical amygdala we observe broad patches of projections that are spatially stereotyped for individual glomeruli. The identification of a distributive pattern of projections to the piriform cortex and stereotyped projections to the cortical amygdala suggests distinct roles for each of these brain areas in processing olfactory information. Acknowledgements: NIH Director's Office DP2OD007109, NIH NIDCD RO1DC011558, Burroughs Wellcome Fund, Searle Foundation, McKnight Foundation, Sloan Foundation.

#40 SYMPOSIUM: WIRING NEURAL CIRCUITS IN OLFACTORY SYSTEMS

Tracing Innate and Adaptive Olfactory Circuits in the Fly Brain

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Certain odors induce stereotyped instinctive behaviors suggesting that they activate genetically specified neural circuits. However, the vast majority of odors have no inherent valence to an individual but only acquire behavioral significance through associations formed in the context of experience. How is olfactory information differentially processed in the brain to support these instinctive or adaptive behaviors? We are addressing this question in the fruit fly, *Drosophila melanogaster,* an insect that exhibits a rich repertoire of odor-driven behaviors mediated by a relatively simple olfactory system with an analogous architecture to that in mammals. Interestingly, in the fly brain olfactory signals are transmitted in parallel to two discrete higher brain centers, the mushroom body and the lateral horn, that mediate learned and innate olfactory behaviors. We have devised novel neural tracing approaches using photoconvertible fluorophores, precise electroporation of diffusible dyes and single cell electrophysiology to reveal the functional organization of olfactory pathways in the lateral horn and mushroom body. We will describe our recent data identifying differences and commonalities in the wiring of these higher brain centers.

#41 PLATFORM PRESENTATIONS: TASTE

Shh-expressing basal cells are immediate precursors of taste receptor cells

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Taste buds are aggregates of modified epithelial cells that transduce gustatory stimuli into electrochemical signals which are transmitted to the brain. In addition to this neuron-like function, taste cells retain the epithelial characteristic of continuous turnover throughout adult life. The current model of taste bud regeneration holds that taste progenitors reside outside of buds; these cells divide to produce daughters, which exit the cell cycle, enter buds as postmitotic precursors, and differentiate into 1 of 3 types of taste cells. In addition to these 3 fusiform types, taste buds house a set of basal cells, many of which express the morphogen, Sonic hedgehog (Shh). Previously, Miura et al. (2006) showed that Shh+ cells are postmitotic, and proposed that Shh+ basal cells are immediate precursors for taste receptor cells. To test this hypothesis, we used molecular genetic cell labeling to track the fate of Shh+ basal cells in taste buds of adult mice. Specifically, $ShhCre^{ER}$;R26RLacZ mice were treated with tamoxifen, daily or every other day, for 4, 8, or 16 days to drive Cre activation and thus beta-gal expression in Shh+ cells. In taste tissue from these mice examined at 1, 7 or 10 days after the final tamoxifen dose, we found Shh+ cells had differentiated into fusiform taste cells, including both types II and III, as assessed via specific immunomarkers. We also encountered beta-gal+ cells with complex morphology where they appeared to wrap other taste cells, consistent with type I identity. Importantly, we found that Shh+ descendent cells occurred singly in taste buds, rather than in pairs, consistent with the observation that Shh+ cells are postmitotic. Thus, we show that Shh+ basal cells are postmitotic precursors that differentiate directly into each of the 3 functional taste cell types. Acknowledgements: Supported by NIH/NIDCD R01 DC008373 and ARRA DC008373-03S1 to LAB, and the Rocky Mountain Taste & Smell Center, P30 DC003947 to D. Restrepo.

#42 PLATFORM PRESENTATIONS: TASTE

Sweet taste responses are enhanced by adenosine acting through A2B receptors

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Mammalian taste cells are susceptible to modulation by a number of circulating factors. Some of these factors affect the transduction of a single taste quality. Examples include leptin which selectively affects sweet taste (Kawai et al, 2000), or insulin, which affects salt taste (Baquero & Gilbertson, 2011). Here, we show that adenosine is another such modulator, specific for sweet taste. ATP is released from taste cells upon detection of sweet, bitter or umami compounds. Because the enzymatic machinery to degrade ATP to AMP is present in abundance in taste buds, we reasoned that AMP might be further degraded to adenosine. Indeed, we found that both the ecto-nucleotidase NT5E, and to a lesser extent prostatic acid phosphatase (ACPP), are present in taste buds, primarily on Type III (Presynaptic) cells. This suggests that adenosine is present in significant quantities in taste buds. Adenosine is a powerful neuromodulator in the nervous system, acting on both excitatory and inhibitory receptors. Using RT-PCR on single taste cells, we demonstrated that the excitatory A2B receptor is predominantly expressed in cells expressing T1R sweet receptors. In taste cells, Ca^{2+} mobilization evoked by artificial sweeteners was significantly enhanced by adenosine (50 μM). Furthermore, by using biosensor cells, we found that sweet-evoked ATP release from Type II (Receptor) cells was greatly amplified by adenosine (5 μM). Blocking A2B receptors with MRS 1706 (250 nM) significantly reduced sweet-evoked ATP release, indicating that adenosine modulation is intrinsic to taste buds. Bitter or umami tastes were unaffected. The findings demonstrate that adenosine, formed during taste stimulation by the degradation of ATP, exerts positive feedback selectively on sweet responses. Acknowledgements: This research was supported by NIH Grants 2R01DC007630 and 5R01DC000374 to S.D.R. and R01DC006021 and R01DC006308 to N.C.

#43 **PLATFORM PRESENTATIONS: TASTE**

Genetic deletion of ectoATPase reduces specific taste responses

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In taste buds, ATP is crucial in the transmission of the taste signal from sensory cells to nerve fibers. ATP is released from Type II taste cells via hemichannels in response to taste stimulation and activates ionotropic P2X receptors on afferent nerve endings as well as metabotropic P2Y receptors on Type II and Type III taste cells. The released ATP is then degraded to ADP by the specific ectoATPase, NTPDase2, present in the membrane of Type I cells. To determine if ectonucleotidases play a role in taste function, we examined responses to taste stimuli in NTPDase2 knockout mice. Although taste buds are present in the knockout mice and appear morphologically normal, they completely lack ectoATPase activity, as assessed by histochemical staining with both ATP and ADP as substrates. Thus, these mutant mice should have decreased breakdown of the released ATP, resulting in a longer lifetime of ATP in the extracellular space surrounding taste buds. To determine if the persistence of ATP affects taste function, we recorded from the chorda tympani nerve in response to a battery of taste stimuli. Interestingly, responses to sweet and umami stimuli were profoundly depressed in knockout mice compared to wild type mice, although responses to non-specific electrolytes and sour stimuli were similar in knockout and wild type mice. Preliminary behavioral tests confirmed the lack of response to sweet stimuli, suggesting that the prolonged presence of ATP in extracellular space may desensitize P2X receptors on the chorda tympani nerve fibers, particularly those that respond to sweet and umami stimuli. Alternatively, the lack of generated ADP may modulate the sensitivity of Type II cells to taste stimuli. Acknowledgements: Supported by NIH grants R01DC007495 and P30DC004657.

#44 **PLATFORM PRESENTATIONS: TASTE**

Bitter taste stimuli induce differential neural codes in the mouse brain

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A growing literature suggests tastants commonly assigned to the "bitter" category induce heterogeneous neural and perceptual responses. Here we electrophysiologically recorded taste activity (spikes) to bitter stimuli from nucleus tractus solitarii neurons in isogenic inbred C3HeB/FeJ mice and a congenic mouse line bred to be homozygous at a genetic locus influencing bitter taste. Using these mice allowed removal of genetic heterogeneity as a factor influencing bitter responses. Stimuli (26 total) included concentration series of quinine (QUI), denatonium (DEN), cycloheximide (CYX), sucrose octaacetate (SOA), and other taste stimuli, all delivered "whole mouth" for 5 s then rinsed. 79 neurons were tested with all stimuli; in many cases multiple cells (2 to 5) were recorded from single mice. Results showed "bitter" stimuli induced variable responses. For example, although some neurons possessed robust responses to QUI, DEN, and CYX, other cells displayed concentration dependent activity (P <0.05) to QUI and DEN, but not CYX. Differential "bitter" activity was found across bitter-sensitive cells recorded from the same mouse, indicating that variability in bitter responses exist in individual animals. Multivariate analyses of responses showed that QUI and DEN induced correlated spatial patterns that differed from those to CYX and SOA. A higher resolution multivariate approach applied to sequential 500 ms bins of activity across concentrations/trials revealed response patterns to QUI/DEN and CYX/SOA diverged during only the initial ~1.5 s of the taste response. Activity to all "bitters" converged to a common pattern in follower epochs. Our findings extend data suggesting differences among "bitter" taste codes, data which challenge a strict monoguesia model for the bitter quality. Acknowledgements: NIH DC011579 (C.H.L.)

#45 **PLATFORM PRESENTATIONS: TASTE**

Deletion or Inhibition of Trpm5 Decreases the Gain in Body Weight and Fat Mass in Mice

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Receptors and downstream signal transduction molecules involved in taste signalling on the tongue are also expressed in the gastrointestinal tract. Trpm5, a calcium activated ion channel necessary for sweet, bitter and *umami* taste transduction, is also strongly expressed in solitary cells distributed throughout the gastrointestinal tract. Here, we show that Trpm5 knockout mice are leaner than their wild type littermates. A similar effect is obtained by feeding mice quinine, an inhibitor of Trpm5. Compared with mice consuming AIN, a regular balanced diet, mice consuming AIN diet supplemented with 0.1% quinine gain less fat mass (1.61g *vs* 3.35g) after 12 weeks of diet, with identical increase in lean mass, and have lower blood glucose and plasma triglycerides. No difference is observed in food intake, activity or energy expenditure between treatment and control. Quinine fed mice do not regain weight up to one month after removal of quinine from the diet. The consumption of quinine led to only a small decrease in fat mass gain in Trpm5 knockout mice compared to Trpm5 knockout mice consuming regular diet (1.38g *vs* 2.14g), indicating that the effect of quinine is largely Trpm5-dependent. Quinine treated wild type mice have higher faecal energy and lipid contents than mice fed a regular diet, showing that deregulated intestinal nutrient uptake contributes to the quinine-induced decrease in weight gain.

#46 PLATFORM PRESENTATIONS: TASTE

The effect of the CALHM1 gene on behavior and taste nerve responses

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Type II taste receptor cell (TRC) bears either sweet receptors, T1R2/3, or umami T1R1/3 or bitter T2Rs receptors. These receptors constitute the first links in an intracellular cascade, which leads to impulses in taste fibers. Important here is the finding that sweet and bitter receptors never co-localize in the same TRC. Studies have also shown that in the Type II TRCs a calcium activated sodium channel, TRPM5 is important (Damak *et al.* 2006). In the following we studied the gustatory effects of another calcium activated channel CALHM1. In taste its existence was first described by (Hevezi *et al.* 2009) who found a high concentration in the Type II TRCs. Here we present results of two-bottle preference tests and electrophysiological recordings from the chorda tympani proper nerve in mice with (WT) and without expression of the CALHM1 gene (CALHM1 null mice). We used ammonium chloride as standard, and as test solutions NaCl, IMP, MSG, monocalcium di-L-glutamate, QHCl, sparteine, denatonium benzoate, ascorbic and citric acid and six sweeteners. Our data show that: the CALHM1 null mice don't discriminate between water and sweet and have an impaired ability to taste bitter, CALHM1 null mice discriminate between salty and water or acid and water at the same concentrations as the WT. These deficits can be explained with an absence of a taste response in the chorda tympani nerve to sweet and a lowered response to bitter. The chorda tympani nerve response is not different to salty and sour compounds in WT and CALHM1 null mice. References: Damak S, et al. 2006. Trpm5 null mice respond to bitter, sweet, and umami compounds. Chem Senses 31: 253-264. Hevezi P, et al.. 2009. Genome-wide analysis of gene expression in primate taste buds reveals links to diverse processes. PLoS One 4: e6395. Acknowledgements: Medical School-Duluth, MN, USA

#47 PLATFORM PRESENTATIONS: TASTE

Regulation of Artificial Sweetener Acceptance by Glucose Metabolic Rate

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The formation of preferences for sweet tastants is influenced by both gustatory and postingestive signals. Accordingly striatal dopamine targets, which regulate food intake, are responsive to both classes of cues. We had previously shown that disrupting glucose utilization with 2-deoxyglucose (2-DG) injections inhibits dopamine release in dorsal striatum. We therefore hypothesized that 2-DG injections would depress acceptance for non-caloric sweeteners but would be ineffective in suppressing glucose acceptance. We have found that one single 2-DG injection produced a significant and long-lasting suppression in intake levels of the artificial sweetener sucralose, but not of glucose. We concluded that 2-DG does not affect glucose preference because glucose, unlike artificial sweeteners, can counteract the negative physiological effects of 2-DG. The effect did not depend on sweet signaling since short-term preference tests show that sucralose remained equally preferred over glucose even after 2-DG injections; in addition, ingesting sucralose concomitantly to intragastric glucose was unaltered by 2-DG injections. Furthermore, striatal dopamine levels were strongly suppressed by 2-DG injections during sucralose, but not glucose, sessions. Our findings therefore demonstrate that pairing sweeteners with negative physiological states produce a long-lasting suppression in the intake of sweeteners lacking energy content. More generally, our findings indicate that artificial sweetener intake is strongly influenced by glucose metabolism. Acknowledgements: NIDCD Grant RO1 DC009997

#49 SYMPOSIUM: THE ROLE OF RESPIRATION IN OLFACTORY & FLAVOR PROCESSING

Dissecting the effects of sniff variations on olfactory bulb (OB) activity

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In terrestrial mammals, odorant molecules sampling is inextricably related to the respiratory dynamics. Therefore, odorant molecules reach the olfactory epithelium with a variable concentration depending on i) the respiratory phase, ii) the frequency and flow rate of the successive respiratory cycles. We have been interested in the way OB activity is modified by such variations, rather than in the informational content of the respiration-related activity. The question is how variations in OB input, related to respiratory dynamics, are reflected in the OB activity? We addressed this question using a simulated nasal airflow protocol in anesthetized rat combined with either voltage sensitive dye imaging (VSDi) of OB glomerular maps or electrophysiological recordings of OB LFP and mitral/tufted cells activity. This model allowed us to impose sniff frequency and flow rate independently or concomitantly. Both VSDi and electrophysiological signals revealed that sniff frequency and flow rate could act synergistically to maintain OB sniffing-related rhythmicity even during high-frequency sniffing (10 Hz). However, both signals show that flow rate and frequency can also

act independently to modify specific parameters of the OB response. For example, only the phasic component of the VSDi response was impaired by high frequency sniffing. Similarly, odor-evoked response latency could be shortened only by increasing flow rate. These results show that sniffing variations confer an important degree of adaptability to the olfactory system. This probably helps, as suggested by others, in improving olfactory capabilities by allowing the optimization of the deposition of odor molecules through the olfactory epithelium. We address this question in one of our current projects.

#50 SYMPOSIUM: THE ROLE OF RESPIRATION IN OLFACTORY & FLAVOR PROCESSING

Active sampling and gain control in olfaction: how sniffing does and does not shape odor representations in the early olfactory pathway

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Active odor sampling is associated with a repertoire of sniffing strategies involving changes in multiple parameters of respiration, including the amplitude and duration of an individual sniff and the frequency of sniffs in a bout. Our laboratory has investigated how such variations in sampling shape the responses of olfactory receptor neurons (ORNs) and olfactory bulb (OB) neurons. We earlier reported that sniff frequency affects the magnitude, or gain, of ORN input to the OB and, more modestly, the gain of mitral/tufted cell output from the OB. Here we focus on the effect of sniff amplitude - as defined by peak intranasal airflow generated by inhalation - on ORN inputs. In particular we tested the longstanding hypothesis that sniff amplitude can shape ORN inputs in a manner determined by an odorant's sorption onto the olfactory epithelium. This hypothesis predicts that ORN responses will be differentially correlated depending on the sorption properties of the sampled odorant. If true, animals may differentially modulate sniff magnitude in order to optimally sample different odorants. We tested this hypothesis — for the first time in awake rodents — by imaging from ORNs and monitoring intranasal airflow. We found that ORN responses were poorly correlated with sniff flowrate and that this correlation was weak for both high and low-sorption odorants (mean r^2=0.04). We also tested whether rats modulated sniff flowrate depending on odorant sorption properties during an odor discrimination task, and found little evidence for such modulation. These results suggest that sniff strength has surprisingly little effect on ORN response amplitudes; instead, sniff frequency may be the most effective bottom-up mechanism for gain control of olfactory inputs during active sensing.
Acknowledgements: NIDCD

#51 SYMPOSIUM: THE ROLE OF RESPIRATION IN OLFACTORY & FLAVOR PROCESSING

Respiration drives network activity and modulates synaptic and circuit processing of lateral inhibition in the olfactory bulb

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Respiration produces rhythmic activity in the entire olfactory system, driving neurons in the olfactory epithelium, bulb (OB) and cortex. The rhythmic nature of this activity is believed to be a critical component of sensory processing. OB projection neurons, mitral and tufted cells, exhibit both spiking and subthreshold membrane potential oscillations rhythmically coupled to respiration. The network and synaptic mechanisms that produce respiration-coupled activity, and the effects of respiration on lateral inhibition, a major component of sensory processing in OB circuits, are not known. Is respiration-coupled activity in mitral and tufted cells produced by sensory synaptic inputs from nasal airflow alone, cortico-bulbar feedback, or intrinsic membrane properties of the projection neurons? Does respiration facilitate or modulate the activity of inhibitory lateral circuits in the OB? Here, in vivo intracellular recordings from identified mitral and tufted cells in anesthetized rats demonstrate that nasal airflow provides excitatory synaptic inputs to both cell types and drives respiration-coupled spiking. Lateral inhibition — inhibitory post-synaptic potentials evoked by intrabulbar microstimulation — was modulated by respiration. In individual mitral and tufted cells inhibition was larger at specific respiratory phases, but was not uniformly larger during a particular respiratory phase in either cell type. Removing nasal airflow abolished respiration-coupled spiking in both cell types and nearly eliminated spiking in mitral, but not tufted, cells. In the absence of nasal airflow, lateral inhibition was weaker in mitral cells and less modulated in tufted cells. Thus, respiration drives distinct network activities that functionally modulate sensory processing in the OB. Acknowledgements: NIH/NIDCD: DC000086, F31DC009921, and 5T32NS007224

#52 SYMPOSIUM: THE ROLE OF RESPIRATION IN OLFACTORY & FLAVOR PROCESSING

Sniff-locking of mitral and tufted cells: Two distinct temporal channels of olfactory bulb output

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Rhythmic neural activity is a hallmark of brain function, used ubiquitously to structure neural information. In mammalian olfaction, repetitive sniffing sets the principle rhythm but little is known about its role in sensory coding. Here, we show that mitral and tufted cells, the two main classes of olfactory bulb projection neurons, tightly lock to this rhythm, but to opposing phases of the sniff cycle. This phase shift is established by local inhibition that selectively delays mitral cell activity. Furthermore, while tufted cell phase is unperturbed in response to purely excitatory odorants, mitral cell phase is advanced in a graded, stimulus-dependent manner. Thus, phase separation by inhibition forms the basis for two distinct channels of olfactory processing. Acknowledgements: Max-Planck Society, DFG, Humboldt foundation

#53 SYMPOSIUM: THE ROLE OF RESPIRATION IN OLFACTORY & FLAVOR PROCESSING

Phase coding in Olfaction

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In mammals, the temporal dynamics of olfactory stimuli are largely determined by breathing, which gates access of odorants to olfactory receptor neurons. To establish the relationship between the sniffing/breathing rhythm and neuronal coding of odor information in the olfactory bulb we recorded activity of mitral/tufted cells in awake headfixed mice. We found that the firing rate odor responses of mitral/tufted cells are locked to the phase of the sniffing cycle with high temporal precision about 10 ms. Thus temporal sequence of neuronal events scales with the duration of the sniffing cycle. We proposed the model of how the cortex may solve the odor identification problem independently of the pace of inhalation based on the synchrony between cell assemblies. To proof that an animal can perceive the sniff phase we performed behavioral optogenetic experiments stimulating olfactory receptor neurons, which express ChannelRhodopsin with short light pulses at different phases of sniffing cycle. Mice can report the shiff phase of optogentically driven activation of olfactory sensory neurons. Furthermore, mice can discriminate between light-evoked inputs that are shifted in the sniff cycle as little as 10 ms, which is similar to the precision of the olfactory bulb odor responses. Our work suggests that timing of activity relative to the sampling behavior is a potent cue that may enable accurate olfactory percepts to form quickly. Acknowledgements: HHMI funding

#54.5 CLINICAL LUNCHEON

Bitter taste, a major determinant for food preferences

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The sense of taste enables mammals to decide within seconds if a mouthful can be swallowed because it is safe and of nutritional value or is to be rejected because it contains potentially harmful substances. Errors could have serious health problems ranging from malnutrition to acute or chronic intoxication. Each basic taste fulfills a specific role in the food evaluation process. Bitter taste detects potentially harmful substances and is associated with neuronal networks that elicit rejection, thereby preventing food poisoning. It involves the recognition of countless molecules with different chemical structures. Depending on dose, these molecules can be toxic or healthy. Accordingly, consumers strongly prefer some bitter tasting foods and beverages whereas they avoid others indicating that bitter chemicals exert strong effects on food choice, and eventually diet and health.

My group aims at a fundamental understanding of the importance of bitter taste for food preference and rejection. To this end my presentation summarizes our recent results of research into bitter taste. Starting from a description of bitter chemicals, I will examine the interaction of bitter compounds with their receptors, describe the expression profile of bitter taste receptors in oral sensor cells, and analyze how these sensor cells are coupled to the 1st order central gustatory neurons in the brain stem. Finally, I will present data on how oral bitter stimulation initiates behavioral responses The results of above experiments will be described and their implication for bitter taste driven appreciation or rejection of food discussed.

#55 SYMPOSIUM: MODULATION OF EARLY OLFACTORY PROCESSING BY INTERNAL PHYSIOLOGICAL STATES

Neuromodulatory Effects in the Olfactory epithelium Vary with Odorant and Physiological State

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The terminal nerve extends between the nasal cavity and basal forebrain, and its fibers contain a number of potentially neuromodulatory compounds. Working with aquatic salamanders, axolotls (Ambystoma mexicanum), we have been examining modulatory effects on the olfactory epithelium of two terminal nerve peptides, gonadotropin releasing hormone (GnRH) and neuropeptide Y (NPY). Although GnRH is often associated with reproduction and NPY with feeding, our studies indicate that both peptides modulate activity in the olfactory epithelium in complex ways: their effects depend on the animal's sex, nutritional state, and reproductive state, as well as the behavioral significance of the odorant. For example, electro-olfactogram (EOG) responses evoked by whole-body odorants from females are suppressed in the presence of GnRH in males with a larger gonadosomatic index (GSI) but are unchanged in males with a smaller GSI. Among females exposed to GnRH, EOG responses evoked by females odorants increase in low-GSI, food-deprived animals, remain constant in low-GSI, well-fed animals, and decrease in high-GSI animals. In contrast, we find that isoamyl acetate, a behaviorally meaningless odorant for axolotls, evokes fairly constant responses

in axolotls exposed to GnRH, NPY, or a control treatment (Ringer's solution). We also find that multiple genes for both GnRH and NPY receptors are expressed in the olfactory epithelium, again suggesting these compounds may have complex effects on odorant processing. The vertebrate brain actively regulates processing in the retina and cochlea. Our studies suggest that the brain also regulates activity in the olfactory epithelium to emphasize stimuli that are most relevant to the animal's current behavioral and physiological state. Acknowledgements: Supported by the National Science Foundation (IOS 0817785), fellowships from the Marine Biological Laboratory, and Michigan State University

#56 **SYMPOSIUM: MODULATION OF EARLY OLFACTORY PROCESSING BY INTERNAL PHYSIOLOGICAL STATES**

Metabolic Sensor in *Drosophila* Olfactory Receptor Neurons

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The modulation of behavior by internal physiological states is essential for animal survival. Like many other animals, hungry fruit flies exhibit different food searching behaviors. We have identified key olfactory sensory neurons for innate odor preference and discovered that nutrient sensors in these neurons play an important role in appetitive decisions. Our studies indicate that two neuropeptides short neuropeptide F (sNPF) and tachykinin causes presynaptic facilitation and inhibition, respectively, in specific neurons, and the concerted effect controls appetitive behavior in the fruit fly. Using two-photon calcium imaging, we demonstrate that starvation-triggered behavioral change is accompanied by dramatic shifts in the odor map. The neuropeptide sNPF, a homolog of the mammalian NPY, is highly implicated in hunger signaling and is expressed in *Drosophila* olfactory sensory neurons (OSNs). sNPF signaling in DM1 glomerulus is necessary for the starvation-dependent modulation of both olfactory representation and food search behavior. Furthermore, the sNPF receptor is expressed in OSNs and mediates a feedback enhancement of sensory transmission in DM1. We then investigated starvation modulation in DM5—a glomerulus that mediates innate aversion behavior. Starvation suppresses DM5's sensitivity to odor stimulation, and that this suppression is mediated by tachykinin signaling. Furthermore, starvation modulation of DM5 also influences food search behavior. Thus, early olfactory processing and appetitive behavior are profoundly controlled by metabolic states in *Drosophila*. Starvation does not simply scale up or down global activity in the antennal lobe. Rather, it upregulates activity in certain sensory channels and downregulate it in others towards a concerted modulation of appetitive behaviors. Acknowledgements: NIDCD (R01DC009597,1F31DC009511), NIDDK (R01DK092640).

#57 **SYMPOSIUM: MODULATION OF EARLY OLFACTORY PROCESSING BY INTERNAL PHYSIOLOGICAL STATES**

Neuromodulation of granule cell function in the olfactory bulb

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The neural network in the olfactory bulb (OB) provides the first and only synaptic relay in the olfactory pathway to cortex. Therefore, it plays an important role in olfactory processing. The activity of neurons in the OB is highly influenced by modulatory afferent systems that are triggered by behavioral context. Among these neuromodulatory systems, the noradrenergic and cholinergic systems play an especially important role in promoting synaptic changes underlying aspects of olfactory function such as odor discrimination and learning that are crucial for the execution of social behaviors. Yet, despite this important role of noradrenaline and acetylcholine in olfactory information processing our understanding of the cellular and physiological mechanisms underlying their actions remains poorly understood. Recent work from our lab has determined general functional principles governing neuromodulation by noradrenaline and acetylcholine of two important components of the OB circuit, the most prominent inhibitory neuron in the OB, the granule cell (GCs), and the output neurons (mitral/tufted cells). Our work indicates that noradrenaline and acetylcholine produce a marked excitation of GCs and that this excitation is exacerbated by the activation of a non-selective cationic current. Thus, activation of these neuromodulatory systems increases the inhibitory input onto mitral/tufted cells. In contrast, only acetylcholine produces a marked excitation of output neurons, via two mechanisms, activation of nicotinic and muscarinic receptors respectively. Nevertheless, under subthreshold stimulation of these receptors, inhibition mediated by GCs is predominant. Thus, we conclude that a major effect of these systems is to increase the inhibition of output neurons as a result of the increased excitation of GCs. Acknowledgements: NIDCD R01DC009817

#58 **SYMPOSIUM: MODULATION OF EARLY OLFACTORY PROCESSING BY INTERNAL PHYSIOLOGICAL STATES**

Inhibitory Control of Sensory Input in the Mammalian Olfactory Bulb

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Sensory information is transformed at various stages to allow the parsing and assembly of sensory features. In the mammalian olfactory system, odor information is first detected by the olfactory sensory neurons (OSNs) and is relayed to the olfactory bulb through the OSN axons converging in the olfactory glomeruli. The glomeruli are considered as the functional units of odor information processing. In order to study the transformation of sensory input at the glomerular level, we have developed transgenic mice that express the genetically encoded Ca^{2+} sensor G-CaMP2 in the olfactory sensory neurons. We have imaged the glomerular response to large panels of odors in live animals in the dorsal olfactory bulb. We find strong presynaptic inhibition of the glomerular responses. The inhibition normalizes odor-evoked responses and its patterns are odor-dependent. Moreover, the

signals appear to be modulated differently by brain states. These observations suggest a mechanism that modifies odor representation at the glomerular input. Acknowledgements: NIDCD008003 Stowers Institute

#59 SYMPOSIUM: MODULATION OF EARLY OLFACTORY PROCESSING BY INTERNAL PHYSIOLOGICAL STATES

Feedback Control of Circuits and Codes in the Olfactory Bulb

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The formation of sensory percepts in our brain is often described as a feed-forward process that involves serial transformation of sensory stimuli into neural activity. Yet our everyday experience clearly shows that higher brain areas can actively modulate how sensory information is processed even in the earliest stages. In the mammalian olfactory system, the first stages of synaptic processing are in the olfactory bulb, which receives massive feedback projections from the cortex as well as midbrain neuromodulatory regions. In this talk, I will present our studies on the circuitry of these feedback projections as well as their influence on odor coding. First, I will present data on how on serotonergic innervation from the raphe nucleus influences odor-evoked responses in vivo, both at the level of input to and the output of the olfactory bulb. Then, I aim to discuss recent work on identifying the functional targets of feedback inputs from the anterior olfactory nucleus to the olfactory bulb, done in slices using optogenetic methods. Finally, I will describe the consequences of this centrifugal feedback on odor evoked responses in the olfactory bulb.

#60 IFF LECTURE

Neural & molecular mechanisms of taste reception, transmission & modulation: A sweet (taste) story that began with simple Mendel's law

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Gustatory system plays the important role in maintaining homeostasis in animals. If animals lack nutrients essential for their survival, such as carbohydrates, minerals and essential amino acids, they may be able to find these insufficient nutrients using taste cues. However, for a long time it has been unknown how these taste cues are detected and transmitted to the brain and how they are modulated by homeostasis. When I started taste research in 1970's, there was the lack of understanding of the taste coding system from signal detection in taste cells to transmission to taste nerves. My collaborators and I studied the taste coding using combined techniques in physiology, molecular biology and genetics. In my lecture, results of these studies will be illustrated by our research on reception, transmission and modulation of sweet taste.

These studies began with identification of a Mendelian genetic locus (dpa) responsible for sweet taste, which was mapped to the mouse chromosome 4, and which subsequently led to the finding of the Sac locus encoding the T1R3 sweet/umami receptor component. Using our recently developed techniques for recording of taste-evoked activity and analyses of gene expression in the same taste cells, we have shown that T1R3 and its heterodimeric partner, T1R2, determine taste selectivity of sweet responsive cells. Using this approach, we also demonstrated the role of action potentials and a hemichannel, pannexin 1, in ATP release by taste cells.

Our earlier genetic studies have shown that the db locus is involved in inhibitory modulation of sweet taste by leptin. These studies led to our recent discovery of other sweet taste modulators, endocannabinoids (EDs), which enhance sweet taste responses, i.e., have an effect opposite to the action of leptin. Leptin and EDs are known as anorexigenic (reducing food intake) and orexigenic (stimulating food intake) mediators, respectively, that act via their receptors in the hypothalamus and limbic forebrain. Reciprocal regulation of peripheral sweet taste sensitivity by leptin and EDs may contribute to their opposing actions on food intake and thereby sweet taste cue plays an important role in regulating energy homeostasis.

#P1 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Relationships between taste phenotypes and alcoholic beverage liking vary by beverage type – evidence of gene by microenvironment interaction?

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A substantial body of literature has attempted to link taste phenotypes with alcohol outcomes (liking, intake, abuse) with mixed results. Previously, differences in population or psychophysical methods have been implicated as reasons for these discrepancies. Here, we suggest that there may be gene by microenvironment interactions arising from the different sensory properties of varied alcohol beverages. As part of a larger ongoing laboratory study on the genetics of oral sensation (Project GIANT-CS), we explored hedonic relationships among multiple alcoholic everages and their relationship with taste phenotypes. In a laboratory setting, participants completed a 63 item hedonic survey with 20 alcoholic beverages and 27 foods. Ratings were collected on a generalized liking scale; the survey included 16 non-food items to encourage participants to make ratings within the context of all experiences. Propylthiouracil bitterness and capsaicin burn were assessed via standard methods. DNA was also collected. When liking was compared across beverages, both positive and negative correlations were observed. For example, liking for different beers (r's > .7) and sweet alcoholic beverages (r's >.4) were correlated. Moreover, strong negative relationships were seen between liking of sweet and dry drinks, and sweet and bitter drinks. Taste phenotypes (propylthiouracil bitterness and capsaicin burn) were associated with liking for some drinks but not others. Collectively, it seems not all alcoholic beverages are created equal in regard to the putative protective effects of propylthiouracil on liking (and presumably intake). This suggests alcohol researchers should account for alcoholic beverage sensations and preferences and not merely standard units of ethanol when studying taste genetics and alcohol outcomes. Acknowledgements: Supported by funds from the Pennsylvania State University and NIH grant DC010904.

#P2 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Revisiting personality factors, capsaicin intensity, preference for spicy foods, and intake

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Previously, Rozin and Stevens proposed that personality plays a role in determining sensitivity to, liking for, and intake of capsaicin containing foods. As part of a larger ongoing study on the genetics of oral irritants (Project GIANT-CS), we revisited relationships between personality measures, capsaicin burn, spicy food liking, and annual chili intake. In our laboratory, participants completed a 63-item survey of foods and beverage liking; including 16 non-food items to encourage participants to rate items in a broader hedonic context. Capsaicin (25uM) was rated on the generalized Labeled Magnitude Scale. Participants also completed personality measures online, including the Sensitivity to Punishment-Sensitivity to Reward Questionnaire (SPSRQ), the Arnett Inventory of Sensation Seeking (AISS), Miller's Private Body Consciousness (PBC), and the novelty seeking subscale of the short Tridimensional Personality Questionnaire (ShortTPQ-NS). When capsaicin burn, spicy food liking and intake were compared to the personality measures, positive and negative correlations were observed. Sensitivity to Punishment (SP) associated with greater burn (r>.3). Conversely, SP associated with lower liking for spicy foods (r's >-.3). High sensation seeking associated with lower burn (r=-.34), and higher spicy food liking, explaining between 10-21% of the variance in liking of spicy foods. Likewise, sensation seeking associated with greater reported intake (r=.27). When exploring personality and non-food items on the hedonic survey, liking of 'driving fast on a twisty road' associated negatively with punishment sensitivity (r=-.3) and positively with sensation seeking (r=.6). In contrast to prior reports, liking for roller coasters and PBC were not associated with any of the capsaicin/spicy measures in our sample Acknowledgements: Supported by funds from the Pennsylvania State University and NIH grant DC010904.

#P3 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

A Chemosensory Component in the 2012 National Health and Nutrition Examination Survey (NHANES): Adults Ages 40+ Years

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A chemosensory component has been added to NHANES, a nationally-representative survey of the health and nutritional status of the U.S. population from questionnaire, clinical and physiological measures. The home interview collects self-reported chemosensory-related problems, diagnoses, treatments and co-morbidities. The standardized exam protocol underwent pilot testing. It includes brief assessments of taste intensity and odor identification conducted in a mobile exam center. After prescreening and orientation to the general Labeled Magnitude Scale, participants rate the intensity of 5 LED-generated lights (low, moderate, high luminescence). The light ratings allow scale use practice, assessment of scale understanding, and cross-modality comparisons. From 10cc pre-packaged aliquots (Hayes Laboratory), participants rate intensity of NaCl (0.32, 1 M) and quinine hydrochloride (1 mM) solutions; whole mouth for all tastants, 1 M NaCl and quinine on the tongue tip. Intensity ratings identify taste dysfunction and normal variation in taste (e.g., low, medium, supertaster). After pilot testing, propylthiouracil was removed as a tastant due to the lengthy consenting process. Next, participants identify food odors and other common odors (leather, soap, smoke, natural gas) in an 8-item scratch-and-sniff test (Sensonics, Inc) to generate an olfactory dysfunction score. The exam ends with replicate NaCl taste testing to evaluate within-session reliability of the ratings and then technician

assessment of how well the participant understood the protocol. The chemosensory component will be used to: (a) generate population-based estimates of chemosensory variation and dysfunction; (b) test associations between taste or smell scores and indices of diet and health; and (c) monitor Healthy People 2020 objectives. Acknowledgements: Funding support from NIDCD/NIH Interagency Agreement Y1–DC–0013 with NCHS/CDC.

#P4 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

The Effects of Infant Satiety and Mothers' Feeding Style on Infants' Food Acceptance

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Due to the rising concern about childhood obesity and the prevalent belief that children are not able to regulate their own food consumption, many parents feel the need to control their infants' food intake. The goal of the present study was to determine whether 4-8 month-old infants would regulate their intake of a highly palatable fruit and a less palatable green vegetable of equal calories, and whether their mothers' feeding styles mediated the infants' food regulation. To this end, 34 mother-infant dyads were tested under naturalistic conditions in which the infants determined the pace and duration of the feeding on two separate test days. Acceptance and liking of the foods were assessed using a variety of measures, including amount and rate of consumption and the frequency of facial distaste expressions using the anatomically-based Facial Action Coding system. On Days 1 and 2 of the study, mothers fed the target food while the infants were either moderately hungry, or after a pre-feeding of infant cereal. Results indicated that infants did not compensate for the caloric pre-load regardless of which target food they were fed. Although mothers' ratings of their infants' enjoyment of the target food was lower when it was preceded by cereal, infants' acceptance of the target food was the same on both days, and did not differ between the children who received a fruit or vegetable. Individual differences in consumption were predicted by mothers' feeding style. Infants whose mothers indicated that it was more important that they finish their food were more compliant while feeding; i.e., they were less likely to cry, ate for longer, and accepted the spoon offers faster while eating the target food. Acknowledgements: This work was funded, in part, by an HHMI undergraduate summer fellowship and a William & Mary Faculty Summer Research Grant.

#P5 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

The Satiety Value of Sugar Free Orbit Bubblemint Chewing Gum

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Purpose: The aim of this study is to determine the satiety value of Sugar Free Orbit Bubblemint Chewing Gum in American children. **Procedure:** Twelve boys and ten girls self-assessed their degree satiety on a visual analogue scale, before and after chewing Sugar Free Orbit Bubblemint Chewing Gum for one minute, fifteen minutes, and thirty minutes on a separate occasion. This was repeated, with Butternut Texas Toast white bread (110 calories) or vice versa (the order of presentation being counterbalanced). The satiety index was computed for each, and the statistical significance was determined compared to the satiety index of white bread. **Conclusion:** No statistical significant difference ($p > 0.05$) was found between the gum and white bread. All gums tested induced the same satiety index as white bread, however, with less than $1/20^{th}$ the calories. The results suggest chewing Sugar Free Orbit Bubblemint Chewing Gum may have a role to promote satiety in children as part of a weight loss program. Further investigation is warranted.

#P6 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

The Satiety Value of Flavored Ice in Women

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Objectives: Chemosensory input and sensory specific satiety are two key elements contributing to satiety. By manipulating these, hunger level can be influenced. Currently, where obesity has become a pandemic, temperature manipulation of food may be one of the solutions to the challenge. Iced food, through thermogenic calorie expenditure and possible impact on satiety, may play a role in aiding weight loss. Temperature is one of the stimuli to which the orbitofrontal cortex responds. Through additional influence of sensory specific satiety, greater impact on hunger may be anticipated. Method: 70 ml of sugar free tropical fruit flavored popsicles (SENSA Quench) and equal volume flavor-free ice were studied and compared to a slice of white bread (110 kcal) as the baseline. Eighteen female subjects, average age of 32.8 years old (range 20 to 57), were recruited for this IRB approved study. Satiety levels prior to, and 15 min and 30 min after food consumption were documented. The influence on satiety was adjusted for the initial hunger level, and the satiety value of white bread was calibrated to equal 100%. Satiety index and palatability of each food was calculated and compared. Results: The satiety index of popsicles was 104.5%, and 77.3% for ice. Popsicles had a greater satiating effect than either white bread (p=0.02) or ice (p=0.00). Ice, although less than white bread (p=0.00), still displayed some satiety value. Alternatively, the difference between palatability of the foods was not significant (p>0.05). Conclusion: Ice accompanied with flavor has the satiety index that exceeds white bread, and thus should be considered as a part of a weight loss program. Funding: Intelligent Beauty.

#P7

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Does color modify the identification of associated flavors?

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To examine how color affects the identification of beverage-like flavors, we created a new experimental design to measure the influence of color on flavor identification, while manipulating the association between the colors and flavors. The stimuli were mixtures created by varying the relative proportion of two flavorants. Five of the ten subjects judged mixtures of banana + peach and the other five judged orange + watermelon. These mixtures could be colored either green or red such that color was a reliable, although not perfect, predictor of the stronger flavor in the mixture. In the first condition, the two colors appeared equally often, while in the other two conditions, one color or the other appeared more frequently. We found, in line with our predictions, that increases in the association of flavor with color led to increases in the probability of identifying the flavors in terms of the associated colors; that is, presenting a given peach-banana mixture in green or red increased the probability that the flavor was identified as banana or peach, respectively. Moreover, also in line with our predictions, flavor identification was sensitive to changes in the underlying joint probabilities of colors and flavors presented in the three conditions. The results support the view that subjects relied on contiguity (conjoint probability) or sensitivity (conditional probability of the associated color, given a specific flavor), rather than validity (conditional probability of the associated flavor, given a specific color). Acknowledgements: This work was supported by grant R01 DC009021-04 from the National Institute on Deafness and Other Communication Disorders, NIH, USA, to LEM.

#P8

PPOSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Olfactory function in patients before and after temporal lobe resection

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Objectives: The study aimed to assess olfactory function in patients with temporal lobe epilepsy before and after resection of temporal lobe structures and especially addressed the question whether there are any significant olfactory differences as a function of side of epileptic focus, or resection. Methods: Seventy pre- and post-operative patients, and age- and sex-matched healthy controls underwent tests for odor thresholds, odor discrimination, and odor identification. Results: Patients with unilateral epileptic focus but without temporal lobe resection tended to have impaired identification abilities only compared to healthy controls. There were no significant differences in olfactory function on the side of the epileptic focus compared to the non-affected side. However, patients after temporal lobe resection presented with significantly impaired olfactory abilities compared to healthy controls and with lower olfactory scores on the side of the lesion compared to the non-lesioned side. Conclusions: Olfactory function in patients with temporal lobe epilepsy is only partially impaired preoperatively; it will deteriorate further after partial resection on the side of the lesion.

#P9

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Parosmia as symptom of lateralized posttraumatic olfactory disorders — preliminary data

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Objectives: Parosmia is a quantitative disorder and seems to be most commonly present in postinfectious disorders, even though it also occurs in posttraumatic disorders. Its exact pathomechanism still remains a matter of debate. So far parosmia has never been distinctly linked to severely lateralised olfactory disorders.
Methods: Five patients (1 men, 4 women, age range: 40-61 years) were complaining predominantly about parosmia after mild to moderate head trauma. Olfactory function in patients was evaluated using the Sniffin´ Sticks test battery based on the TDI score (composite score of threshold, discrimination and identification). Olfactory testing was performed separately for the right and left nostril. On a visual analogue scale subjective disturbance, the presence of parosmia (ranging from 0 [“no disturbance / parosmia at all”] until 10 [“maximum disturbance / constant parosmia”]) and olfactory function were rated (ranging from 0 [“no olfactory function”] to 10 [“very good olfactory function”]). Magnetic resonance imaging (MRI) of the frontobasis has been performed.
Results: According to results of the lateralised olfactory testing, all subjects differed by 10 or more points in the TDI score between right and left nostril. Moreover, in four patients MRI revealed pathologic findings in the region of the olfactory bulb. The subjective olfactory function was rated with a mean of 4.1 ± 1.8 units, mean disturbance caused by the olfactory disorder was rated as 4.9 ± 2.0 units, the extent of parosmia was 8.62 ± 0.78 units.
Conclusion: Parosmia can be the predominant symptom in patients suffering from a severely lateralised posttraumatic olfactory disorder. Moreover, in the majority of patients MRI revealed a lateralised lesion which might be considered as a structural correlate of the parosmia.

#P10 POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Affect Dependent Phantosmia

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Objective: Mood can influence olfactory threshold (Dumlao 2010). The impact of mood on quality of phantosmia has not previously been described. **Methods:** A 50 year old woman presented with a 7 year history of closed head injury induced anosmia and phantosmia. Since then, she complained of depression, frequent crying, indecisiveness, anxiety, and inability to get along with others. She felt all food had no taste, but when presented alone, she could easily detect salt, sweet, bitter, and chocolate. Alcohol only had a burning sensation. Intermittently, for a few seconds duration, when happy, she notes a floral odor, but when sad, she detects a chemical/gasoline/sulfur odor; both resolve with distraction. Abnormal examination finding: bilateral: scalloped tongue, palmar erythema, pale fundi, ptosis, cerebellar spooning, distal vibratory sensation reduction, 3+ and pendular quadriceps femoris reflexes. **Results:** Chemosensory testing: Phenol Ethyl-Alcohol Threshold Test L: -2.5, R: > -2.0; University of Pennsylvania Smell Identification Test L: 8, R: 7 (Anosmia). Dirhinous, Quick Smell Identification Test 0, Alcohol Sniff Test 0. MRI normal sinuses; focal area of encephalomalacia and gliosis in bilateral inferior frontal lobes. **Discussion:** The mechanism for such affective dependent phantosmia is unclear. It may represents psychodynamic projections of the underlying mood state. Or, mood state may be associated with an imbalance of neurotransmitters, which also influence the entorhinal cortex, inducing selective firing of olfactory neurons. Mood state may have induced selective attention towards the hedonics of the phantosmia. Alternatively, the hedonics of the phantosmia may have impacted on the mood. Quality of phantosmia in relation to affect warrants further evaluation. **Source of Funding**: None.

#P11 POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

A Quick, Non-Invasive, and Reliable Diagnostic Test for Alzheimer's Disease

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This study was to assess a quick clinical test of CN 1 that may help diagnose probable Alzheimer's disease (AD). Many symptoms/signs of AD are shared with other neurodegenerative disorders. Early diagnosis and treatment may reduce disability, enhance quality of life, and aid clinical trials. The olfactory cortex is one of the earliest areas damaged in AD and the left hemisphere is often affected earlier than the right. Thus, the purpose of this study was to investigate odor detection in each nostril of patients with AD versus controls. The experimental participants were patients with a diagnosis of AD based on the NIND and SADRDA criteria. Patients with a comorbid dementia, severe AD, allergy to peanuts, or history of a brain tumor, stroke, nasal polyps, or severe head injury were excluded. The patient's odor detection was tested one nostril at a time while their eyes, mouth, and one versus the other nostril were closed. A container of 14g of peanut butter was raised up from the bottom of a 30 cm ruler 1cm at a time. Upon detection, the distance from their nostril to the peanut butter was measured. Patients with AD were significantly more impaired at detecting an odor with their left nostril (mean detection distance = 4.43cm) than with their right nostril (mean detection distance = 18.14 cm) ($p<0.0001$). The mean difference of the left nostril's detection distance minus the right nostril's detection distance was -13.71cm which was significantly different from patients with other types of dementia and controls by at least $p<0.00001$. A Fisher exact test on the $\chi 2$ of the frequency distribution of this difference score of the probable AD patients was significantly different from patients with other types of dementia, those with Mild Cognitive Impairment, and from older controls (all with a $p<0.00001$) Acknowledgements: TL1RR029889 from the National Center for Research Resources and by the NIH Roadmap for Medical Research via UF's Clinical and Translational Science Institute

#P12 POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Patterns of ERP Brain Activity During Odor Identification Differ in Those at Risk for Alzheimer's Disease

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Alzheimer's disease (AD) affects 5.3 million people in the US and is the 6th leading cause of death. This study examined 60 healthy non-demented individuals across three age groups (young, middle, old). Half of each age group were positive for the genetic risk factor for AD, the ApoE ε4 allele, and half were negative. Fourteen different odors were presented repeatedly via computer controlled olfactometer and each subject was asked to identify the odors via button press response to four multiple-choice options presented on a computer screen. Event-related potentials (ERPs) were recorded from the scalp via a 64-channel AG/AG/CL sintered electrode cap and analyzed offline. This study examined topographical ERP brain activation in this population at risk for AD. In the young age group ε4+ participants showed greater overall brain activation at left parietal electrodes than ε4- participants. In the middle age group ε4+ and ε4- participants demonstrated similar brain activity patterns with slightly more activity for ε4+ participants in right hemisphere electrodes compared to left during the 900-1000ms time interval. The greatest differences were seen in the older age group where ε4- participants showed an increase in activation over left and central electrode sites between 900-1100ms, while ε4+ participants showed relatively less overall activation during that time period, but increasing activation over right frontal electrodes between 1000-1200ms. Overall these findings indicate that patterns of brain activity while identifying odors differs not only by age, but also by ApoE status. This suggests that possession of the ApoE ε4 allele may affect how the brain processes olfactory information, which in turn, may at some point, aid in early pre-clinical diagnosis of AD. Acknowledgements: Supported by NIH Grant DC02064 to Claire Murphy. The authors would like to acknowledge the late Dr. Leon Thal and the ADRC for genotyping (P50AG05131), Krystin Corby, Roberto Zamora, Joel Kowalewski, Melissa Cervantes, and Richard Vail for their contributions.

#P13

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

OERP differences as a function of age, the Apolipoprotein E (ApoE) ε4 allele, electrode site, and response type during retrieval using odor labels in an odor-recognition memory task

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Alzheimer's disease affects 5.4 million Americans. Evidence suggests that individuals who are ApoE ε4+ are at higher risk for developing the disease. Studies have also shown that ApoE ε4 is linked to olfactory decline. Olfactory functioning may be investigated using olfactory event-related potentials (OERP). The high temporal resolution of OERP enables an understanding of the neural correlates of olfactory processing and functioning. This study investigated the effects of age, ApoE ε4 status, electrode site, and response type on OERP latency and amplitude during retrieval in an odor-recognition memory task. Participants were divided into 3 equal age groups: younger, middle, and older. Each subgroup had an equal number of ApoE ε4+ and ε4- individuals. The study design was composed of separate visual and olfactory components. The odors were presented with a computer-controlled olfactometer. Both visual and olfactory retrieval sessions were conducted. Participants were notified during encoding that this was a task of odor memory. Results indicated differences in OERP activity between individuals who are ApoE ε4+ versus ApoE ε4- during retrieval using odor labels. These findings highlight the potential for OERP to differentiate between ApoE ε4+ and ApoE ε4- individuals. Acknowledgements: Supported by NIH grant # DC00264-14 from the National Institute on Deafness and Other Communication Disorders. We thank Paul Gilbert for his statistical expertise, and Jessica Bartholow, Roberto Zamora, Ariana Stickel, Derek Snyder, Kyle Sigel, Jean-Loup Bitterlin, Kristina Constant, and Sanae Okuzawa for their assistance with data collection and entry.

#P14

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Chemical intolerance in patients with rhinologic diseases

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Various environmental agents adversely affect the quality of life in the general population and many diseases may be associated with the chemical intolerance, but the exact mechanisms are lacking. In some of the ENT diseases, environmental agents can induce or aggravate the symptoms of each disease. In allergic rhinitis (AR), allergic symptoms can be manifested by the nonspecific odorants, which are not associated with airborne antigen(s). We investigated the prevalence of the chemical intolerance of rhinologic diseases using QEESI□ and compared the prevalence rate. Next, we compared the chief complaint and ARIA classification of AR with the degree of suggested chemical intolerance. Compared to the control group, the prevalence rate of very suggestive cases was higher in rhinologic diseases, especially AR, chronic rhinosinusitis (CRS), and non-allergic rhinitis (NAR). In AR, the rate of very suggestive scores was about 15%. When we compared the chief complaint according to the degree, in the cases of very suggestive scores, rhinorrhea occurred more than nasal obstructions. In the very suggestive cases, all have the persistent/ moderate-severe classification. In the CRS cases, we divided them into 3 groups - CRS without nasal polyp (NP), with NP and with AR. The groups with AR or NP had more very suggestive scores than the group without AR or NP. In the NAR group, the finding was very similar to the AR group. The prevalence rate of chemical intolerance is higher in rhinologic diseases, especially AR, CRS and NAR. Many rhinologic diseases, including AR can be aggravated and caused by environmental factors. More advanced control of those diseases can be accomplished with more study on chemical sensitivity.

#P15

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Pain-relieving effect of olfactory exposure in patients with chronic back pain?

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Aim: The aim of this investigation was to find out whether patients suffering from chronic back pain would benefit from short-term exposure to odors in terms of an increase in pain thresholds to electrical stimulation of the fore-arm. **Methods:** A group of patients with chronic back pain was analyzed in reference to olfactory function, pain threshold, and mental health state. Short-term odor exposure was performed over a period of four weeks. Patients were exposed to four odors (rose, vanilla, chocolate, peach) every two hours during daytime. The patients' pain threshold was obtained before and after the training using electrical stimulation. Olfactory testing was performed before and after training using the Sniffin Sticks. **Results:** Compared to baseline measurements electrical pain thresholds in patients tended to be higher (P=0.09) after the training period. A significant increase of olfactory function however, was not found. **Conclusions:** The present results indicate that olfactory training may increase pain threshold in patients with chronic back pain.

#P16

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Olfactory Dysfunction is Associated with Reduced Sexual Appetite

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Introduction: Individual reports from patients about sexual dysfunction since the onset of smell loss was the motivation for the present study. The study aimed to investigate sexual appetite and depression in relation to olfactory function in patients with self reported smell loss. Methods: One-hundred-twenty-five patients who complained about reduced sense of smell were enrolled in the study. The sense of smell was evaluated by tests for odor threshold

(t), odor discrimination (d) and odor identification (i) by means of the "Sniffin' Sticks" test battery. The results of these three tests are summed up to a composite score- the so called tdi- score. Depression was evaluated by means of the Beck Depression Inventory (BDI). Patients answered 11 questions for evaluation of sexual appetite in regard to the time before the onset of olfactory dysfunction and since the olfactory dysfunction. The points received for the latter questions were summed up to the so called Sexual Appetite Index (SAI). Results: Eighty-six patients filled the questionnaires completely and unambiguously and were available for further analyzes. Olfactory testing revealed in 38, 39 and 9 patients anosmia, hyposmia and normosmia, respectively. The BDI score was 11.0 ± 8.4 points (average± standard deviation). The SAI significantly (p=0.003) decreased from 22.7 ± 4.5 points from the time before to 21.4 ± 4.9 points since the onset of olfactory loss. The BDI score correlated negatively with the SAI since the onset of olfactory dysfunction (r85 = -0.36; P = 0.001). Conclusion: Depression caused by olfactory loss appears to be the main cause for the self-reported decrease in sexual appetite since the onset of olfactory dysfunction.

#P17 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Exercise is Associated with Lower Long-Term Risk of Olfactory Impairment

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Regular exercise has been shown to reduce the risk of many age-related conditions. In the Epidemiology of Hearing Loss Study (EHLS), exercising at least once a week was associated with a reduced risk of developing olfactory impairment in five years. The purpose of the present study was to determine if exercise remained associated with a lower risk of developing olfactory impairment over a longer time period. Olfaction was measured with the San Diego Odor Identification Test (SDOIT) at three examinations (1998-2000, 2003-2005, 2009-2010) of the EHLS. The frequency of regular exercise was obtained by interview. At baseline there were 1881 participants age 53-97 years at risk for olfactory impairment. Preliminary analyses found the 10-year cumulative incidence of olfactory impairment was 27.6% (95% confidence interval (CI)=25.3, 29.9) and those who were older (Hazard Ratio (HR)=1.88, 95% CI=1.74,2.03 for every 5 years) or male (HR=1.27, 95% CI=1.00,1.61) had an increased risk of olfactory impairment. Exercising at least once a week long enough to work up a sweat was associated with a decreased risk of olfactory impairment (HR= 0.76, 95% CI= 0.60, 0.97) in an age- and sex-adjusted model. Results were similar after adjusting for other covariates previously associated with the incidence of olfactory impairment in this population. In addition, increasing frequency of exercise was associated with decreasing risk of developing olfactory impairment (p for trend = 0.03). These results suggest that those who exercise regularly may reduce their long-term risk for olfactory impairment. Further research is needed to determine the pathway of this association. Acknowledgements: Supported by R37 AG011099 (KJC) from the National Institute on Aging and U10EY06594 (RK, BEKK) from the National Eye Institute.

#P18 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Norepinephrine-responsive cells juxtaposed with the apical tips of taste buds

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Many neurotransmitters including GABA, serotonin, adenosine and norepinephrine (NE) signal via intracellular cAMP. To visualize cAMP-mediated signaling in and around taste buds, we used a genetically-encoded cAMP reporter that is imaged by Fluorescence Resonance Energy Transfer (FRET). We biolistically transfected the cAMP reporter into lingual slice cultures of rat vallate and foliate papillae. This permitted us to see changes in cAMP levels in real-time and with cellular resolution within 24 hr. About 11% of transfected cells (74/704) responded to NE with an elevation in cAMP. The response to NE was concentration-dependent (EC_{50}=38 μM). Isoproterenol (100 μM), a non-selective β-adrenergic receptor agonist and formoterol (1 μM), a β_2-adrenergic receptor agonist also elevated cAMP levels. Xamoterol (10 μM), a selective β_1-adrenergic receptor agonist, failed to raise cAMP levels. In addition, ICI 118551 (50nM), a highly selective β_2-adrenergic receptor antagonist, blocked the NE-induced increase in cAMP in a reversible manner. In contrast, CGP 20712A (500nM), a highly selective β_1-adrenergic receptor antagonist did not inhibit the response to NE. Thus, the NE responses are mediated via β2 receptors. *Post-hoc* immunostaining for the cAMP reporter showed that the NE responding cells were closely juxtaposed to taste buds, near the taste pore. We also see strong immunoreactivity to β_2 adrenergic receptor in cells adjacent to the taste pore. To identify the source of NE that may activate these cells, we immunostained for tyrosine hydroxylase (TH), an enzyme for NE synthesis. TH was seen in fibers projecting around taste buds and terminating superficially in the epithelium, including near the NE-responding cells. The role of these NE responding extra-gemmal cells remains to be elucidated. Acknowledgements: Supported by NIH/NIDCD R01DC6021 (NC)

#P19 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Dopamine-beta-hydroxylase and norepinephrine transporter immunoreactivity in rat taste buds

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Although great progress has been made in the understanding of norepinephrine's role in gustatory transduction, there is still a great deal of work that needs to be done in order to fully elucidate the mechanism of adrenergic modulation in this system. To do so, it is vital to localize the various proteins that make up this machinery. The adrenergic system includes many proteins that are essential for the transport, degradation and synthesis of adrenergic neurotransmitters, as well as the various transmembrane proteins that act as receptors for adrenergic modulation. The present study has focused on localizing and characterizing the synthetic enzyme

dopamine-beta-hydroxylase (DBH) and the norepinephrine transporter (NET) using techniques of immunocytochemistry. **Dopamine-beta-hydroxylase:** Our data indicate that DBH-like immunoreactivity (LIR) colocalizes with the Type II cell markers α-gustducin and PLCβ2. Quantitative analysis indicates that approximately 41 % of PLCβ2-LIR expressing cells also express DBH-LIR. However, DBH-LIR does not appear to be present in Type III cells, as DBH-LIR did not colocalize with the Type III cell marker, NCAM. We are currently investigating the possibility of colocalization between DBH-LIR and NTPDase-2-LIR, a standard Type I cell marker. **Norepinephrine Transporter:** Our data show that NET-LIR is present in both Type II and Type III taste cells. NET-LIR colocalizes with a subset of IP_3R3-LIR cells as well as with two Type III cell markers: serotonin (5HT) and syntaxin-1. We are currently conducting quantitative studies for these colocalizations. Based on our preliminary results, we suggest that DBH-LIR is present in Type II taste cells and that NET-LIR is present in both Type II and Type III taste cells. Acknowledgements: This work is supported by NIH grants DC00285 and P30 DC04657

#P20 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Serotonin's modulatory effects in the rat taste bud facilitate the gustatory afferent neural response

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Serotonin (5-HT), once thought to be the primary neurotransmitter of the taste bud, is now believed to have a modulatory role in the generation of the afferent gustatory signal. The nature of this modulation is not well understood. We have previously demonstrated that the rat taste bud expresses only the $5\text{-}HT_{1A}$ and $5\text{-}HT_3$ receptor subtypes, and that the $5\text{-}HT_{1A}$-expressing taste receptor cell (TRC) is paracrine to the 5-HT TRC. The receptor $5\text{-}HT_3$ is presumed to be expressed in postsynaptic neural elements. We seek to further understand the nature of 5-HT's modulatory role in the rat taste bud and its influence on the afferent signal by: (1) phenotyping the $5\text{-}HT_{1A}$-expressing cell using immunocytochemistry and/or *in situ* hybridization double labeling and RT-PCR, and (2) exploring 5-HT's role at the neural level through chorda tympani (CT) recordings in combination with systemic administration of $5\text{-}HT_{1A}$ or $5\text{-}HT_3$ receptor antagonists WAY100635 (at 0.01, 0.025, 0.1 or 0.2 mg/kg) and NAD-299 (0.35 mg/kg), and $5\text{-}HT_3$ receptor antagonist ondansetron (1mg/kg). Our data show extensive, but not complete co-expression of $5\text{-}HT_{1A}$ and Type II cell markers gustducin, GAD, NPY, and NPY1 receptor, and almost no co-expression with NCAM, a type III cell marker. In CT recordings, WAY-100635 at 0.1 mg/kg caused a reversible reduction in CT response to NaCl (34% reduction), sucrose (59%), quinine (57%), and HCl (51%). Recovery to near pre-drug values averaged 45 minutes after drug injection. NAD-299 caused an irreversible reduction in CT response to NaCl (17% reduction), sucrose (30%), quinine (30%) and HCl (29%). Administering either ondansetron or a saline vehicle had no significant effect on CT responses. We postulate that 5-HT is part of a negative feedback mechanism for the regulation of ATP release from Type II cells. Acknowledgements: NIH NIDCD R01 DC00401

#P21 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Expression of NPY Family Genes in Lingual Cells: Novel Anatomical Domain and Physiological Functions

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The hormones Neuropeptide Y (NPY), Peptide YY (PYY), Pancreatic Polypeptide (PP) and their cognate receptors YR1, YR2, YR4, and YR5 are memebers of the NPY gene family and are widely expressed in the brain as well as on the periphery mediating multiple metabolic functions. Recently, we have shown the presence of PYY in the saliva, and the expression of its preferred receptor, Y2R, in the lingual epithelia. We now extend our finding to all main NPY family members and characterize their expression in the lingual basal cell epithelia and in taste receptor cells (TRCs) in mice. Using IHC and RT PCR protocols, we now show the expression of the genes coding for NPY, PYY, and PP in the tongue epithelia and TRCs. In the stratified keratinized lingual epithelial cells in the dorsum of the tongue, Y receptors are expressed in a cascade fashion following epithelial cell differentiation. The cascade manifested in switching from Y1R/Y2R+ progenitor cells in the basal layer, to Y1R+ cells in the prickle cell layer, to Y1R/Y5R+ cells in the granular layer, to Y5R+ cells in the keratinocytes. In addition, Y4R is shown to be expressed in somatosensory neurons innervating basal layer. In taste buds of the CV, Y4R was shown to be expressed in nerve fibers innervating TRCs. Moreover, significant population of TRCs was positive for Y1R, Y2R, Y4R, or Y5R showing preferential accumulation of YRs within the microvilli of the apical part of the cells. TRCs expressing Y receptors also expressed Neural Cell Adhesion Molecule suggesting their possible role in the gustatory signal transduction. Taken together these experiments characterize, for the first time, the expression of all NPY family members in the lingual mucosa suggesting multiple and diverse functions in the proliferation/differentiation and in taste perception. Acknowledgements: University of Florida

#P22 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Analysis of Taste Information-coding Mechanisms in Gustatory Neurons

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Five basic taste modalities are inputted with separate populations of taste receptor cells, although taste discrimination mechanism in peripheral nervous system remains unclear. In our previous

studies, we generated transgenic mouse lines in which sweet/umami, bitter, and sour taste pathways were visualized using genetically introduced trans-synaptic tracer wheat germ agglutinin (WGA) to produce t1r3-WGA, t2r5-WGA, and pkd1l3-WGA mice, respectively. Using these mice, we performed gene expression profiling to elucidate neuronal wiring in periphery. First, we performed a comprehensive search for the genes expressed in the rat cranial sensory ganglia containing the gustatory neurons: geniculate ganglion (GG), petrosal ganglion (PG), and nodose ganglion (NG). We examined the expression of some particular genes in these tissues by *in situ* hybridization and found that *Eya1*, *Eya2*, *5-HT3A*, and *5-HT3B* were expressed in mouse GG and/or nodose/petrosal ganglia (NPG). Then we examined molecular characteristics of WGA-labeled neurons. In the GG of t1r3-WGA and t2r5-WGA mice, almost all the WGA-positive neurons expressed *Eya1*. However, about 40% of WGA-positive neurons expressed *Eya2* in t1r3-WGA mice, and few WGA-positive neurons expressed *Eya2* in t2r5-WGA mice. In NPG, signals of WGA proteins were observed in almost all the Eya1 expressing neurons. Most of WGA signals were detected in *5-HT3A* expressing neurons of t1r3-WGA and t2r5-WGA mice, while few WGA positive neurons expressed *5-HT3A* in pkd1l3-WGA mice. WGA signals were observed in most of *5-HT3B* expressing neurons in t1r3-WGA mice, whereas few WGA positive neurons expressed *5-HT3B* in t2r5-WGA mice and pkd1l3-WGA mice. Altogether, gustatory neurons that transmit the sweet/umami, bitter, or sour signals are at least partially segregated from each other.

#P23 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Calcium-sensing Receptor Agonist Enhances Basic Taste Signaling in Mouse Taste Buds

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We reported that calcium-sensing receptor (CaSR) is a receptor for taste enhancing substances of salty, sweet and umami tastes. Furthermore, all of CaSR agonists, including γ-glutamyl peptides, have activities of taste enhancer ("*kokumi*" flavor) (Ohsu *et al*. J Biol Chem). Interestingly, CaSR agonists enhance specific basic tastes, although the agonists do not induce any taste themselves. Recently, we showed that CaSR agonists induce response in mouse lingual slice preparation (AChemS 2010). In this study, we determined the relationship between CaSR-expressed taste receptor cells and T1R3-expressing umami/sweet receptor cells in mouse taste buds. In immunohistochemistry, anti-CaSR immuno-positive cells were observed in circumvallate, foliate, fungiform and palate taste buds. Surprisingly, these taste cells comprised a totally different subset than T1R3-positive cells. In ATP biosensor experiments with CHO cells expressing P_{2X} receptors, the sweet substance SC45647 (10 μM) induced ATP secretion from isolated mouse circumvallate taste buds. SC45647-induced ATP secretion was enhanced by co-applying a potent CaSR agonist, γ-glutamyl-valinyl-glycine (10 μM). This enhancement was abolished with pre-treatment of NPS2143 (3 μM), a CaSR antagonist, or atropine (3 μM), an inhibitor of muscarinic acetylcholine receptors. Almost all CaSR positive taste cells co-expressed acetylcholine markers, indicating that CaSR positive taste cells contain acetylcholine. These observations show that *kokumi* flavor stimulation enhances sweet taste-induced ATP release from sweet receptor cells via cholinergic cell-to-cell (paracrine) signaling within a taste bud (Dando *et al*. AChemsS 2010).

#P24 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Sweet taste receptor ligand binding interactions and conformational studies by CD and NMR spectroscopy

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The sweet protein brazzein activates the human taste sweet receptor, a heterodimeric G-protein coupled receptor (GPCR) composed of 2 heterodimeric subunits T1R2 and T1R3 (hT1R2/T1R3). Previously, we used saturation transfer difference spectroscopy (STD) to monitor the direct binding of brazzein and a set of sweet agonists and antagonists to the human taste receptor in membranes prepared from human embryonic kidney (HEK293) cells transfected with and expressing the sweet receptor. Recently, we have overexpressed either selectively or uniformly labeled the amino terminal domains (ATD) of T1R2 and T1R3 in E. coli to map differential ligand binding domains in each subunit. Our results show that both T1R2- and T1R3-ATDs are folded as shown by NMR and CD studies. The saturation transfer NMR binding assay confirmed ligand-receptor binding interactions with both small ligands and brazzein to T1R2-ATD. The two-dimensional transverse relaxation optimized ^{1}H-^{15}N homonuclear single quantum correlation (TROSY-NHSQC) spectrum of ligand-free [U-^{2}H, U-^{15}N]-labeled T1R2-ATD showed poor chemical shift dispersion and a large dynamic range in peak intensities, implying that the conformation of the uncomplexed protein is dynamic and undergoes order-disorder conformational exchange in NMR time domain. Both CD and TROSY-NHSQC showed a significant conformational change upon neotame binding to T1R2-ATD. These studies support that purified ATDs are functional and folded for future structural and ligand binding studies by NMR and X-ray.
Acknowledgements: R01DC00901804

#P25 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

The effects of the Itpr3 gene on taste-evoked responses in mice

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The BTBR T^{+} tf/J (BTBR) and NZW/LacJ (NZW) mouse strains vary in their preferences for sucrose, $CaCl_2$, and umami solutions. Furthermore, the strain difference in taste preferences has been captured in a BTBR.NZW congenic strain with a 1.2-Mb introgressed region that includes Itpr3 on chromosome 17. In two-bottle choice tests, mice inheriting the BTBR/NZW (BN) haplotype in this interval have strong preferences for sucrose and

umami solutions, and strongly avoid $CaCl_2$. In contrast, littermate controls with the BTBR/BTBR (BB) haplotype are indifferent to sucrose, umami and $CaCl_2$. These behavioral differences might be mediated by several possible mechanisms, including gustatory or post-ingestive. We therefore measured taste-evoked multi-unit chorda tympani nerve responses in BN and BB mice, in order to compare them on taste sensation more specifically. The BN mice had higher responses to sucrose and the umami compound IMP than did the BB mice. This suggests that differences in sweet and umami taste perception, mediated by Itpr3, influence the strain differences in behavioral preferences. Additional data will be needed to compare the strains on responses to $CaCl_2$ and other compounds. Acknowledgements: Funding provided by NIH R01 DK-46791

#P26 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Taste-evoked chorda tympani responses in Fawn Hooded Hypertensive and Brown Norway rats

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Recent studies have shown that Fawn Hooded Hypertensive (FHH) and Brown Norway (BN) rat strains vary in their 2-bottle preferences for ethanol, sucrose, $CaCl_2$, and other taste solutions. However, it is not known whether these strain differences in behavior are due to differences in taste sensation or due to other factors. We performed multiunit electrophysiological recordings from the chorda tympani (CT) nerve in these two strains, in order to examine whether these behavioral differences are associated with variation in peripheral taste responsiveness. Rats were anesthetized, the CT was accessed, and ethanol, sucrose, $CaCl_2$ and other solutions were flowed over the anterior tongue as we measured the integrated whole-nerve activity. Taste-evoked responses were of similar size in the strains, even for those solutions on which they are known to differ behaviorally. These data suggest that differences in non-gustatory mechanisms, or possibly taste-related mechanisms in areas not innervated by the CT nerve, are responsible for the previously observed strain differences in 2-bottle preferences. Acknowledgements: Funding provided by NIH R01 DC-10149

#P27 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

CD36 Contributes to, but is not Required for, Fatty Acid Transduction in the Taste System.

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The scavenger receptor CD36 is expressed in a variety of tissues where it is involved in multiple fat-related biological processes including angiogenesis, atherosclerosis, inflammation and lipid metabolism in mammals as well as in the detection of lipid-like pheromones in insects. It is initially suggested involved in the fatty acids gustatory detection with the immunocytochemical identification in the taste cell apical membranes by Fukuwatari et al. in 1997. Then evidences accumulated both in cellular and behavior level (El-Yassimi et al. 2008; Sclafani et al. 2007 and Laugerette et al. 2005) after the CD36-deficient mice were generated. Nonetheless, the role of CD36 in fatty acid gustatory detection, as a direct lipid sensor or as a protein that facilitates the function of fatty acid-activated G protein coupled receptors, such as GPR120 expressed in taste cells, remains to be determined. To investigate this, we measured concentration-response functions for the ability of fatty acids to activate cells using ratiometric calcium imaging. Comparisons were made among cell lines expressing GPR120 with or without CD36 or CD36 alone as well as taste cells freshly isolated from CD36-deficient mice and wild type mice. In both cases, the presence of CD36 caused a leftward shift of the concentration-response function, which is consistent with the facilitating ability of CD36 to fatty acid responsiveness. However, taste cells lacking CD36 were still capable of responding to fatty acids. At the behavioral level, we observed a reduced responsiveness to linoleic acid in CD36-deficient mice after formation of an aversion conditioned to the taste of linoleic acid. These results suggest CD36 is not required but certainly contributes to fatty acid responsive pathways in the taste system. Acknowledgements: NIH grant DK059611 (to TAG) and International Flavors & Fragrances.

#P28 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Medium chain fatty acid transduction in mouse taste cells is TRPM5-independent

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Previous studies concluded that transient receptor potential channel type M5 (TRPM5) plays a critical role in long chain fatty acid transduction in mouse taste cells. Cellular responses to linoleic acid in Type II cells, for example, occur in a qualitatively similar fashion to sweet, bitter and umami stimuli (Liu et al., *J Neurosci* 31: 8634, 2011). We have previously shown that mice respond behaviorally to other classes of fatty acids including medium chain saturated fatty acids ($C_{8:0}$-$C_{14:0}$) and their taste cells respond to these stimuli as well. However, the transduction mechanism underlying these responses is unknown. We have used both cell-based and behavioral assays to explore the mechanism of medium chain fatty acid transduction in mouse taste cells and found that unlike the case for the polyunsaturated fatty acids, this process is TRPM5-independent. Using fura-2 based calcium imaging, we found that lauric acid ($C_{12:0}$) elicited a robust and reversible increase in intracellular calcium in taste cells isolated from wild type mice and similar responses, in terms of response magnitude, percentage of responsive cells and concentration dependence, were seen in taste cells from mice lacking TRPM5. These results suggest that TRPM5 is not involved in medium chain fatty acid transduction in mouse taste. Currently we are investigating the behavioral responses to a series of medium chain fatty acids in wild type and TRPM5 knockout mice. Thus, our preliminary data are consistent with the interpretation that medium chain fatty acid transduction pathway is significantly different than for the polyunsaturated fatty acids in terms of its dependence upon TRPM5. The specific elements of the pathway for medium chain fatty acid transduction remain to be elucidated. Acknowledgements: Supported by NIH grant R01DK059611

#P29

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

MUPP1 is a General Organizer for Olfactory Signaling

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Olfactory signaling is dependent on various proteins and fine-tuned through different processes. These individual signaling steps have to be organized in the densely packed neuron in a spatiotemporal manner. Most of the essential components of this pathway are already known but the question arises how those get orchestrated. In the present study, we identified the PDZ protein MUPP1 as the first potential scaffolding candidate for olfactory signaling. We were able to demonstrate various MUPP1-OR interactions, using a large-scale peptide microarray approach with the 13 individual PDZ domains of MUPP1 and murine olfactory receptors of every subfamily. Moreover, co-immunoprecipitations of MUPP1 and important olfactory signaling proteins validated the existence of an olfactory PDZome. To functionally characterize the PDZ-dependency of olfactory signaling in olfactory neurons, we established patch clamping of olfactory sensory neurons in acute slices of transgenic mOR-EG mice and designed an inhibitory peptide, specific for PDZ proteins. Remarkably, odor-evoked current amplitudes were strongly reduced and adaptation was impaired after uncoupling the PDZ-OR interaction. In conclusion, we confirmed the presence of a MUPP1-mediated olfactory signalosome in olfactory sensory neurons and showed that accurate olfactory signaling is a PDZ-dependent mechanism.

#P30

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Combinatorial and modular encoding of the mouse olfactory signatures by major urinary proteins (MUPs): an overview of the past two decades

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The first evidence that the activity of androgen-dependent pheromones in mice may be strongly associated with main urinary protein fraction (major urinary proteins, MUPs) was presented at 14th AChemS meeting two decades ago (Churakov et al., 1992). Coupled with further data on differential capacities of various MUPs to bind several physiologically active ligands (Bacchini et al., 1992; Böcskei et al., 1992), these studies opened practically unexplored avenue of MUPs' significance in the neurobiology of olfaction in *Mus musculus*. In this report we present results of our recent and ongoing studies on MUPs significance in encoding olfactory signatures (images) in laboratory mice of genealogically unrelated strains (CBA/LacY and C57BL/6JY) and their reciprocal F1 hybrids. Quantitative evaluation of MUP fractions with different electrophoretic mobility reveals that strain-specific *combination* and *proportion* of individual fractions can encode age, sex, physiological state, and genotype of the mouse. The genotype-specific adult MUP combinatorial profile consists of two distinct protein subsets (modules), which appear in both sexes very soon after weaning and resemble a "bar-code". Taking into account that MUPs without native ligands can efficiently activate vomeronasal neurons (Chamero et al., 2007; 2011) and that the expression patterns of pheromone receptors (V2Rs) are also combinatorial (Silvotti et al., 2007) and partially sex-specific (He et al., 2008; 2010), our data provide valuable insights into fine molecular mechanisms of decoding unique pheromone blends, based on an intriguing MUPs↔V2Rs *complementary* protein interplay. Coupled with other data on modular organization of the olfactory decoding our studies proposed that the recognition of MUP' functional modules is also based on modular principles.
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#P31

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Unraveling the Mechanism Behind Scent-Marking in Male Mice

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Previous work has shown urine to be a rich source of chemical information, carrying odor cues as well as pheromonal information. Urinary marks can signal the gender, sexual maturity and social status of the depositing animal. Mice have the ability to distinguish their own urinary deposits from that of another conspecific. However, the precise mechanism by which individual recognition is accomplished is yet to be elucidated. The objective of this project is to gain insight into the mechanisms underlying individual recognition in male mice as manifested by their countermarking behavior. Biochemically fractionated urine and recombinantly expressed major urinary proteins were tested in a countermarking behavioral assay to uncover the mechanism by which urinary signals are used to distinguish the identity of the depositing animal. It was found that, as previously suggested, the protein containing high molecular weight fraction of non-self adult male urine was necessary and sufficient to promote countermarking behavior in BALBcByJ male mice. Recombinantly expressed individual proteins were sufficient to produce the behavior. Experiments are underway to further characterize how self and non-self urine signatures are differentially perceived. Investigation of these hard-wired circuits will allow for a greater understanding of how neural coding is employed to translate chemical informationinto action.

#P32

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Morphological study on the glandular epithelium associated with the primordial vomeronasal organ in the lungfish

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Several lines of evidence suggest that the vomeronasal system has already begun its development during phylogeny in fishes, although fishes lack the distinct vomeronasal organ. The African lungfish possesses a sensory epithelium containing microvillous olfactory receptor cells as in the vomeronasal organ of tetrapods, and the olfactory epithelium containing both ciliated and microvillous olfactory receptor cells. The former, temporarily designated as a recess epithelium in this study, was found in the recess at the base of the olfactory lamella, and the latter on the surface of the olfactory lamella. Both epithelia consisted of supporting cells, olfactory receptor cells and basal cells. In this study, we examined the structure of a glandular epithelium in the recess at the base of the olfactory lamella and its relationship to the recess epithelium. The glandular epithelium consisted of columnar cells with basally-located nuclei. These cells contained well-developed rough endoplasmic reticulum and abundant secretory granules in the supranuclear cytoplasm. Although supporting cells in both the olfactory epithelium and the recess epithelium contained secretory granules in their cytoplasm, they showed different staining patterns by lectin histochemistry from those of the glandular epithelium to suggest that they secrete different kinds of substances modified by respective sugar residues. Furthermore, all recesses were constituted by both recess epithelium and the glandular epithelium, as confirmed by the serial sectioning of a whole nasal sac. These results suggest that the primordial vomeronasal organ in the lungfish possesses an associated gland and the secretory function of this gland is different from that of the supporting cells in the olfactory epithelium and the recess epithelium.

#P33

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Characterization of the Domesticated Cat Vomeronasal 1 Receptor Family

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Pheromones are involved in chemical communication between individuals within species and can modify social and sexual behavior as well as physiology. These signals are primarily detected in the vomeronasal organ (VNO) located at the bottom of the nasal cavity. Within the VNO the apical epithelium houses vomeronasal sensory neurons which express vomeronasal receptors (V1R). The V1R proteins are seven transmembrane G protein-coupled receptors, and the genes are a single exon of approximately 1000 nucleotides. Rodents possess over 100 functional V1R proteins and are the best characterized to date. Due to pseudogenization events, most mammals have fewer functional receptors than rodents, with primates expressing few if any. In general, the V1R repertoire within a species is unique with few orthologs between species with the exception of ruminants. Although V1R repertoires of domesticated animals have been investigated, the domesticated cat (*Felis catus*) has not been included in great detail despite the completion of the genome in 2007. We sought to determine whether the 17 predicted cat V1R sequences had any similarities to other domesticated animals. In our analysis we compared all of the cat V1R protein sequences to those of dogs, cows, sheep, goats, pigs, and horses. This diverse group of domesticated animals allowed us to examine whether V1R diversity and orthologs are influenced by dietary habits, VNO anatomical structure and development, or pheromone-related behaviors such as the flehman response or induced ovulation. Understanding these relationships may lend insight into the evolution and function of the vomeronasal system in cats and the environmental influences that shape chemosensory receptor repertoires.

#P34

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Evidence of singular response to round goby pheromones within a sub-population sample of Perciformes species in the Great Lakes region

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Pheromone trapping is an increasingly viable strategy to reduce invasive fish populations, largely due to the pheromones' function of evoking behavioral responses among conspecifics. Prior to attempting such population control techniques, the pheromones must be identified and their possible influence on non-target species addressed. The round goby (*Neogobius melanostomus*) is a fish invasive to the Great Lakes region. Steroids released by reproductive males (3α-hydroxy-5β-androstane-11,17-dione (11-O-ETIO) and 3α-hydroxy-5β-androstane-11,17-dione 3-sulfate (11-O-ETIO-3-s) evoke olfactory sensory responses (field potentials) from conspecifics. The lack of responses by goldfish also support that these steroids function as pheromones in round gobies. We further investigated whether alternative Perciformes species sharing the same ecosystem as round gobies in the Great Lakes region respond neurophysiologically to the putative pheromones. Rock bass (*Ambloplites rupestris),* bluegill sunfish (*Lepomis macrochirus),* pumpkinseed sunfish (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), and yellow perch (*Perca flavescens*) were the targets of an electro-olfactogram experiment designed to record the summed generator potential within the exposed olfactory epithelium in response to odors. The olfactory epithelium was exposed to water until odors representing amino acids, bile acids, putative round goby pheromones, and control solutions were introduced intermittently. We found that although fishes within this order responded to amino acids and bile acids, only round gobies showed a response to the putative pheromones. This study supports that a pheromone trapping trial could be conducted in the field without adversely affecting non-target fish populations in the area. Acknowledgements: Supported by the Natural Sciences and Engineering Research Council of Canada Strategic Program.

#P35

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Deorphanization of human olfactory receptors by Luciferase and Ca-imaging methods: Differences & similarities

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Olfactory receptors (ORs) expressed at the cell surface of olfactory sensory neurons lining the olfactory epithelium and act as first actors for perception and recognition of odorants. Up to now, few human ORs have been deorphanized, mainly because the difficulties encountered to express ORs functionally in a recombinant system. Within this work, our aims were 1) to deorphanize human ORs and 2) to compare outcome of the 2 techniques mostly used for deorphanization. For this, we used two tests for deorphanization of some several ORs and analyzed the responses of them to a number of alcohol & ketone compounds. We found that some of these ORs are able to induce cellular responses by the use of Ca-imaging and CRE-luciferase assay. Our experiments indicated that in Ca-imaging assays OR4X2 was activated by ketones and OR5D13, OR1N1 & OR8D2 by alcohols. In the CRE-luciferase assay, only cells transfected with OR5D13 or OR8D2 were significantly activated by alcohols. Our results represent, OR4X2 is receptor for ketones and OR5D13, OR1N1 and OR8D2 are activated by alcohols. Different results by CRE-luciferase and Ca-imaging method could reflect some technical reasons like stimulation or transfection time. Finally, according to these results it could be suggested, that using of two complementary tests in parallel can benefit deorphanization.

#P36

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Sequencing the olfactory receptor repertoire

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Humans have approximately 400 functional olfactory receptors, but among this set there are a large number of variations between individuals. In some cases, these variations cause a receptor to be nonfunctional in a subset of the population. These variations likely underlie inter-individual variation in olfactory perception. We identified ligands for 19 odorant receptors and, along with previously published ligands for 9 additional receptors, characterized polymorphic variation in an ethnically diverse population. We related the genotypic variation to functional variation using a heterologous system. In our population, 86% of the odorant receptors we examined had polymorphisms that caused functional changes. On average, two individuals differ functionally at 42% of their odorant receptor alleles. This high level of functional variability in the primary receptors transducing olfactory information is strongly suggestive of high interindividual variability in odorant detection at the receptor level. Here we set out to translate this variability at the receptor level to a human subject by applying a targeted capture method to enrich the odorant receptor repertoire for next-generation sequencing. We demonstrate that we are able to fully sequence an individual's OR repertoire with enough coverage to call heterozygous sites. This method can be used to identify the functional role of a single odorant receptor in olfactory perception. Acknowledgements: R01 DC005782 R03 DC011373 F32 DC008932

#P37

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

Exploring the variation in molecular receptive range among mammalian olfactory receptors

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The recognition of odorant molecules by odorant receptors (ORs) is a critical early step in olfaction. Mammalian ORs are a large family of G-protein coupled receptors located on the cilia of olfactory sensory neurons. The molecular receptive ranges (MRRs) of ORs are thought to vary in breadth, from narrowly tuned ORs activated by few odorants, to broadly-tuned ORs recognizing a large variety of odorant molecules, all contributing to a combinatorial mechanism of odorant recognition. To explore MRR variation, we screened 55 mouse ORs (MORs) that were representative of many MOR subfamilies with a panel of 155 odorants chosen to represent a broad portion of odor space. MORs were expressed in Xenopus oocytes, together with Gαolf and the human cystic fibrosis transmembrane regulator, to allow assay of odorant responses by two-electrode voltage clamp electrophysiology. Of the 55 MORs screened, 9 gave significant responses to at least one odorant in our panel. The MRRs of these receptors varied in breadth from receptors responding to a single odorant (for example, MOR283-3 responded only to 2-ethylpyrazine) to MORs responding to a wide variety of odorants (for example, MOR208-3 responded to about a third of the odorants). To explore how MRRs overlap and diverge among members of the MOR family, we cloned and are screening an additional series of receptors related to MOR260-3 (a receptor responding to cyclic alcohol and ester structures). These additional receptors were chosen based on a phylogenetic organization of the MORs, as well as an alternate organisational scheme (Man et al., 2007, PLoS One 2: e682). This work should help distinguish among different organisations of MORs into groups that exhibit similar surveillance of odor space. Acknowledgements: NIH RO1DC008119

#P38

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

First agonists of a human trace-amine associated receptor (TAAR) expressed in the human olfactory epithelium

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Trace-amine associated receptors (TAAR) belong to the family of G-protein coupled receptors and can be activated by amines. All TAAR-subtypes except TAAR1 were exclusively expressed in the main OE of mice and can be activated by different volatile amines,

among them pheromonal active substances from mice urine. Therefore, TAARs were currently suggested to be a second class of olfactory receptors (OR) in the olfactory epithelium (OE) of vertebrates in addition to the canonical ORs. In contrast to several deorphanized mouse TAARs, agonists for the functional human TAAR-genes 2, 5, 6, 8 and 9 that are potentially expressed in the human OE have not been determined so far. Moreover, the physiological relevance of TAARs still remains elusive. We present the first sucessful functional expression of a human TAAR and the agonists of human TAAR5. We performed a ligand-screening using recombinantly expressed TAARs in Xenopus laevis oocytes and HEK293/HANA3A cells. In order to measure receptor activity, we used 2-electrode voltage clamp technique and cAMP-dependent reporter-gene assays. As a result, human TAAR5 can be activated by trimethylamine (TMA) and with less potency and efficacy by dimethylethylamine (DMEA), but not by any other of the 25 tested single amines with related chemical structure or other odorant mixtures. TMA is the prototype of fishy odor with a low odor threshold. It is used for cholin metabolism and appears in human vaginal secretion. This results demonstrate that human TAARs can be functionally expressed in heterologues systems and human TAAR5 responses can specifically evoked by TMA and DMEA.

#P39 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Ectopic expression of human olfactory receptors

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Olfactory receptors (ORs) provide the molecular foundation for the detection of volatile odorant molecules from the environment. Recent studies showed that the expression of these receptors is not restricted to the olfactory epithelium (e.g. testes, prostate and gut). The aim of this work is to create a comprehensive expression analysis of ectopically expressed olfactory receptors in several tissues of the human body. Isolated RNA from several human tissues were analyzed by Next Generation Sequencing with the Illumina Genome Analyzer II and compared to a panel of already existing sequencing data of other different human tissues. These data show that human tissues express a large number of ORs which was verified by quantitative RT-PCR. We could observe the presence of ORs which were expressed in one particular type of tissue as well as ORs which presented a broader distribution. Further characterization of these ORs will provide new insights to the physiological role of distinct ORs outside the olfactory epithelium.

#P40 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Diffusion-based molecular dynamics of odorant binding in olfactory receptors

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With increasing availability of high performance computing systems, all-atom molecular dynamics (MD) simulations of olfactory receptor (OR) models in realistic chemical and thermodynamic environments are almost indispensable so that insight may be gained into the molecular basis of odor-ligand OR activation. We performed a series of MD simulations within a solvated lipid bilayer system of the human OR, OR 17-209 (OR1G1). To further approach physiological conditions of the chemical environment surrounding an olfactory receptor, experimentally-determined (Matarazzo, et al. 2005) activating concentrations of isoamyl acetate molecules were randomly introduced into the extracellular solvent space instead of docking a single molecule into the solvent accessible binding pocket of an otherwise static receptor structure. This novel technique allows the receptor to sample its own conformational space while the ligand molecules are free to interact with it, allowing the identification of the entry pathway into the binding pocket. In addition, systems of varying odorant concentrations and different odorant combinations can be simulated and compared to experimental results. Finally, measuring structural changes in the OR as it undergoes the transition from inactive to active conformations helps to further elucidate the mechanism for receptor activation and odorant specificity. References: Matarazzo, V., Clot-Faybesse, O., Marcet, B., Guiraudie-Capraz, G., Atanasova, B., Devauchelle, G., Cerutti, M., Eitievant, P., and Ronin, C. Chem. Senses 30, 691-701 (2005) Acknowledgements: NIH (NIDCD) (1R21DC011068-01)

#P41 **POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY**

Ligand-Dependent Olfactory Receptor Selectivity for Olfactory Transduction and Modulation

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In the mammalian olfactory system, one olfactory sensory neuron (OSN) expresses a single olfactory receptor gene. We characterized a subset of mouse OSNs (Ho-OSNs) in intact mouse olfactory turbinates using calcium imaging. Ho-OSNs were sparsely positioned in the most ventral olfactory receptor zone, and were sensitive to 2-heptanone (Ho), heptaldehyde (H) and cis-4-heptenal but not to other six odorants tested. Odor-evoked amplitudes were dose-dependent and saturated within one logarithm unit of concentration, a feature comparable to that from isolated OSNs. Application of eight pharmacological reagents affecting adenylate cyclase (AC) or phospholipase C (PLC) pathways showed that Ho and H activated Ho-OSNs through distinct transduction pathways. Ho-evoked responses were mediated by AC-cAMP signaling, while H triggered the PLC-DAG-PKC pathway. Ruthenium Red and 2-aminoethoxydiphenyl borate, reagents inhibiting IP_3 signaling, had no effects on either Ho- or H-evoked responses. Cross-adaptation and binary mixture studies indicate that Ho and H competed for the same binding sites in Ho-OSNs.

Furthermore, pharmacological studies suggest expression of purinergic receptors $P2X_3$ and $P2Y_2$ in Ho-OSNs. Purinergic signaling suppressed odor-evoked responses. Alleviation of $P2X_3$ suppression by $P2X_3$ antagonist RO3 increased H-evoked responses to 200% of its original level. However, RO3 did not change Ho-evoked responses. In summary, our study showed ligand-dependent functional selectivity and modulation of olfactory receptor activity. For the first time, we have provided evidence of complex signaling and modulation mechanisms in olfactory transduction through conformational changes of an olfactory receptor, which has important implications to understand the mechanism of G-protein coupled receptor activation.

#P42

POSTER SESSION I: MULTIMODAL RECEPTION; CHEMOSENSATION & DISEASE; TASTE PERIPHERY; OLFACTION PERIPHERY

drOlfCc1 is an Amino Acid Receptor with the Highest Responsiveness to Isoleucine

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The repertoire of olfactory receptor genes comprises five different families, the rhodopsin-like odorant receptors (ORs), vomeronasal receptors (V1Rs and V2Rs), trace amine-associated receptors (TAARs) and formyl peptide receptors (FPRs). Zebrafish olfactory receptor drOlfCc1 is an ortholog of the mammalian V2R2 gene that is broadly expressed in the olfactory epithelium. It belongs to the "C family" of G-protein coupled receptors (GPCRs). The full coding sequence of drOlfCc1 was cloned into the pCI based expression vector. A Rho tag encoding the first twenty of N-terminal amino acids of rhodopsin was attached in frame ahead of the drOlfCc1sequence. The expression vector was transfected into the Hana3A cell line, a modified HEK293 cell line that stably expresses $G\alpha_{olf}$ and receptor transporting proteins. Expression of drOlfCc1 in Hana3A was confirmed by immunolabeling of the Rho tag to visualize the olfactory receptor protein. Immunocytochemistry revealed that the olfactory receptor was integrated into the surface membrane of cells. Deorphanization of drOlfCc1 was conducted in Hana3A cells by coupling the receptor activity with transients of cAMP-dependent firefly luciferase reporters. Luciferase assay in Hana3A cells showed that drOlfCc1 was sensitive to several amino acids with the highest responsiveness to Isoleucine, followed by methionine, leucine, alanine, phenylalanine, histidine, and tryptophan when tested at 200 μM. Other twelve amino acids tested were nonstimulatory. In conclusion, drOlfCc1 is an amino acid receptor mainly sensitive to a few neutral amino acids. Its receptive profile is narrower than a well characterized zebrafish olfactory receptor drOlfCa1. Acknowledgements: Supported by NIH/NIDCD grant DC011650.

#P43

POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Assessment of intranasal trigeminal chemosensitivity in patients with olfactory dysfunction

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Objective To investigation intranasal trigeminal sense changes in patients with postviral olfactory dysfunction (PVOD) and post traumatic olfactory dysfunction (PTOD). **Methods:** A total of 90 participants (30 healthy subjects, 30 patients with PVOD and 30 patients with PTOD) aged 20 to 70 years. Their chemical sensory functions were examined using T&T olfactometer, trigeminal event-related potentials (tERPs). **Results:** Patients with olfactory dysfunction showed higher thresholds than healthy subjects. Compared to controls, N1/P2 latencies of tERPs increased and amplitudes decreased in patient with olfactory dysfunction. Patients with PTOD exhibited worse olfactory function and decreased trigeminal sensitivity than patients with PVOD. **Conclusions:** Olfactory and intranasal trigeminal systems are closely connected. With regard to intranasal trigeminal ERP, patients with olfactory dysfunction showed longer latency and lower amplitude, which indicated decreased trigeminal sensitivity. Different etiology and olfactory status also affect trigeminal sensitivity differently.
Keywords: Olfactory dysfunction, T&T olfactometer, trigeminal event-related potentials Acknowledgements: China Natural Scientific Foundation under project No. 30973284, Capital Medical Development Foundation under project No. 2007-1034.

#P44

POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Understanding the time course and quality of oral sensations from over-the-counter analgesics

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The acceptability and palatability of children's medications is an ongoing problem for parents and medical professionals. rejection of unpalatable medications hurts compliance with medical regimes and can lead to harm of the child. unfortunately, many biologically or pharmaceutically active compounds taste bitter and/or irritate the mouth or throat. the irritation and bitterness of ibuprofen has been studied previously, but it is not clear how the sensory properties of other commonly used over-the-counter (otc) pain medications compare. this is particularly important when considering appropriate palatability improvement strategies, as techniques to reduce bitterness and irritation may not be the same across pharmaceutical agents whose sensations arise from physiologically distinct systems. here, using a panel of minimally trained participants (n=20), we show that the time course and qualitative aspects of acetaminophen, naproxen, and ibuprofen differ, despite the structural similarity of naproxen and ibuprofen. naproxen and ibuprofen were rated as mostly irritating, with some bitterness, where acetaminophen was mostly bitter with some irritation. none of the compounds were rated as being significantly sour. this

suggests a physio-chemical method for masking these compounds in liquid formulations may be more broadly successful than the development of novel compounds intended to block specific sensory receptors. it seems likely that a combination approach using perceptual mechanisms (addition of sweeteners), physical partitioning, and direct manipulation of receptor-agonist relationships will be the most successful approach to providing a product with acceptable sensory attributes. Acknowledgements: Supported by funds from the Pennsylvania State University and NIH grant DC010904.

#P45 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Sucrose and Menthol Modulate Cough Reflex Sensitivity

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Cough is a vital defensive reflex that protects the airways by clearing accumulated secretions, chemical irritants, and other xenobiotics. However, airway hypersensitivity and coughing that accompany various disease states prompt more physician visits than any other complaint, with billions of dollars spent annually on medication. Interestingly, in clinical trials of cough suppressants, control formulations that lack pharmacologically active ingredients are often almost as effective as formulations with active ingredients, a finding often taken as an unusually strong placebo effect. We hypothesized that chemical stimuli commonly added to cough syrups, including sucrose (sweet taste is analgesic) and menthol (which can modulate the sensitivity of airway afferent nerves) can suppress cough sensitivity. Cough sensitivity was measured using a single-inhalation challenge, a test that determines the minimum concentration of aersolized capsaicin solution needed to elicit a criterion number of coughs (3). In Experiment 1, each subject rinsed their mouth with either a sucrose solution or water (control) before each inhalation of capsaicin. In Experiment 2, subjects inhaled either the headspace above a menthol solution or above a mineral oil blank (control) before each inhalation of capsaicin. Relative to control conditions, rinsing the mouth with sucrose (Experiment 1) or inhaling menthol vapor (Experiment 2) produced a significant increase in cough thresholds, i.e. reduced measured sensitivity. Past research has shown that chemical irritants can trigger cough. The current results suggest that chemical stimuli can suppress cough sensitivity as well, and may help account for the efficacy of cough suppressants and lozenges that lack known pharmacologically active ingredients. Acknowledgements: NIHDC02995 NIHDC03704

#P46 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

The Effect of Smoking and Exposure to Tobacco Smoke on Cough Thresholds

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Cough is a protective reflex that clears the airways of accumulated secretions and chemical irritants. Cigarette smoking alters cough sensitivity, and thus impacts the ability to respond appropriately to such irritants. But smoking not only affects the health of the smoker since it adversely affects children who are passively exposed to environmental tobacco smoke (ETS). ETS exposure puts children at higher risk for adverse health effects, including lower respiratory tract infections such as pneumonia and bronchitis, wheezing, asthma, and ear infections. The present study tested the hypothesis that higher concentrations of an irritant are needed to elicit the cough reflex in ETS-exposed children than Non-ETS exposed children. The parents of these children were also tested to confirm the reported difference in cough sensitivity between smokers and non-smokers. To this end, 2 groups were tested. The ETS-Exposed Group consisted of children whose parents smoked at least 3 cigarettes daily with the child living in the home continuously, whereas Non-ETS Exposed Group consisted of children whose parents had never smoked in their lifetime. Cough sensitivity was measured using a standard single-inhalation challenge, a test of the minimum concentration of the irritant capsaisin needed to elicit cough. Each subject inhaled ascending concentrations of capsaicin, interspersed with control blanks, from a nebulizer until the subject coughed twice in immediate succession. Preliminary analyses revealed that, like their parent, ETS-exposure children had higher cough thresholds than Non-ETS exposed children. Whether attenuation of the negative consequences of smoking increases the odds that these children will experiment with smoking and suffer negative health consequences is an important area for future research. Acknowledgements: The project described was funded, in part, by a grant from the Pennsylvania Department of Health and Award Number R01HD37119 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health and Human Development or the National Institutes of Health. The Pennsylvania Department of Health specifically disclaims responsibility for any analyses, interpretations, or conclusions.We acknowledge the valuable technical assistance of Ms. Fiona Crowley, whose position was created by supplement 3R01HD037119-10S1 received under the American Recovery and Reinvestment Act (ARRA).

#P47 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Solitary chemosensory cells in biopsies of human nasal mucosa

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The nasal respiratory epithelium in rodents is endowed with a population of solitary chemosensory cells (SCCs) innervated by the trigeminal nerve. The SCCs detect irritants including bacterially produced molecules, and evoke trigeminally-mediated protective airway reflexes including neurogenic inflammation and changes in respiration. These cells express all of the components of the bitter taste transduction pathway expressed in taste receptor cells of the tongue including T2R bitter taste receptors, the G protein α-gustducin, and the downstream signaling effectors, PLCβ2 and the transduction channel TrpM5. We have begun studies to examine SCCs in the human nasal cavity. We used PCR and immunohistochemistry on biopsy material from human sinonasal mucosa to evaluate the presence, location, and density of

SCCs. Our experimental group consisted of patients that have pain associated with chronic rhinosinusitis, while the control group consisted of healthy patients undergoing nasal surgery. We used PCR to determine expression of the downstream signaling effectors α-gustducin, PLCβ2, and TrpM5 as correlated with pathogenic states. Moreover, immunohistochemistry was used to reveal anatomical features of these cells and possible innervation by peptidergic fibers (polymodal nociceptors) of the trigeminal nerve. Our preliminary findings indicate the presence of SCC markers in the septum, inferior and middle turbinates, and uncinate processes. Further investigation will test for an association between the density and location of SCCs and patient characteristics of local inflammation and pain. Acknowledgements: Supported by NIH grants R01DC009820 and P30DC004657 and by Dept. of Otolaryngology Resident Research Funds

#P48 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Distribution of solitary chemosensory cells (SCCs) in the nasal mucosa of mice

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Background: Solitary chemosensory cells (SCCs) seem to have a supporting function of the intranasal trigeminal system. SCCs are isolated elements located in the epithelia of the respiratory and digestive organs. Previous studies found SCCs at the surface of the nasal mucosa in rats and mice which form synaptic contacts with trigeminal afferent nerve fibers and express essential elements of chemosensory transduction. Aim of this study was to investigate the topographical distribution of these SCCs in mice in detail. *Material and Methods:* Noses of 10 mice, 5 2-years-old (3 female, 2 male) and 5 12-weeks-old (2 female, 3 male), were investigated so far. Following euthanasia and perfusion the whole mouse nose was carefully dissected, processed and cryostat sections (30µm) were prepared for immuno-fluorescense. As primary antibody rabbit anti-α-gustucin (1:1000) was used. Specimens were visualised on a special epifluorescence microscope (Z, Mosaic) and SCCs were counted (anterior-posterior and caudal-cranial). *Results:* SCCs were found in all mice. Preliminary analyses indicate that SCCs are not distributed symmetrically in the nasal cavity. They can appear singularly or arranged in groups. Their numbers appear to decrease from anterior to posterior and from caudal to cranial. Many SCCs are located in the anterior vomeronasal duct. *Conclusions:* The present data indicate a distinctive existence of SCCs in mice and suggest topographical differences in their arrangement. Acknowledgements: Acknowledgement: Supported by a grant from the Deutsche Forschungsgemeinschaft (DFG) (SCHE 1737/1-1) to Mandy Scheibe

#P49 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Nasal epithelium inflammation: involvement of solitary chemosensory cells after short term presentation of the irritating compound denatonium benzoate

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Airways are continually assaulted by harmful compounds carried on the incoming airstream. The airway epithelium houses a population of trigeminally innervated solitary chemosensory cells (SCCs) that express T2R taste receptors along with their downstream signaling components: Gα-gustducin and TrpM5. We have shown that nasal SCCs are necessary to evoke trigeminally mediated respiratory reflex reactions to the T2R-ligand denatonium benzoate and to acyl–homoserine lactones (AHL), quorum-sensing molecules of Gram-negative bacteria (Gulbransen 2008, Tizzano 2010). These studies showed the necessity for SCCs in triggering respiratory depression to certain types of irritants. We investigated here the possibility that SCC activators, e.g. denatonium, also trigger an inflammatory and immune response in the nasal cavity. We exposed the nasal passageways to denatonium benzoate (10mM) and injected the animals intravascularly with fluorescently-conjugated albumin. Within 20 min., we detected leakage of plasma albumin into the nasal epithelium. In addition, we find that short term stimulation with denatonium of the nasal epithelium, causes mast cells degranulation. Genetic deletion of either Gα-gustducin or TrpM5, essential elements of the T2R transduction cascade, eliminates the plasma leakage and deletion of TrpM5 eliminates mast cells degranulation. These findings indicate that activation of the SCCs can lead to rapid local inflammatory responses in the nasal epithelium, likely via neurogenic mechanisms, i.e. release of peptide mediators from the activated nerve fibers. These fast inflammatory responses may represent a defense mechanism to activate a local response of the epithelial innate immune elements before a toxin can cause severe damage to the airways and lungs. Acknowledgements: Supported by NIH/NIDCD RO1DC009820 to TF

#P50 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Chemosensory Brush Cells of the Trachea: Turnover, Proliferation and Regeneration

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Tracheal chemosensory brush cells (CBCs) are specialized epithelial chemosensors which utilize the canonical taste transduction pathway (T2Rs, Gα-gustducin and TRPM5) to detect irritants. To determine if CBCs turnover with the surrounding epithelium, as do solitary chemosensory cells and taste receptor cells, we used 5-bromo-2'-deoxyuridine (BrdU) to label dividing cells in adult C57Bl6 mice. Although scattered BrdU labeled tracheal epithelia cells (TECs) are present 5-20 days post-BrdU, no CBCs were labeled at any time. These data suggest that CBCs are a static population, an uncommon trait among epithelial chemosensory cells. Since CBCs are not replaced in normal adult trachea, we questioned at what time the cells were generated during

development. After we injected 5 day old mice with BrdU, both CBCs and TEC were labeled 5 days post-BrdU. Over the following 60 days, the percent of labeled CBCs increased while the percent of labeled TECs decreased. These data suggest that CBCs are generated from non-CBC progenitor cell during development, particularly postnatally while the trachea is growing. We then asked if new CBCs could be generated from the adult epithelium or if the capacity to generate new CBCs was lost after the perinatal period. TECs were recovered from adult A/J mice and grown in an air-liquid interface (ALI) culture. After 14 days at ALI, the number of CBCs increased to 1% of the total population. BrdU added to ALI cultures labeled CBCs, indicating that the increase in CBC density was due to new cell divisions. We conclude that: 1) CBCs are normally a static population in adult mice; 2) CBC progenitors proliferate during neonatal development while the trachea is growing; and 3) CBCs can be regenerated from a proliferative population resident in the adult epithelium. Acknowledgements: Supported by NIDCD & NHLBI

#P51 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Biophysical Characterization of the Human Nociceptor Channel, hTRPA1

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There is striking similarity in the functional role of TRPA channel orthologs among evolutionary diverse species. Abundantly expressed in the somatosensory system, including in trigeminal neurons, mammalian TRPA channels detect and integrate noxious stimuli of different sensory modalities including mechanical and thermal. They also function as broad-spectrum "alarm" chemoreceptors, signaling potentially harmful exposure to irritants and pungent compounds. Despite a growing understanding of potential modulators, agonists, and antagonists for these channels, the exact mechanisms of channel regulation and activation remain mostly unknown or are controversial, including even the basic biophysical parameters of both native and heterologously expressed TRPA channels. Here we transiently express the human TRPA1 (hTRPA1) channel in HEK293T cells and use conventional single channel inside-out and outside-out patch recording to characterize the basic properties and the ion selectivity of the channel. The relative permeability of the channel to inorganic cations is: Ca^{2+}(5.1) > Ba^{2+}(3.5) > Mg^{2+}(2.8) > NH_4^+(1.5) > Li^+(1.62) > Na^+(1.0) ≥ K^+(0.98) ≥ Rb^+(0.98) > Cs^+(0.95). To organic cations it is: Na^+(1.0) ≥ DiMA(0.99) > TriMA(0.7) > TetraMA(0.4) > NMDG(0.1). Activation of the channel appears to recruit the channel to a conformational state with increased permeability to large organic cations. The pore of the channel in this state can be characterized as being dilated approximately 1-2.5Å (from ~6.5/8.2 to ~7.4/10.6 Å) based on estimates of the minimum cation diameter/mean cation diameter). Overall our findings further characterize and refine the basic parameters of the hTRPA1 channel, in particular to help predict water soluble (low logD) ligands and pharmacological compounds that can permeate the channel. Acknowledgements: This work was supported by National Institute on Deafness and Other Communication Disorders (DC005995 and DC001655). We thank Drs. Gunter Gisselmann and Hanns Hatt for generously providing hTRPA1.

#P52 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

The involvement of TRP channels in trigeminal odour sensation

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To date, the detection of different odorants by the olfactory system is well investigated and understood. However, much less is known about the activation of the trigeminal system (TS) caused by the majority of odorants in higher concentrations. Some members of the transient receptor potential (TRP) superfamily of ion channels are highly expressed in trigeminal sensory neurons. In order to investigate if different TRP channels are involved in the detection of several odorants by the TS, we used primary cultures of rat trigeminal sensory neurons (TSN's) to perform an overlapping study with classical TRP channel agonists and different odorants using calcium imaging. The findings of this study gave first hints to an involvement of TRPV1, TRPM8, and TRPA1 in the detection of the odorants we used. To obtain a better understanding of the odorant-effect on the specific TRP channels, we performed current clamp measurements on TSN's during which we applied different odorants in the presence and absence of respective antagonists. Although the blockers failed to completely inhibit odorant induced depolarisations, the effects on the membrane potentials were significantly decreased in the presence of these substances. Finally, we used CHO cells heterologously expressing either rTRPA1, rTRPV1, or rTRPM8 performing whole-cell measurements, in order to test the direct effect of the odorants used on the respective channel proteins. Our experiments indicate that TRPV1, TRPM8, and TRPA1 seem to play crucial roles in the detection of different odorants via the TS. A better understanding of the odorant interaction with different TRP channels might lead to a more detailed understanding of the properties of the TS.

#P53 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Microglial Responses After Injury of the Chorda Tympani Nerve

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The chorda tympani (CT) nerve, which innervates taste buds on the anterior tongue, is vulnerable to injury during dental and inner ear procedures. The CT is primarily a sensory nerve restricted to fine caliber fibers that convey special visceral, or gustatory, sensation. When the CT is damaged, robust microglial responses occur in the first central gustatory relay, the nucleus of the solitary tract (nTS). Microglial cells rapidly become morphologically reactive and their density increases significantly on the injured side as a result of proliferation and migration. Although the CT nerve does not carry pain fibers, the general profile of microglial responses in the nTS is similar to that described in nerve injuries that model chronic pain. In pain models, microglial responses actively contribute to the initiation of chronic pain signaling that persists long after the initial nerve damage. Recent studies have demonstrated a crucial role for the microglial Toll-like receptor 4 (TLR4) in this microglial

reactivity after sciatic nerve injury. To test if TLR4 may also be fundamental to microglial responses in the nTS, CT injury was performed on TLR4 point-mutant mice (C3H/HeJ), which express only a mutated and nonfunctional TLR4 protein. From 3-5 days after CT damage, microglia still reacted in the nTS. In particular, a cluster of microglial cells appeared in the CT terminal field and microglia underwent typical transformations to display reactive morphologies with shorter, thicker processes and an amoeboid shape. Although deletion or blockade of TLR4 prevents microglial reactivity after sciatic nerve injury, TLR4 signaling does not appear to be required for microglial responses after CT injury. This suggests that different signals activate microglia after CT damage compared to pain models. Acknowledgements: Supported by NIDCD grants R56DC000147 and P30DC004657 to T.E.F. and D.R.

#P54 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Biophysical, morphological, and synaptic properties of intramedullary projection neurons in the rostral nucleus of the solitary tract

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The efferent circuitry of the first-order gustatory nucleus, the rostral nucleus of the solitary tract (rNST), arises from two major pathways. Although much is known regarding the characteristics of ascending projections to the pons, the biophysical, morphological, and synaptic properties of the intramedullary descending projections remain less clear. To identify rNTS descending projection neurons, unilateral iontophoretic injections of DiI were made into the reticular formation (the major target of this neuron population). One to three days post-injection, 300-400mm coronal or parasagittal (parallel to the solitary tract) brain slices containing the rNST were prepared for whole cell patch clamp recording. Retrogradely labeled neurons were bilaterally located in the ventral and rostrocentral rNST subdivisions. The majority of neurons responded to depolarizing current injection with a tonic firing pattern, although initial burst and irregular firing patterns were also observed. Descending projection neurons also exhibited a number of different voltage activated currents, with some neurons expressing post-inhibitory rebound spikes, Ih currents, and A-type potassium currents. Small current pulses delivered to the rostral tip of the solitary tract with a bipolar stimulating electrode evoked monosynaptic excitatory post-synaptic currents in approximately half of the neurons tested. The remainder responded with postsynaptic currents with variable latency and reliability, indicative of polysynaptic circuitry. The majority of neurons recorded were multipolar with spiny dendrites extending into multiple rNST subdivisions. This study has revealed that descending rNST projections arise from heterogeneous subpopulations of neurons, which may exert equally complex control over oromotor reflexive behaviors. Acknowledgements: NIH: R01DC000288-25, T32DC000011-33

#P55 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Morphology and Distribution of GFAP Labeled Elements in the Developing Solitary Tract and Nucleus of the Solitary Tract

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Glial fibrillary acidic protein (GFAP) is a marker of intermediate filaments that identifies cells of astrocytic origin in the developing central nervous system. We surveyed GFAP expression in the developing solitary tract (ST) and rostral nucleus of the solitary tract (rNST) to characterize glial morphology and distribution in this gustatory brainstem area. The ST consists of afferent fibers that originate in the oral cavity and project to the rNST, the site of the first synaptic relay in transmitting taste-related information to higher brain areas. In horizontal sections of rat brainstem, fasciculated GFAP labeled fibers were present in the ST as early as embryonic day 14 (E14) and persisted throughout development. At E18, radially oriented GFAP labeled fibers were observed in addition to those found in the ST. There were no GFAP labeled astrocytic-like cells in the presumptive rNST at any embryonic age examined (E14, E15, E16 and E18). Postnatally (P1, P5 and P10), GFAP labeled fibers persisted in the ST, but were less fasciculated. A continued postnatal presence of radially oriented GFAP labeled fibers was also noted. In addition, astrocytic-like cells appeared in the rNST and were found more rostrally as development progressed. In coronal sections, these astrocytic-like cells were predominantly localized to the ventral subdivision of the rNST. Interestingly, the initial, embryonic appearance of GFAP labeled fibers was concurrent with the appearance of fibers labeled with neuropilin 1 and neuropilin 2, transmembrane proteins that bind semaphorins, suggesting a possible role for GFAP in axon guidance and fasciculation. Labeling for GFAP with additional markers, such as calbindin and neurofilament, will highlight potential interactions between glia and neurons in the developing brainstem. Acknowledgements: NIDCD, NIH Grant DC009982

#P56 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Neuropilin 1, Neuropilin 2 and calbindin expression in the developing rat solitary tract and rostral nucleus of the solitary tract

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The rostral nucleus of the solitary tract (rNST) receives orosensory information via cranial nerves VII, IX and X. These nerves enter the brainstem, form the solitary tract (ST) and synapse with rNST neurons. We studied development of ST and rNST in E (embryonic) 13 to E18 rats. DiI was applied to VII and the geniculate ganglion to identify ST. Immunolabeling of neuropilin 1 (Npn1) and 2 (Npn2), axon guidance receptors, was used to investigate their contribution to ST formation. Calbindin was used to label rNST neurons. At E13, DiI-labeled ST extends caudally in

the brainstem. Medially directed collaterals of ST appear at E15 as single unbranched fibers that extend to the IV ventricle. By E16, ST collaterals differ in length and morphology, often with a beaded appearance. Npn2 also labels ST at E13 and E14. At E14 and E15, large Npn2 positive, tuft-like processes surround presumptive rNST neurons located medial to ST. By E16, ST consists of a broad band of Npn2 positive fascicles and medially directed collaterals. In contrast, at E14, Npn1 labels ST and trigeminal tract and this expression pattern persists through E18. At E14 and E16, co-labeling Npn1 and 2 showed that both antibodies label ST, whereas the trigeminal tract is only labeled with Npn1 and the tuft-like processes are only labeled with Npn2. At E13, calbindin is expressed in a group of cells medial to ST. Calbindin labeled cells increase in number, have a migratory appearance and are scattered across Npn2 positive fibers by E14. By E18, the rNST is obvious as a cluster of calbindin-positive neurons. These results describe formation of ST projections and their relation to developing rNST neurons. Furthermore, results suggest that Npn 1 and 2 are molecular determinants involved in formation of ST and rNST.
Acknowledgements: NIDCD, NIH Grant DC009982

#P57 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Post-Oral Glucose Activates Central Taste Areas with Dissociated Involvement of Parabrachial and Amygdalar Projections: Fos Immunohistochemistry in Rats With Asymmetrical Lesions

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Whereas integration of intestinal chemosensory and metabolic signals is required to generate appropriate homeostatic and behavioral responses, the underlying neural substrates remain obscure. This pilot study challenged the hypotheses that central taste areas also play role in mediating post-oral effects of glucose, and that projections from the pontine parabrachial nucleus (PBN) to the central nucleus of the amygdala (CeA) influence activation of the reward circuitries. First, rats received ibotenic acid (IBX, n=6) or vehicle injections (n=6) in the PBN in one hemisphere and the CeA in the other. IBX rats showed reduced 10-s lick-responses to sucrose but no difference in body weight or food intake. Fos immunoreactivity (IR) was used as an index of neural activity following gastric gavage of glucose (IG, 20%, 2g/kg). IG glucose stimulated Fos-IR in the NTS (caudal > rostral), the PBN (lateral > medial), the hypothalamus (ARC, PVN, VMH, DMH, LH), the lateral habenula, the amygdala (CeA > BLA), the lateral BNST, the VTA and the NAcc (core > shell), the thalamus (VPMpc, CM, CL, PVN, SPF), the gustatory and medial prefrontal cortices. Whereas the lesions had no effect on glucose-induced activation of the NTS, hypothalamus, VTA, and NAcc core, IBX rats showed decreased Fos-IR in the NAcc shell, mPFC, and the gustatory cortex with all effects limited to the side of CeA lesions. These findings demonstrate the efficiency of IG glucose to activate – in addition to energy regulatory circuits – all major central gustatory areas. Moreover, this initial data suggests that amygdalo/BNST-(thalamo-cortico)-striatal networks rather than direct (ipsilateral) PBN projections to the CeA or to the VTA play a role in activating the forebrain reward system – at least – when glucose stimulation bypasses the oral receptors. Acknowledgements: Supported by NIH grant DC000240 to A.H.

#P58 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Anorectic Signaling Pathway Mediated by Salivary PYY

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Peptide YY (PYY), a hormone that induces satiety, is synthesized in L-endocrine cells of the distal gut epithelia. It is secreted into circulation in response to food intake (FI) and induces satiation upon interaction with its preferred receptor, Y2R. Recently we have demonstrated the presence of the truncated form, PYY_{3-36}, in saliva from both mice and humans, as well as the expression of the Y2R receptor in lingual epithelia cells. In the current report, we describe a novel neural circuit activated in response to the acute pharmacological augmentation of salivary PYY_{3-36} at doses which reliably results in a significant reduction of FI and body weight (BW). In fasted mice, neurons in hypothalamic nuclei that mediating feeding, hunger and satiation were activated significantly in response to orally applied PYY_{3-36}, similar to a fed control group and a peripherally injected PYY group. Activated areas in the nucleus of the solitary tract (NST), identified by the increased numbers of c-Fos positive neurons, were markedly different for the rostral relative to the caudal NST, in response to systemic vs local oral PYY treatment. This distinctive pattern of neuronal activation was corroborated by behavioral studies assaying liquid and solid food intake after conditioned taste aversion (CTA) induction. Remarkably, orally applied PYY_{3-36}, while inducing strong anorexigenic responses, did not induce CTA. Taken together, these data provide support for the existence of a putative metabolic circuit associated with Y2R-positive cells in the oral cavity which extends through brainstem nuclei into hypothalamic satiety centers. The discovery of this alternative metabolic pathway which regulates ingestive behavior reinstates the potential of PYY_{3-36} for the treatment of obesity.

#P59 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Anxiety- and depression-like behaviors with decreased brain dopaminergic activity in rats with lingual nerve transectomy

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Sensory information plays an important role to determine psycho-emotional behaviors of individuals. In this study, we have examined changes in anxiety- and depression-related behaviors of rats after blocking the oral sensory relay to brain. Male SD rats were subjected to behavioral sessions two weeks after bilateral transectomy of lingual nerve (LNX) or sham operation, and then tissue contents of dopamine and its metabolites in each brain regions were analyzed by high-performance liquid chromatography. Initial weight loss after the surgery was bigger in LNX rats and this effect remained during the whole experimental period, although

daily food intake per 100 g body weight became greater in LNX rats. Ambulatory activity was decreased, anxiety-related behaviors during the activity test increased, time spent in the open arms during elevated plus maze test decreased, and immobility duration during Porsolt swim test increased in LNX rats compared with sham rats. Dopamine contents in the hippocampus, nucleus accumbens, and the mid-brain dopamine neurons were decreased in LNX rats compared with sham rats. Results suggest that aberration of oral sensory relay to brain may lead to the development of depression- and anxiety-related disorders, and decreased dopaminergic activity in the brain regions play a role in its underlying mechanism. Acknowledgements: Supported by the 21st Century Frontier Research Program (2009K001269) and the NRF (2010-0003642) funded by MOEST

#P60 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Mixture suppression of sweet and umami taste by quinine in the mouse brain: Implications for taste coding

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Sweet and bitter-tasting compounds produce opposite patterns of ingestive and aversive taste reactivity. Previous studies in rodent taste nerves or brainstem neurons have shown that quinine has a suppressive effect on the neural response to sucrose. This is likely dependent on the TRPM5 channel in taste cells (Talavera et al., 2008). We have recently demonstrated that sucrose and a "synergistic" mixture of MPG and IMP evoke highly similar patterns of neural activity in the mouse parabrachial nucleus (PBN). In this experiment, we extend these findings by assessing the potential suppressive effects of quinine on the response to sucrose, MPG, IMP or an MPG-IMP mixture. We recorded extracellularly from 70 mouse PBN neurons in response to a total of 15 taste stimuli, including quinine mixtures. Quinine effectively blocked the response to sucrose and the MPG-IMP mixture in neurons characterized as sucrose-best (S-best), as well as in NaCl-best neurons highly responsive to sucrose, but not in other neuron types. However, the suppressive effect on sucrose was greater than the effect on the MPG-IMP mixture. The residual response in this case is likely to due to other, non T1R- or TRPM5-dependent transduction mechanisms for umami stimuli. Multi-dimensional scaling analysis showed that when sweet or umami-tasting stimuli are mixed with quinine, they cluster with quinine in the 3-dimensional "taste space". Reconstruction of recording sites support quality-based topography in the PBN, with S-best cells occurring preferentially either in the medial or waist region, while Q-best and N-best cells were most often recorded in lateral subnuclei. Acknowledgements: NIH DC000353 (J.D.B.)

#P61 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Taste responses of simultaneously recorded parabrachial and cortical neural ensembles in awake rats

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Taste neurons in the rodent parabrachial pontine nuclei (PbN) take almost direct input from the mouth, and are capable of controlling some basic taste-driven behaviors. Thus it is reasonable to assume that PbN taste responses might reflect activation of taste cells on the tongue in a simple manner. However, these neurons also receive strong feedback from forebrain regions such as gustatory cortex (GC), which has been shown to respond to tastes with complex "temporal codes" that signal first the presence, then identity, and finally the palatability of tastes (Katz et al 2001, Grossman et al 2008, Sadacca et al, under review). Therefore it is also reasonable to suggest that PbN taste responses may reflect this strong feedback, in the form of similarly complex temporal codes. In order to determine whether PbN taste responses reflect simple ascending information, complex descending information, or both, I recorded taste responses of multi-site PbN/GC single-neuron ensembles in conscious female long evans rats (n=11). Rats received 40 µl aliquots of 0.1 M NaCl, 0.01 M citric acid, 0.0001 M quinine HCl, 0.05 M sucrose passively delivered via interoral cannulae. Analysis of these data demonstrates that approximately 32% of PbN neurons respond distinctly to different tastes in the time domain, a percentage similar to that observed in simultaneously recorded GC neurons. Furthermore, we observed evidence that PbN taste responsive neurons may actually be more temporally complex than those in GC, changing rates at a time point amidst one of the previously-described GC "epochs." These results help to clarify how taste processing occurs in real time, and also shed light on the processing performed in any sensory system characterized by extensive feedback from forebrain to early relays. Acknowledgements: NIH T32 NS007292 NIH/NIDCD RO1DC007703

#P62 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Characterization of gustatory event related potentials related to salt and sweet quality

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Aim: The present study aimed to characterize the EEG-derived event related potentials (ERPs) in response to salt and sweet stimulation. We compared results from a classical approach with those from a high spatial resolution model. Methods: An EEG System with 128 electrodes was used to record ERPs. For the classical approach 5 electrodes, corresponding to Cz, Fz, Pz, C3 and C4 positions, were extracted. The main ERP components were

analyzed. Moreover, a high resolution map of the distribution of the electrical field was produced for each component. Twenty-five healthy volunteers (mean age: 24 years) participated. Normal gustatory and olfactory functions were ascertained tested by means of "Sniffin' Sticks" and taste spray tests. Stimuli for ERP recordings were delivered using a gustometer (GM01-Burghart Medizintechnik, Wedel, Germany). This device is controlled by computer, with special characteristic able to elicit ERPs (quasi-squared pulsed stimuli, constant temperature of 38°C). Results: Our preliminary results show a faster response related to salt stimulation compared to sweet (ΔP1= 75±4 ms; ΔN1= 70±4 ms; ΔP2 = 148±8 ms). The strongest response (highest peak-to-peak amplitude) was observed for salt at the frontal position. The right side of the brain exhibited stronger than the left side (C4 amplitude >C3 amplitude). The topographic distribution of the potentials shows an early positivity on the right side of the brain (P1) that moves to the posterior with strong negativity on the frontal side (N1). Finally the component at P2 is related with a strong positivity in the central part of the brain (P2). Conclusions: High-resolution gustatory ERP appears to be useful in the investigation of the development of the central-nervous response, especially during the early processing.

#P63 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Brain correlates of mental imagery in "olfactorily" and "auditorily" creative thinkers

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There are large individual differences in the ability to form vivid mental images. Experience accounts for some of this variability and its long-term effect can be seen in creative thinkers, such as Chefs or musicians. If Chefs and musicians have respectively better olfactory and auditory imagery ability than do lay persons, how is such advantage reflected in brain activity? Does their expertise transfer to imagery in other modalities, or is it modality-specific? To test these questions, we recruited 43 participants (13 cooks, 15 musicians, 15 lay controls; mean age: 29.7+/-10.8) who completed a 2-step imaging task: first, they read 2 words (A and B) naming 2 fruits (or 2 musical instruments). Then, a third word (C) was presented and participants had to decide whether the odor of fruit C (or the timbre of instrument C) was more similar to that of word A or B. Response times were compared between the odor (or timbre) imagery task and a control task (size imagery of fruits or instruments). Evoked potentials were recorded using a 64-channels EEG system. Whereas cooks responded faster during odor imagery than size imagery for fruits, musicians responded faster during timbre imagery than size imagery for instruments. Controls did not differ between these tasks. At the neural level, a hemispheric dissociation emerged for a late positive complex (time window: 800-1200ms): (1) tasks involving mental imagery of size (fruits or instruments) involved significantly more strongly the left hemisphere in all three groups, (2) odor imaging recruited equally strongly both hemispheres in cooks, (3) timbre imaging recruited equally strongly both hemispheres in musicians. These findings suggest that sensory experience in creative thinkers involves a domain-specific brain modulation of mental imaging ability.
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#P64 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

No effects of handedness on passive processing of olfactory stimuli: an fMRI study

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The study aimed to investigate possible differences in lateralized olfactory processing in left- and right-handed subjects using a functional MRI paradigm. Twenty-four (14 female, 10 male) right handers and 24 (14 female, 10 male) left handers participated; their mean age was 24.0 years, all were in excellent health with no indication of any major nasal or other health problems. The rose-like odor phenyl ethyl alcohol and the smell of rotten eggs (H_2S) were used for relatively specific olfactory activation in a block design using a 1.5 T MR scanner. Results indicated no major differences in lateralized olfactory activation between left- and right-handers. This suggests that in simple olfactory tasks handedness does not seem to play a substantial role in the processing of olfactory information.

#P65 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Dynamic Behavior of fMRI BOLD Signal in Olfaction: Curbing Habituation Effects and Identifying Associated Olfactory Neural Networks

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Introduction The study investigated patterns of spatial and temporal BOLD signal behavior in the olfactory network of healthy adults following presentation of multiple concentrations of lavender. Olfactory functional activity was investigated using converging methods of General Linear Model (GLM), Group Independent Component Analysis (ICA), and unified Structural Equation Modeling (uSEM). We hypothesize that specific functional networks subserve primary perceptual as well as higher-order olfactory-related cognitive processes. **Results** Time course plots of average POC activity for each stimulus revealed that different odorant strengths elicited similar BOLD effect responses. Group ICA analysis delineated separable neuronal circuits that were spatially centered in the primary olfactory cortex, striatum, dorsolateral prefrontal cortex, rostral prefrontal cortex /anterior cingulate, and parietal-occipital junction. The uSEM analysis identified biologically plausible olfactory networks that subserve primary perceptual as well as affective/motivational and higher-order olfactory-related cognitive processes, with each expressing unique spatio-temporal BOLD signal characteristics. **Conclusion** The novel olfactory stimulation paradigm greatly reduced habituation effects and permitted the identification of five olfactory networks. Findings were interpreted within a model that specifies

primary and secondary levels of olfactory processing. The converging analyses fit well with the recently proposed concept of "*olfactory objects*" and provide a basis to investigate how these objects may be mapped at different levels of perceptual processing and anatomical activity. Acknowledgements: National Institute of Aging, R01-AG027771

#P66 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Olfactory habituation in the human brain

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A thorough understanding of the dynamic behavior of the blood-oxygen-level-dependent (BOLD) signal due to habituation in the central olfactory system is essential for clinical applications of olfactory functional magnetic resonance imaging. In this study, we characterized the dynamic behavior of the BOLD signal in the primary olfactory cortex and related structures when subjected to odor habituation. Responding to 60 second prolonged odorant presentations, the primary olfactory cortex showed a transient, strong activation followed by a weakened but sustained activation until the odorant was undetectable by the subjects. The activation in the secondary olfactory structures all followed similar signal-time course, including such structures as the orbitofrontal cortex, insular cortex, prefrontal cortex, supramarginal cortex, precuneus cortex, and anterior and posterior cingulate cortex. Short-term olfactory habituation that happened within seconds and was fully recovered in less than 98 second. These results suggest that the olfactory habituation in the various brain structures follows the same mechanism, which may be controlled by the primary olfactory cortex. Acknowledgements: This study was supported in part by the Pennsylvania Department of Health and NIH RO1 EB00454.

#P67 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Complexity of odorant structure influences human olfactory cortex activity: an fMRI study

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An important issue in olfaction research is to relate percept to the molecular structure of stimuli. Previous studies attempted to relate odor quality to the odorant's physicochemical parameters. Recently, we showed a quantitative structure-odor relationship in which the more structurally complex a monomolecular odorant, the more numerous the olfactory notes it evokes (Kermen et al., 2011). The present study examined how such quantitative structure/percept relationship was reflected in the human olfactory system. To this end, twenty-one participants were stimulated with low (guaiacol, isoamyle acetate) and high complexity odorants (R-limonene and terpinenol). Responses were assessed by fMRI (1.5T -Siemens Sonata; slices: 26; FOV: 19.2cm; Matrix: 64x64; TR: 3sec; TE: 45ms; FA: 90°; Voxel size: 3x3x3mm). Stimuli were delivered to the subjects using an air-dilution olfactometer (1.5 l/min); after the functional scans, participants were to estimate intensity, pleasantness, familiarity of the stimuli and the number of olfactory notes: whereas low and high complexity odorants were assessed with the same intensity, pleasantness and familiarity ($p>.05$ in all cases), the latter induced more olfactory notes than the former ($p=.015$). A preliminary analysis performed on the imaging data using SPM8 and Activis revealed significantly greater piriform activation for high than low complexity odorants. Taken together, these findings suggest that molecular complexity provides a framework to explain both the subjective experience of smells and its neural processing in primary olfactory cortex. *Kermen, F. et al. Sci. Rep. 1, 206; DOI:10.1038/srep00206 (2011).* Acknowledgements: Region Rhone-Alpes CIBLE 2011 ANR EMCO - ICEO Project

#P68 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Food craving studied by combined visual and olfactory stimulation

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Tasting, smelling, and seeing food combine to provide an experience that triggers our reward system. It has been demonstrated that the taste of food, especially sweet food, evokes activation in the caudate, putamen, and orbitofrontal cortex when compared to a tasteless solution. It has also been shown that just seeing and smelling food can cause craving. In this study we combined congruent olfactory and visual cues for a more reliable response than either might provide alone to examine if the degree of food craving was correlated to activation in the reward system. We used functional magnetic resonance imaging (fMRI) to study blood oxygen level dependent (BOLD) signal change in the reward system during presentation of the stimuli. During the paradigm, subjects also rated how much they wanted to eat the food after each stimuli presentation. Five subjects performed two runs for a total of ten runs. The data showed intense global activation in the brain and specifically in the putamen, caudate, insula, orbitofrontal cortex, and anterior cingulate (p <0.001) that correlated to when the subject really wanted the food. We also examined if visual-olfactory cue presentation would activate the reward areas as well as the insula as is seen in taste fMRI studies. When all stimuli were averaged for all five subjects (p <0.005), activation was observed in the insula, operculum, anterior and posterior cingulate, caudate, and putamen. These preliminary data suggest that the level of food craving is highly correlated to brain activation in the reward system when an olfactory and visual food stimulus is combined. Furthermore, it appears that olfaction with visual stimuli triggers areas, specifically reward areas, which are similar to those stimulated by taste stimuli. Acknowledgements: Supported by the Penn State Social Sciences Research Institute and, in part, under a grant with the Pennsylvania Department of Health using Tobacco CURE Funds. The Department specifically disclaims responsibility for any analyses, interpretations or conclusions.

#P69 WITHDRAWN

#P70 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Negative Olfactory Alliesthesia in Anxiety: An fMRI investigation

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Olfactory hedonic evaluation tends to depend on the perceiver's internal state (known as olfactory alliesthesia). Accordingly, the internal state of anxiety can negatively shift odor valence and confront anxious people with increased olfactory stress in everyday life. Combining anxiety provocation and fMRI techniques, we interrogated anxiety-state-dependent affective evaluation and perceptual coding of initially neutral odors.We predicted that anxiety would increase aversion to odors via altered hedonic judgments subsequent to the experimental manipulation (negative olfactory alliesthesia). In parallel to behavioral observation, we predicted fMRI response amplification in olfactory and limbic circuitry with increased anxiety. Analyses indicated that induced anxiety led to more negative hedonic judgments for neutral odors (pure odors and mixtures; N=12; p<.05). Consistently, anterior piriform, hippocampus, orbitofrontal, and insular cortices showed significant response enhancement to both pure and odor mixtures (versus air) post anxiety induction (N=12; p<.001, uncorrected). Therefore, our data highlighted the possibility that anxiety can negatively bias affective evaluation of one's olfactory environment, causing otherwise benign odors to become intrusive. This finding may provide a novel etiological model of anxiety where anxiety subjects affected individuals to heightened olfactory distress, thereby fueling and perpetuating anxiety symptoms.
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#P71 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Correlation between olfactory bulb volume and olfactory function in children and adolescents

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The olfactory bulb (OB) is considered to be the most important relay station in odor processing. The present study aimed to investigate the volumetric development of the human bulb and the olfactory function during childhood and youth. Furthermore the present study aimed to investigate a possible correlation between OB volume and specific olfactory functions including odor threshold, odor discrimination and odor identification. A total of 87 subjects (46 male, 41 female), aged 1 to 17 years (mean age 8 years), participated in this study. None of them reported olfactory dysfunction or had signs of a dysfunctional sense of smell. Whenever possible, participants received a volumetric scan of the brain (MRI) and lateralized olfactory tests. Volumetric measurements of the right and left OB were performed by manual segmentation of the coronal slices through the OB. Significant correlations between OB volumes and olfactory function was observed. Both, OB volumes and olfactory function increased with age, although the correlation between structure and function was not mediated by the subjects' age. In conclusion, for the first time the present study showed a correlation between OB volume and olfactory functions in children. Acknowledgements: Supported by the DDELTAS (Dijon-Dresden European Laboratories for Taste and Smell - LEA 549), underwritten by the Centre National de la Recherche Scientifique-Paris and the Technische Universität Dresden, and awarded to BS and TH, and a grant from the Roland Ernst Stiftung to TH.

#P72 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Cholinergic modulation of olfactory bulb mitral/tufted cell glomerular odor responses

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Olfactory receptor neurons project their axons to specific glomeruli across the olfactory bulb. This convergence of ORN input into the OB forms the basis of odorant-specific spatial maps of mitral/tufted (M/T) cell glomerular activity. This initial stage of olfactory information processing receives heavy cholinergic fiber input from the horizontal limb of the diagonal band (HDB). In other sensory systems, basal forebrain cholinergic input has been shown to enhance responses to salient or novel stimuli by increasing signal-to-noise ratios and altering neuronal receptive fields. While much work has focused on the role of cholinergic modulation of sensory responses to input in primary cortical areas, comparatively little is known about its impact on earlier sensory regions. To explore this question, we visualized OB glomerular odor responses to ORN input in transgenic mice expressing a calcium-sensitive fluorescent indicator of neuronal activity (GCaMP2) in all M/T cells while manipulating cholinergic release into the olfactory system. We found that electrical stimulation of the HDB causes a large and immediate increase in M/T cell population glomerular odor responses that lasts the length of the odor response. Through combined HDB stimulation and pharmacological manipulation, we also found that cholinergic enhancement of M/T cell population glomerular odor responses is primarily driven by muscarinic receptor activation within the OB. Current experiments are underway investigating the functional consequences of this cholinergic enhancement of glomerular odor responses in terms OB odor coding and plasticity. Overall, these studies will enhance our understanding of how neuromodulation shapes neuronal processing of sensory stimuli at the earliest stages of sensory input into the central nervous system. Acknowledgements: Acknowledgements: R03 DC009853 and the Pew Scholars Program in the Biomedical Sciences

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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Cholinergic modulation of sensory processing in the rodent olfactory bulb

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The olfactory bulb (OB) receives centrifugal input from multiple sources whose role in shaping early olfactory processing remains unclear. Here, we examine how cholinergic projections from the horizontal limb of the diagonal band of Broca (HDB) modulate sensory neuron (ORN) input to and mitral/tufted cell (MT) output from the OB using imaging, electrophysiological and optogenetic approaches *in vivo*. First we tested whether HDB stimulation affected ORN inputs by imaging transmitter release from ORN terminals; we found no effect of HDB stimulation on ORN inputs. Next we tested whether HDB stimulation affected MT cell excitation by imaging from mice in which GCaMP3 was selectively expressed in MT cells. HDB stimulation caused a transient increase in excitation apparent as an increase both in the baseline fluorescence and in the inhalation-evoked response. We confirmed this effect with extracellular recordings from presumptive MT cells, finding that HDB stimulation enhanced spontaneous as well as inhalation-evoked spiking. Finally, to selectively examine the influences of cholinergic (as opposed to GABA-ergic) projections and to localize their site of action to the OB, we expressed channelrhodopsin2 in cholinergic HDB neurons. Optical activation of these neurons in HDB or their axon terminals in the OB led to enhanced MT cell excitation that was qualitatively similar to that seen with electrical HDB stimulation. In all of the above experiments, the effects of cholinergic activation were blocked by OB application of muscarinic ACh receptor antagonists. Together, these experiments are consistent with the hypothesis that cholinergic modulation enhances sensory-evoked MT responses and implicate muscarinic receptor-mediated signaling in superficial OB layers as an important step in this modulation. Acknowledgements: Supported by DFG (MR) and NIDCD (MW, RC).

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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Expression of the Nicotinic Acetylcholine Receptor Subtype α7 in Adult-Born Periglomerular Cells

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Adult neurogenesis is an ongoing process of neuronal replacement in the brain that is subject to modification by environmental factors. Two significant sites of ongoing neuronal replacement are in the granule cells (GC) of the dentate gyrus and interneurons in the main olfactory bulb. We are interested in how nicotine influences these processes. Nicotine targets the nicotinic acetylcholine receptors, of which the alpha7 (α7) subtype is being investigated for its role in both neurogenesis and age-related changes in sensory function. To measure α7 expression with spatial and temporal sensitivity, we developed mouse (*Mus musculus*) strains in which homologous recombination was used to introduced a bi-cistronic IRES-tau:GFP reporter (α7GFP). Using immunohistochemistry, we find α7GFP expression in the adult olfactory bulb is restricted to a subset of periglomerular cells (PGC). Unexpectedly, these cells do not co-label with markers of mature PGCs, including parvalbumin, calbindin, calretinin, tyrosine hydroxyase, glutamic acid decarboxylase, and somatostatin. In the dentate gyrus, α7 is expressed only transiently by immature GCs where it participates in mechanisms leading to final neuron differentiation. We examined this possibility for PGCs. Pulse-chase experiments using 5-ethynyl-2'-deoxyuridine (EdU) revealed labeled cells co-expressing α7GFP prior to acquisition of maturation markers. Further, lineage analysis indicates that all mature PGCs did express α7 in their history, consistent with transient expression of α7GFP in PGCs prior to differentiation. These results may provide a basis for correlations between α7 expression level and olfactory discrimination abilities. Ongoing experiments are defining the impact of exposure to nicotine and other receptor ligands on α7 expression and PGC fate. Acknowledgements: S.W.R. was supported by DA025057, Z.T.F. was supported by T32-MH076693.

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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

α7-Nicotinic Acetylcholine Receptor: Role in Early Odor Learning Preference in Mice

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Recently, mice with decreased expression of α7-nicotinic acetylcholine receptors (α7) in the olfactory bulb were associated with a deficit in odor discrimination compared to wild-type mice (Hellier et al., 2010). However, it is unknown if mice with decreased α7-receptor expression (i.e., α7 heterozygous knockouts – HET; α7 homozygous knockouts – KO) also show a deficit in early odor learning preference (ELP), an enhanced behavioral response to odors with attractive value observed in rats. In this study, we modified ELP methods performed in rats and implemented similar conditions in mice. From post-natal days 5-18, wild-type mice were stroked simultaneously with an odor presentation (conditioned odor) for 90 s daily. Control mice were only stroked, exposed to odor, or neither. On the day of testing (P21), mice that were stroked in concert with a conditioned odor significantly investigated the conditioned odor compared to a novel odor, as observed similarly in rats. However, mice with a decrease in α7-receptor expression (i.e., HET mice but not KO mice) that were stroked during a conditioned odor did not show a behavioral response to that odorant. These results suggest that decreased α7-receptor expression has a role in associative learning, olfactory preference, and/or sensory processing deficits. Acknowledgements: Funded by NIH grants MH06858, DC 04657, DC00566, and DC008855 (DR).

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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Noradrenergic Modulation of Rhythmic Activity and Sensory Processing in the Main Olfactory Bulb

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Norepinephrine (NE) modulates rhythmic oscillations and sensory processing in cortical circuits. Here, we investigated NE effects on the spontaneous and olfactory nerve (ON) evoked activity of external tufted (ET) and mitral/tufted (M/T) cells in rat and mouse olfactory bulb slices. Bath application or focal glomeruli puffs of NE, NE uptake inhibitors or the β receptor agonist isoproterenol increased the frequency and regularity of rhythmic oscillations and spiking. These effects persisted in APV-CNQX-gabazine or calcium channel blockers, but were abolished by TTX. These and other results indicate that activation of β receptors in the glomeruli directly increases ET cell excitability and rhythmic bursting and in turn enhances rhythmic oscillatory activity in M/T cells. Recordings in normal media showed that low NE concentrations (<1 μM) enhanced the ON-evoked response magnitude, while higher concentrations (>3 μM) reversed the facilitation. This concentration-dependent modulation matches the bidirectional modulation of granule cell excitability and GABAergic inhibition of M/T cells (Nai et al., 2009, 2010). Thus, in addition to direct excitation of ET and M/T cells (Hayar et al., 2000), NE also modulates ON responses by dynamic regulation of GABAergic inhibition. NE also increased the temporal precision of ON responses, reducing onset latency and variability of evoked spikes at all concentrations tested. NE levels vary with behavioral state and context. Our findings indicate that varying NE levels enhance rhythmic oscillations and the temporal precision of ON responses in a manner that would improve fidelity to the respiratory cycle. The concentration-dependent modulation of ON response magnitude by NE may allow for dynamic regulation of odor response strength as a function of behavioral state.
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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Locus Coeruleus Activation Modulates Stimulus-Driven and Spontaneous Firing of MOB Granule Cells on Short and Long Timescales

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Social events such as mate and offspring encounters, imprinting to maternal odors, and individual recognition increase noradrenaline (NA) levels in the olfactory bulbs (OB) via input from the brainstem nucleus locus coeruleus (LC). This surge in NA is obligatory for certain olfactory memories. In anesthetized male mice, LC stimulation paired with odor results in a long-lasting, stimulus-specific habituation of firing in the mitral cells (MC) of the MOB. This suppression may be achieved by either a feed forward or a feedback mechanism. For example, inhibition by periglomerular cells regulates sensory neuron input to MCs. If NA increases inhibition in the glomerular layer, then the odor habituation of MCs may result from a presynaptic removal of drive. Alternatively, GABAergic granule cells (GC) form reciprocal dendro-dendritic feedback connections with MCs. Thus, NA-triggered increases in the synaptic output of GCs could actively suppress MC responses. LC fibers terminate densely at the GCs and their connections with MCs and sparsely at the glomerular layer, favoring the latter mechanism. We therefore recorded spike activity of GCs in vivo in anaesthetized mice using the loose-patch technique in combination with juxtacellular staining, and we paired odor- or light-evoked sensory stimulation with LC activation. As expected, NA-release resulted in short-term suppression of GC activity. Surprisingly, we found that odor responses in GCs are also suppressed long-term when paired with LC stimulation. This is consistent with either a feedforward mechanism of NA plasticity, or alternatively a model in which the dendro-dendritic synapses inhibit MCs in a spike independent manner. To resolve this, we are recording MCs intracellularly in vivo. Acknowledgements: Funded by an award to SDS from the Klingenstein Foundation.

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POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Anesthesia impacts the spontaneous and odor-induced oscillatory activities in the mouse olfactory bulb

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The olfactory bulb (OB) is the first relay of olfactory information processing in the brain. In this structure, large oscillations are recorded in the local field potential (LFP) during spontaneous activity or following odor stimulation. These oscillations have been shown to rely on a specific feature of the OB network, the reciprocal dendro-dendritic synapses between excitatory mitral cells and inhibitory granule cells. While anesthetized animal recordings have been extensively used to decipher odor representation at the level of the OB, little is known about the influence of the anesthetic drugs used to maintain sedation on temporal dynamics. Anesthesia can be induced by injection of a cocktail of ketamine combined with one of the two available agonists at the α2 class of adrenergic receptors, xylazine (low α2 affinity) or medetomidine (high α2 affinity). In this context, the objective of this work is to compare oscillatory activities of the LFP in these two different conditions of anesthesia and in the awake state in the same mouse. We use chronically implanted electrodes (100μ diameter) in the OB to record the spontaneous and odor-induced activities: (i) under ketamine/xylazine (ii) under ketamine/medetomidine (iii) in freely moving animal. Data show that for the three conditions, odor stimulation elicited a decrease in number of detected oscillations in the gamma frequency band together with an increase in the beta band (15-45Hz). We observed that under anesthesia, the frequency of oscillations was lower in the beta band and higher in the gamma band compared to awake. Xylazine tended to increase frequency and power of the spontaneous but not the odor induced activity. This modulation was abolished when a constant air flow was delivered to the mice. To separate the specific effect of the α2 agonists from the perturbation induced by ketamine, we injected intraperitoneally xylazine, medetomidine and NaCl successively in the same awake freely moving mice. We found that α2 agonists decreased oscillations power in the gamma band, and that xylazine increased frequency compared to medetomidine. In conclusion, xylazine and medetomidine differentially impact the temporal dynamics of the olfactory bulb. Acknowledgements: Agence Nationale de la Recherche ANR-09-JCJC-0117-01

#P79 WITHDRAWN

#P80 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Short Axon cells provide both excitatory and inhibitory drive to the mitral/tufted cells

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Short-axon (SA) cells, in the glomerular layer, receive inputs from olfactory sensory neurons and/or external tufted (ET) cells and release GABA and Dopamine, synapsing onto juxtaglomerular cells as far as tens of glomeruli away (Kiyokage et al., 2010). Computational models (Cleland et al, 2007) have suggested that SA cells may be involved in long-range normalization of bulb output, but to date their function in the intact brain has not been investigated. We used a Cre-loxP approach to target neuronal activity reporters (GCAMP3), or light gated switches (Channelrhodopsin2 and Halorhodopsin) to SA cells. We imaged GCAMP3 responses by wide-field microscopy to odor stimulation across a range of concentrations. Odorants induced transient, yet widespread SA responses, in contrast to focal glomerular patterns observed via intrinsic optical imaging. To understand the roles played by the SA network on the bulb output, we recorded extracellularly from M/T cells using tetrodes in anaesthetized mice. In conjunction, we selectively activated/inactivated SA cells by shining blue/yellow light either throughout the dorsal bulb surface or in specific spatial patterns employing a digital micro-mirror device (DMD). Pairing odor presentation at various concentrations with light, indicates that SA cells provide both excitatory and inhibitory drive to the M/T cells in a stimulus specific fashion. At low odorant concentrations, SA cells provide excitatory input, whereas in response to stronger stimuli, both excitatory and inhibitory drives are present. We propose that the SA network regulates the dynamic range of M/T cell firing by amplifying the weak inputs and down-scaling the stronger ones.

#P81 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Emergent spatially distributed synaptic clusters in a large-scale network model of the olfactory bulb

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Odor stimuli set up patterns of activity in the olfactory glomerular layer of the olfactory bulb, which are further processed by a network of mitral and granule cells through their dendrodendritic synaptic interactions. To obtain insight and guide future experiments into the role of these interactions, we constructed and analyzed a computational model of 500 mitral cells and 10,000 granule cells randomly connected with an experimentally-estimated 10% probability. In order to have a realistic representation of the glomerular activation during an odor presentation we used the experimental findings of Mori et al. (2006) to model the activity generated in 73 identified glomeruli by 72 specific odor inputs corresponding to 12 different chemical series. We show that in response to a given odor pattern in the glomeruli, clustered patterns of distributed mitral cell and granule cell synaptic clusters naturally emerge. As the clusters evolve, so do the network dynamics. Granule cells become more active permitting lateral inhibition of weakly driven glomeruli and synchrony between the more strongly activated glomeruli. The resulting clusters of inhibitory synapses appear to play a critical role in transforming the network from a relatively random high-firing rate mode into a more synchronized, sparsely low-firing rate mode. The model gives insight into the possible correlation between odor chemical structure and synaptic cluster size and location, and predicts the possible interactions between different odors. Acknowledgements: NIH/NIDCD R01 DC 009977-01

#P82 POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS

Multiple memory traces after associative learning in the honey bee antennal lobe

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Learning the simple association between two stimuli gives rise to multiple memory traces in the brain. These memory traces are expressed as altered synaptic connections and neural excitability, evolve over time, and are distributed across brain areas. Here we ask how associative learning affects early sensory processing. We investigated the effect of associative odor-reward learning on odor processing in the honey bee primary olfactory area, the antennal lobe, by combining classical conditioning with in vivo calcium imaging of secondary olfactory neurons, the projection neurons in the antennal lobe. We trained bees in a differential conditioning paradigm in which one odor was paired with a reward while another odor was presented without a reward. We found associative plasticity of odor representations 2 to 5 hours after discriminative odor learning, which increased the difference between rewarded and unrewarded odors. Moreover, the learning-induced changes in a glomerulus could be predicted from its response profile before training. The data is consistent with a neural network model of the antennal lobe, which we based on two plastic synapse types and two well-known learning rules: associative, reinforcer-dependent Hebbian plasticity at synapses between olfactory receptor neurons and projection neurons, and reinforcer-independent Hebbian plasticity at synapses between local interneurons and olfactory receptor neurons. The observed changes strengthen the idea that odor learning optimizes odor representations and facilitates the detection and discrimination of learned odors. Acknowledgements: DFG and BMBF

#P83 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Periodic stimulation affects odor representations in antennal lobe of the moth *Manduca sexta*

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Odor representations vary as a function of the context in which they are experienced. Wing beating affects the interaction of the insect antennae with odor molecules by inducing a periodic structure as well as periodic changes of air velocity across the antennae that may affect receptor cell responses. We have recently established that both antenna and antennal lobe (AL) track periodically structured stimuli independent of odor presence or identity. Furthermore, behavioral studies of odor detection suggest that the rate of false positive responses drops when stimuli are presented as pulse trains. The goal of this study was to determine if pulsed odor affects the separation of odor representations in the AL. We used 16 channel electrode arrays to make multiunit and multi local field potential (LFP) recordings to monitor AL responses to olfactory stimuli pulsed at 20 and 25 Hz (wing beat frequency range). We presented a homologous series of five undiluted alcohols and ketones. Power spectral analysis indicated that 23% of the units pulse tracked across odors. Interestingly, odors with longer carbon-chain-lengths induced significantly higher pulse tracking. Next, we varied the durations of the three stimuli (continuous, 10 and 20 Hz) from 500 ms to 3 s for two odors and a blank. LFPs appear to be stimulus duration dependent suggesting a ramping up of oscillations over time. Futhermore, we will use Euclidean analysis to quantify representational distance as a function of pulsing versus continuous stimulation. Our results suggest that neural odor representations are context dependent at the AL level. Acknowledgements: This study is supported by NIH R01-DC009417 to KCD

#P84 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Nitric Oxide Differentially Affects the Excitability of Subsets of Cultured Local Neurons from the *Manduca Sexta* Antennal Lobe

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Nitric oxide (NO) modulates olfactory information processing via multiple molecular pathways. Local neurons in the antennal lobe exist in subsets that have been traditionally described based on morphology and current profiles and only a modest population of LNs are immunoreactive to soluble guanalyl cyclase(sGC), the best characterized target for NO. Subsets of local neurons are differentially affected by the presence of NO, implying that modulation of ion channels may vary between the subsets of LNs. To examine the effects of NO on LNs, electrically evoked responses were monitored using whole cell voltage clamping of cultured AL neurons. We have begun to examine the specific ion currents affected by NO and the molecular mechanisms by which those currents are affected. We found that different subsets of LNs were either hyperpolarized, depolarized or unaffected in the presence of NO. Different currents were affected in these subsets and they also showed differential responses to exogenous cGMP application. These results suggest that there are multiple molecular targets for NO and these targets vary among the different subsets of LNs.

#P85 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Mechanisms of calcium-mediated excitation and plasticity in primary olfactory pathways of the honey bee

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Spatiotemporal processing in the mammalian and invertebrate olfactory systems is subject to plasticity driven by biogenic amines. We study this processing using honey bees, which have been extensively studied with respect to nonassociative, associative and operant based olfactory learning and memory. Octopamine is the invertebrate analog to epinephrine, and it is an important factor in driving associative plasticity in the honey bee antennal lobes (ALs). More recently we started to test hypotheses related to how octopamine might be involved in synaptic organization in the AL circuitry. Octopamine acts via different receptor subtypes, and one specific subtype (AmOA1) gates calcium release from intracellular stores. Calcium also enters AL interneurons via acetylcholine (ACh) receptors, which are driven by ACh release from sensory neuron terminals, as well as through voltage gated calcium channels (VGCCs). We propose that the confluence of the conditioned and unconditioned stimuli occurs via calcium release from these independent sources. We employ 2-photon excitation (2PE) microscopy using fluorescent calcium indicators to investigate the potential sources of calcium in projection neuron (PN) dendrites *in vivo*. PN dendrites within glomeruli in the honey bee AL show calcium increase in response to odor stimulation. Octopamine causes amplified calcium transients when applied prior to olfactory stimuli. We have shown direct activation of nACh receptors upon application of nicotine. The response persists despite cadmium chloride application, a VGCC antagonist, suggesting a direct postsynaptic activation. Our studies will allow for a greater understanding of plasticity in the primary olfactory neuropil of the honey bee and may generalize to an understanding of plasticity in the mammalian olfactory bulb. Acknowledgements: NIH-NIDCD and Office of Naval Research

#P86 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Pulse tracking of antennal lobe neurons is enhanced by input from the thoracic ganglia in *Manduca sexta*

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Natural olfactory stimuli are series of short, discrete events, because odor plumes are filamentous. Moreover, the stimulus is structured by wing beating, which should be reflected by the neural response. Antennal lobe (AL) output neurons, which were recorded intracellularly in isolated head preparations in *Manduca sexta*, showed pulse tracking limited to 10–15 Hz. In intact moths ~7-25%

of the extracellularly recorded units tracked pulsed odors up to 30 Hz. Furthermore, a pair of identified histaminergic neurons, which arborize bilaterally in presumed motor and/or premotor centers of the mesothoracic ganglion, terminates in both ALs. Thus, our working hypothesis is, that intact connections between the brain and the ventral nerve cord are necessary for pulse tracking at wing beat frequencies. We developed a new preparation to test this hypothesis. Legs and wings were removed and the thorax opened to expose the thoracic ganglia and the neck connectives. Brain and ALs were exposed for intracellular recording and staining. A blank and two monomolecular odors, 2-hexanone and 1-hexanol (undiluted and 10 µg/2µl), were presented as 3 s pulse trains. Nine frequencies from 10 and 40 Hz were used at 50% duty cycle. Inter stimulus interval was 10 s. Using power spectral density analysis, we show, for the first time in moth, that projection neurons and local interneurons follow pulsed stimuli up to 25 Hz, some even to 40 Hz. About 25 % of all tested AL neurons tracked pulsed stimuli; in some cases, tracking depended on odor identity. This suggests, that AL neurons only can represent the temporal structure of natural stimuli when the connections between brain and thoracic ganglia are intact. Currently, we test how modifying the functionality of the brain to ventral nerve cord connections affects pulse tracking. Acknowledgements: This work was supported by NIH grant NIH-DC009417 to KCD and DFG grant SCHA 678/3-3 to JS.

#P218 **POSTER SESSION II: TRIGEMINAL SYSTEM; TASTE CNS; NEUROIMAGING; OLFACTION CNS**

Inhibiting DNA methyltransferases during discrimination conditioning impairs recall of the conditioned olfactory associations in honey bees (*Apis mellifera*)

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De novo DNA methylation plays a key role in memory consolidation.[1,2] We asked how it affects olfactory memories by blocking DNA methyltransferase 3 (Dnmt3) activity in honey bees (*Apis mellifera*). Previous work established that Dnmt3 inhibition impairs consolidation of simple associative olfactory memories in bees.[3] We assessed how Dnmt3 inhibition affects recall of olfactory memories following discrimination conditioning, which allowed us to simultaneously assess the role of DNA methylation in associative and nonassociative memories. We injected adult bees with 0.17 µg RG108 (Dnmt inhibitor) or saline. Then, we trained them to discriminate a rewarded odor from an unrewarded odor (1-hexanol and 2-octanone). We assessed learning and short-term memory by monitoring the conditioning trials. After 96-hours, we assessed long-term memory with a series of extinction trials. Acquisition of the conditioned responses was not affected by RG108, indicating that *de novo* DNA methylation may not be involved in learning and short-term memory. However, RG108 did impair performance during extinction trials. RG108-treated bees were less likely to respond to the first trial of the rewarded odor and exhibited a faster extinction of the response to the rewarded odor across the rest of the trials. The probability of a response to the unrewarded odor extinction trials was equal between the treatment groups. These data indicate that DNA methylation-dependent processes mediate consolidation of associative olfactory memories. In contrast, consolidation of the nonassociative memories (unrewarded odor) may not depend on DNA methylation. ***REFERENCES*** *1. Miller, C.A., et al. Nature Neuroscience, 2010. 13(6): 664-6. 2. Miller, C.A. and J.D. Sweatt. Neuron, 2007. 53: 857-869. 3. Lockett, G.A., et al. NeuroReport, 2010. 21(12): 812-6.* Acknowledgements: This study was supported by funding from NIH NIDCD (BHS), Office of Naval Research (BHS), PEW Charitable Trust (GVA), and the Research Council of Norway (180504)(GVA)

#P87 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

The Role of Primary Cilia in the Regenerative Properties of Olfactory Basal Stem Cells

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The olfactory epithelium (OE) is one of the few neuronal tissues to undergo constitutive neurogenesis throughout the lifespan of an organism. The OE is composed of differentiated olfactory sensory neurons (OSNs) and supporting cells, and two populations of basal precursors, globose basal cells (GBCs) and horizontal basal cells (HBCs). While GBCs frequently divide and differentiate into OSNs and supporting cells to restore the OE, HBCs are more quiescent yet able to restore the OE following severe insult. There is growing evidence that primary cilia play roles in cell proliferation and differentiation. In the OE, immunohistochemical (IHC) analysis of Arl13b (a cilia-localized protein) revealed that in addition to being expressed in olfactory cilia of OSNs, Arl13b-labeled primary cilia are on basal cells of the OE. Co-labeling with the HBC markers CD54 (I-CAM1) and p63 showed that Arl13b-labeled cilia are found on HBCs. We therefore hypothesized that primary cilia on HBCs regulate their cell fate. To test this hypothesis, we used the Oak Ridge Polycystic Kidney (ORPK) mouse, which contains a hypomorphic mutation in *ift88*, resulting in depletion of IFT88 (a protein important for ciliogenesis and cilia maintenance) and partial loss of cilia. IHC analysis of ORPK mice revealed a predicted reduction of cilia in the HBC population (p63+ cells) compared to wild-type. Surprisingly, through our staining of the ORPK OE, we uncovered a prominent change in the location of HBCs; whereas in wild-type animals HBCs are restricted to the basal-most region of the OE by P19, HBCs in ORPK animals of the same age are also present in more apical regions of the OE. These data suggest that cilia may be critical for HBC turnover and olfactory tissue maintenance. Acknowledgements: R01DC009606 (to J.R.M.) T32DC00011 (to A.M.J.)

#P88 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Role of Neogenin in Olfactory Epithelium Development

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The birth and differentiation of Olfactory Sensory Neurons (OSNs) is critical for our ability to detect and decode odorant information from the environment. To better define the molecular mechanisms that control neurogenesis in the Olfactory Epithelium (OE), we have examined the role of the transmembrane protein Neogenin in olfactory neurogenesis. Neogenin, a member of the immunoglobulin family, has been implicated in the regulation of diverse processes during development of the nervous system, including axonal guidance, cell migration, and cell differentiation.

Furthermore, multiple families of proteins can bind to the extracellular region of Neogenin including Netrins, Repulsive Guidance Molecules (RGM), and Bone Morphogenetic Proteins (BMP). Using in situ hybridization and immunohistochemical approaches, we have examined the pattern of expression of Neogenin and of its ligands in the OE. Our analyses have revealed that Neogenin is expressed at high levels in the basal progenitor cell region of the OE and in mature OSNs. In contrast, expression of the Neogenin ligand, RGM-b, is restricted to immature OSNs. These patterns of expression suggest that RGM-b-Neogenin interactions may regulate the differentiation of progenitor cells into OSNs. To test this hypothesis, we have examined the development of OSNs in Neogenin mutant mice. Ablation of Neogenin expression leads to an increase in the number of proliferating cells in the basal region of the OE, and to a decrease in the number of mature OSNs, indicating that Neogenin regulates the differentiation of progenitor cells into OSNs. We are currently assessing the role of RGM-b in this process by using a combination of *in vitro* and *in vivo* approaches. Our findings therefore define a new role for Neogenin in olfactory neurogenesis. Acknowledgements: Canadian Institute of Health Research

#P89 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

IS OLFACTORY NEURAL STEM ACTIVITY PERTURBED IN ALZHEIMER'S DISEASE?

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Despite the extensive neurogenic capacity of the olfactory system, it is not able to maintain function during the progression of Alzheimer's disease (AD) and, in fact, shows some of the earliest AD deficits. So, do olfactory neural stem cells (NSCs) in the Olfactory Epithelium (OE) or subventricular zone (SVZ) become dysregulated in their ability to compensate for loss of neuronal function in AD? Familial AD is linked to mutations in Amyloid Precursor Protein (APP) and Presenilins 1 and 2. APP mutations can increase apoptosis of Olfactory Receptor Neurons (ORNs), which should produce a compensatory up-regulation in neurogenesis. However, presenilin mutations could impact the stability of NSCs, or ability of ORNs to be assisted in targeting by Olfactory Ensheathing cells, due to deficits in Notch signaling. This has lead us to test if the olfactory system develops early signs of AD as a result of the failure to maintain neurogenesis from its NSC pools, in human AD post-mortem SVZ, and the OE and SVZ of a symptomatic mouse AD model. To test for the integrity of the NSC niche in human AD, we have developed new techniques to detect human NSC and progenitor markers (including GFAP, GFAPδ, BLBP, Vimentin, PSA-NCAM) in formalin-fixed AD SVZ. We reveal a subpopulation of $GFAP^+$ potential progenitors in the human AD SVZ expressing GFAPδ and BLBP, and that the proliferation index of distinct potential progenitors in the SVZ is variable between AD patients. We are now using multiple thymidine labels and in vitro assays to test if distinct changes in neurogenic capacity and progenitor activity occur from 3-12 months in the SVZ and OE of the PS1/APPSwe doubt Tg mouse model of AD. Our results indicate a potential disruption in the maintenance and activity of progenitors that are direct targets of Notch regulation. Acknowledgements: The Pacific Alzheimer's Research Fund, the Jack Brown family Foundation (to JR) and a Canadian Institutes of Health Research studentship (To AC).

#P90 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Functional and Molecular Characterization of the Cell Turnover in the Olfactory System

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In the olfactory system continuous cell turnover takes place throughout life, making this system to one of the most plastic regions of the brain. In the olfactory epithelium there is a constant replacement of olfactory receptor neurons, while in the olfactory bulb new neurons are continuously integrated into an existing neuronal circuitry. The new olfactory receptor neurons originate from a neurogenic zone residing in the most basal part of the epithelium, the new neurons of the olfactory bulb originate from a neurogenic zone lining the lateral telencephalic ventricles. The maintenance of a functional sense of smell requires a fine-tuned and highly regulated interplay of apoptosis, neurogenesis and neuronal integration. Among many other factors, nucleotides and their receptors have been shown to play an important role in the regulation of neurogenesis during embryonic development as well as in the adult nervous system. Here we have characterized the purinergic system of the olfactory epithelium and the anterior telencephalon of larval *Xenopus laevis* and found that extracellular nucleotides, acting via a multitude of purinergic receptors, play an essential role in the fine-tuning of the cell turnover in the olfactory system. Using calcium imaging, functional apoptosis detection in acute tissue slices and immunohistochemistry, we were able to show the involvement of purinergic signaling in the regulation of apoptosis and neurogenesis in both, the olfactory epithelium and the olfactory bulb. The outcome of the present work is a further step in an effort to understand the so far only poorly understood mechanisms regulating the cell turnover in the olfactory system. Acknowledgements: Supported by DFG CMPB (Project B1/9) to I.M. and DFG Schwerpunktprogramm 1392 (project MA 4113/2-1) to I.M.

#P91 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Effect of Vitamin A Deficiency on Olfactory Marker Protein Expression in Postnatal Mouse Olfactory Neurons

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Previous studies in our lab have shown dietary deficiency in vitamin A (VAD) is associated with decreased numbers of mature olfactory receptor neurons (ORNs) in the postnatal rat olfactory epithelium. We questioned whether a similar effect would be observed in mice. Because mice are more difficult to make VAD, we elected to use a mouse with a mutated lecithin retinyl acyl transferase (LRAT knockout, KO) gene for these studies. Others have shown that essentially all retinol stores are depleted in LRAT mice fed a VAD diet for one month. We set up studies to determine VAD effects on mice, specifically, on ORN numbers. LRAT KO age-matched, males were fed a VAD diet or a diet supplemented with VA (VAS) for 8 weeks (Study 1) or 19 weeks (Study 2). Studies included age matched, male wild type (WT) VAS control groups. Whereas VAD rats exhibit distinct signs of VAD that include alopecia, ataxia, reddened eyes, white teeth and decreased

weight gain relative to controls, LRAT KO mice did not display any of these signs after eight weeks on the VAD diet. LRAT KO mice on the VAD diet for 19 weeks showed a relative weight loss in the latter part of the study. Olfactory tissue was collected from mice in Study 2, and immunoblots were prepared and probed with an antibody directed against olfactory marker protein (OMP), a marker for mature ORNs. Chemiluminescent detection and a BioImaging System were used to evaluate relative OMP protein expression levels in LRAT KO VAD, LRAT KO VAS, and WT mice olfactory tissue cytosolic lysates. Results indicate a modest reduction in OMP expression in the LRAT VAD, but not LRAT VAS olfactory tissue relative to WT controls. Our data to date suggest that VAD may have different and/or less pronounced effects on mice than rats. Acknowledgements: NIH/NIGMS/MBRS/SCORE S06 GM 008092

#P92 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Naris Occlusion Effects Turbinate Development

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Naris occlusion is the method of choice for investigating the effects of odor deprivation in mammals. However, unilateral closure of a naris causes marked changes in the airflow in both the occluded and open nasal cavity. While on the occluded side the airflow is dramatically reduced, the open side is forced to carry a larger than normal volume. Also, naris occlusion abrogates alternating cycles of breathing, forcing constant duty on the open side. We were interested if these changes in airflow effect development of nasal turbinates given that mechanical stress induces bone growth and turbinates express odorant receptors in regionally defined areas. We therefore investigated mice aged 18-25 days, that had been naris occluded or shame operated on the day of birth. Turbinate morphology was examined in coronal serial sections throughout the rostrocaudal extent of the nasal cavity. Results demonstrate that naris occlusion has signficant effects on the size, shape, and position of nasal turbinates, especially rostrally. The most anterior turbinate, endoturbinate-I, takes on a delicate "filigree" appearance on the occluded side relative to the open side: 24% decrease in area/perimeter (open 65.2, closed 52.6; control 59.5 sq µm/µm; $p<0.005$) despite same perimeter; 82% increase in length/width, (open 7.4; closed 13.5; control 7.9 µm/µm; $p <0.001$). That these effects are attributed to airflow is supported by the intermediate values of controls. We conclude that a stimulus from airflow: mechanical, thermal or chemical, causes changes in the ontogenesis of nasal turbinate structure which in turn might induce changes in expression of odorant receptors. Acknowledgements: This study was supported by National Science Foundation grant #0641433 to DC

#P93 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Protein Tyrosine Phosphatase Expression in the Main Olfactory Epithelium and Olfactory Bulb

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Insulin regulates the outward current flow of the voltage-gated potassium channel Kv1.3 expressed in mitral cells of the olfactory bulb (OB). This regulation is due to the protein tyrosine kinase activity of the insulin receptor, which phosphorylates Kv1.3. Protein phosphorylation is a common molecular switch that modifies activities of cellular proteins. However, the cell must also have a mechanism for turning the switch off. This is accomplished by activation of protein tyrosine phosphatases that dephosphorylate proteins. There are numerous studies analyzing the expression and activity of kinases in the olfactory system, but few studies address the phosphatase portion of the signaling pathway. The objective of this study was to analyze the olfactory system expression of protein tyrosine phosphatase, Src-homology domain containing phosphatase-2 (SHP-2), which is known to be involved in the insulin signaling pathway. Cryosections of the OB and main olfactory epithelium (MOE) of mice were utilized in immunohistochemical assays to confirm the expression of SHP-2 in these tissues. Photomicrographs of labeled mouse specimens demonstrate that SHP-2 is expressed in the mitral cell layer, granule cell layer, and the periglomerular cells of the OB and the olfactory sensory neuron layer of the MOE. Western blot analysis of OB tissue indicates that SHP-2 and Kv1.3 form a protein-protein complex in OB neurons. Parallel experiments using transiently transfected Human Embryonic Kidney cells (HEK293) indicate that SHP-2 co-expression attenuates the insulin-induced phosphorylation of Kv1.3, predicting that the insulin-induced modulation of Kv1.3 current in mitral cells may be counterbalanced by SHP-2. Acknowledgements: This work was supported by NIH DC011923 and Student Research Assistant Program from University of West Georgia.

#P94 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Defective Olfactory Sensory Neuron Targeting After Nerve Injury in Proteolipid Protein Null Mice

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Olfactory sensory neurons (OSNs) are replaced throughout life in a remarkable regenerative process. New OSNs extend axons from the olfactory epithelium to the bulb and target one specific ovoid structure, or glomerulus, depending on which particular olfactory receptor the neuron expresses. The topological organization is essential to the processing of olfactory information and is maintained despite continuous regeneration. Following olfactory nerve transection in mice, the OSNs regenerate, but injury can disrupt the organization. Altered rewiring of the olfactory system may underlie olfactory disturbances after injury in humans. Therefore, it is important to understand the mechanisms underlying the regenerative process after injury. Evidence suggests that OSN axon regeneration is supported by olfactory ensheathing cells

(OECs), an olfactory-specific glial cell. OECs wrap around OSN axons as they exit the epithelium and enter the bulb. The mechanisms by which OECs support regeneration are not fully understood. Intriguingly, OECs express proteolipid protein (PLP), a myelin protein, yet OECs do not produce myelin in the olfactory system. The role of PLP in OEC function has not been explored. We propose that PLP is important for OEC-mediated support of OSN regeneration after injury based on the finding that that full glomerular recovery after injury is impaired in the absence of PLP. In this study nerve transection was performed on 1 month old PLP+/Y and PLP-/Y mice. The amount of recovery was evaluated after 2 weeks. PLP-/Y mice had fewer glomeruli structures on the injured side than PLP+/Y mice, and those that formed were smaller and demonstrated lower OMP intensity as compared to PLP+/Y mice, suggesting deficiencies in the regenerative process as a result of the loss of PLP. Acknowledgements: University of Colorado Denver Neuroscience Program Training Grant

#P95 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

High-fat diet or genetically-induced obesity reduces the number of olfactory sensory neurons and their axonal projections

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The nutritional status of an individual impacts olfactory function as mediated through a myriad of internal metabolic cues (nutrients, hormones...) received at the olfactory mucosa (OM) and the olfactory bulb (OB). Here, we examined the structural effect of a long-term deregulation of the nutritional status on the development of the olfactory system. We studied anatomical changes in two models of obese mice 1) a diet-induced obesity where mice were maintained for 6 months on a moderately high-fat diet (MHF, 32% fat) and 2) a late-onset obesity in melanocortin 4 receptor null mice (MC4R-/-) where diabetes secondarily precipitates following disruption of the hypothalamic axis. M72-receptor β-gal positive (M72+) olfactory sensory neurons (OSNs) and the total number of mature, OMP+ OSNs were significantly decreased following the MHF-diet. The reduction in the axonal projections of M72+ OSNs lead to a decrease in the size of the corresponding glomeruli. These effects were more moderate in the MC4R-/- genetically-obese mice. MHF-fed mice also exhibited an increase in proliferation (α-Ki67) and apoptotic (α-activated-caspase 3 and TUNEL) markers at the OM level. We also investigated the effect of Kv1.3 potassium channel deletion (Kv1.3-/-) in mice which, besides a "Super-smeller" phenotype, are resistant to adiposity and weight gain upon MHF-diet challenge. Although Kv1.3-/- mice did not gain weight and remained euglycemic, thin body plan failed to prevent the loss in the number of M72+ OSNs and the reduced glomerular size associated with the MHF diet. Our results suggest that a diet high in fat durably affects the neuroanatomy of the olfactory system independent of body weight. Furthermore, the increased proliferation and apoptosis of OSNs suggests a mechanism attributed to chronic inflammation.
Acknowledgements: This work was supported by R01 DC003387 and ARRA DC003387-SUMM from the NIH/NIDCD.

#P96 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

***Wnt5* AND *DRL* REGULATE DENDRITIC TARGETING IN DROSOPHILA OLFACTORY MAP FORMATION**

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In the development of the *Drosophila* antennal lobes, targeting of the projection neuron (PN) dendrites is alone sufficient to create the nascent olfactory map. The mechanisms regulating PN dendrites targeting are poorly understood. We observed that the secreted protein, Wnt5, and its receptor, Drl, are required for this process. Loss-of-function mutations of the *Wnt5* and *Drl* genes result in distinct dendritic targeting defects. Interestingly, the *Drl* mutant defects could be rescued by the removal of a copy of the *Wnt5* gene, indicating that *Wnt5* and *Drl* act antagonistically. To investigate how Wnt5 and Drl regulate PN dendrites targeting, we examine the relative distribution of the two proteins in the nascent antennal lobe. We show that Wnt5 is expressed in discrete domains, each of which spans only a few glomerular boundaries. Drl expression is also tightly controlled, with adjacent dendritic arbors expressing different levels of the protein. Comparison of the Wnt5 and Drl expression patterns showed that Drl+ arbors are located inside, while Drl- arbors are located outside of the Wnt5 domains, suggesting that Drl modulates dendritic responses to Wnt5. We propose that Drl+ dendrites are attracted to, while Drl- dendrites are repelled by Wnt5. Wnt5 may thus act as a local organizer of the PN dendrites, thereby elaborating the rough dendritic map of the nascent antennal lobe. Our findings begin to define the molecular and cellular mechanisms that guide PN dendrites movement and pattern the early olfactory map. Acknowledgements: NIH/NIDCD 1R15DC010916

#P97 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

How many colors do you need to paint an olfactory map?

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Olfactory sensory neurons (OSN) expressing a particular olfactory receptor selectively project their axons to a particular subset of glomeruli in the olfactory bulb (OB). The resulting olfactory map yields robust odorant- specific activation patterns of the glomeruli. A well understood example of a neural map is the continuous topographic projection of the retinal ganglion cells to the superior colliculus in the visual system. It has been demonstrated that this retinotopic map is a result of a combination of axonal guidance due to global gradients of chemoattractants/chemorepellents and a local map refinement due to correlated neural activity. We study the computational model of the olfactory map formation that is similar to the models of visual map development. We simulate the projection of the OSNs from a receptotopic space to the surface of the OB, similarly to the retinotopic projection to the superior colliculus. The role of the global molecular labels is played by the gradients of axon guidance molecules (Slit1/Robo2, Nrp1/Sema3A, Nrp2/Sema3F). The local activity-dependent refinement is implemented via discrete mosaic levels of OR-specific molecules (EphA/ephrin-A, Kir2/Kir3, Big2). The OSN axons are arranged in the receptotopic space according to Nrp1 and Nrp2 levels, which is

motivated by experimental results, demonstrating intrinsic axon ordering in the nerve fiber before reaching the OB. We show that the model can successfully reproduce the ordering of the OSNs in the developing OB and the formation of the glomeruli, provided that some conditions are met. We demonstrate that the axon types have to be arranged in the receptotopic space in a pattern where no neighbors share the same set of local mosaic labels. We suggest therefore that the arrangement of axon types in the receptotopic space satisfies the so-called coloring constraint, such as in the four color theorem. This is also motivated by experimental results, showing sharp differences in the expression of the local molecular labels in neighboring glomeruli. Using our model we reproduce several experimental results of the olfactory map formation in ephrin-A, Big2, Kir2/Kir3 and CNG knockout mice.

#P98 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Composition of the Olfactory Bulb during Postnatal Development in Mink

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The olfactory bulb is composed of neurons arranged in typical layers accounting for specific functions. In mammals, the bulb grows continuously until adulthood, thus we were interested if the layers expand proportionally. We therefore investigated histologically the olfactory bulb of the American mink (*Neovison vison var. atratus*), a species born very altricial in which a major part of development takes place postnatally. A total of 36 males (newborns, postnatal day 1, P1, up to seven months, P210) were analyzed. The total bulb increases in size continuously from 1.85±0.04 mm^3 at P1 to 152.00±9.14 mm^3 in adults, however the composition pattern is highly significantly different. The subependymal layer (P1: 7.43±0.42%; P210: 0.92±0.72%) and the stratum album (P1: 16.98±0.47%; P210: 8.61±1.26%) decrease in proportion possibly due to the retraction of the ventricle and reduction of centrifugal migration, while the layer of the fila olfactoria increases (P1: 15.92±1.08%; P210: 26.90±5.18%). However, the fila layer increases not continuously but shows significant reduction in relative proportion as well as in the absolute volume in 60days intervals, which might be a result of the lifespan of the sensory neurons. For the external plexiform, mitral cell and internal plexiform layers the major changes happen within the first three postnatal weeks, when mitral cells arrange from several rows to a single row of somata and tufted cells probably pass through the layers to reach their more outer position. The increase of the glomerular layer (P1: 12.34±0.45%, P210: 14.28±1.31%) is small indicating the important function from birth on. Thus, the layers of the olfactory bulb do not just expand proportionally with bulb size but are a dynamic system and exhibit specific developmental and functional compositions.

#P99 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Postnatal requirement of Rac1 for mitral cell dendritic development

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Mitral cells in the mouse olfactory bulb bear a unique morphology with a single non-branching apical dendrite targeting into a glomerulus before elaborating terminal dendritic tufts. This mature mitral cell dendritic morphology is achieved through a rapid pruning process from an exuberant dendritic tree during early postnatal stages. To investigate the molecular mechanisms of dendritic pruning, we generated transgenic mice that express Cre recombinase in postnatal mitral cells. TARSH gene was shown to be specifically expressed in mitral and tufted cells and developmentally regulated to turn on at P0 and to peak at postnatal day 6. Using an 8kb TARSH promoter region to drive Cre expression (TARSH-Cre), we generated and characterized three transgenic lines. Among the three lines, two of them have Cre expression in majority of the mitral and tufted cells at postnatal day 3 (P3), while one of TARSH-Cre line (TB) show Cre expression in a subset of the mitral cells. TARSH-Cre transgenic lines were used to knockout Rac1 expression specifically within mitral and tufted cells in the olfactory bulb. Rac1 is shown to be specifically required for dendritic development. Using a conditional Rac1 knockout (cKO) allele, we analyzed the requirement of Rac1 in postnatal mitral cell morphology by Golgi impregnation. At P0, mitral cell dendritic morphology did not significantly differ between Rac1 cKO and their wildtype littermate. Mitral cells at this stage have multiple apical dendrites. At P6, 78% of mitral cells in wildtype littermates has single apical dendritic while 48% of mitral cells in Rac1 cKO bears multiple apical dendrite. These data suggest that Rac1 is required in postnatal mitral cells for their dendritic pruning process. Acknowledgements: NIH DC011346

#P100 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Using the mouse olfactory system as a new model to study Traumatic Brain Injury

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Loss of olfactory function is one of the earliest indicators of Traumatic Brain Injury (TBI). The regenerative capacity and well-defined neural maps within the olfactory system allow for the investigation of neurodegeneration, regeneration, and possible intervention following injury. Here we introduce an olfactory system-based model that reproduces many hallmarks associated with human brain trauma. We performed a unilateral penetrating impact to the olfactory bulb (OB) and observed a gradation in cell loss with ipsilateral showing a greater reduction than contralateral and both significantly greater than control. We observed a glial response on both the ipsilateral and contralateral bulb. Moreover, cells in the olfactory epithelium (OE), including olfactory sensory neurons (OSNs) that send axonal projections to the OB and

olfactory ensheathing glia, also exhibited a graded expression of injury markers including activated caspase-3, Beta-APP and p75NTR, with ipsilateral showing higher levels than contralateral and both significantly higher than sham. At a behavioral level we also found that this injury results in a clear loss of olfactory function. We demonstrate that following a brief 30 day recovery period there is partial restoration of neural circuitry and olfactory function. Together these data establish the mouse olfactory system as a new model to study TBI, serving as a platform to understand neural disruption and the potential for circuit restoration. Acknowledgements: Henry M. Jackson Foundation/The Center for Neuroscience and Regenerative Medicine

#P101 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Increased sensitivity and decreased selectivity to odorants in controlled cortical impact mice

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Olfactory dysfunction is an early indicator of traumatic brain injury (TBI) with patients often reporting a loss of olfactory function. Using controlled cortical impact (CCI) to the anterior cortex as a TBI model, we studied the olfactory responses in the olfactory bulb (OB) using the UBI7 transgenic mouse line. In these mice, all the olfactory sensory neurons (OSNs) express low levels of the I7 receptor in addition to their endogenous receptors. Using multi-electrode recordings we detected and compared OB responses to Octanal, an I7 receptor ligand, in both CCI and control mice. Here we report clear and reliable odor-induced activation of the OB in all the experiments. Interestingly, we reveal that the CCI mice show activation at lower Octanal concentrations and greater prolonged activity compared to control mice, suggesting increased odor sensitivity in CCI mice. We tested additional odors, Acetophenone, Amyl-acetate, Butanal and Propanal, and again found that CCI mice exhibited higher probability of activation than controls consistent with an increased sensitivity and decreased selectivity in odor responses. Finally, we used a buried-food behavioral assay and showed that CCI mice could indeed locate food faster than controls supporting an enhancement in olfactory sensitivity. As TBI has mild, moderate and severe types, we propose that the olfactory system may provide a new means to distinguish between different TBI types and study their mechanisms. Acknowledgements: Intramural funding from NINDS. Funding from Henry Jackson Foundation.

#P102 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Blocking the lateral olfactory tract *in vivo* alters spontaneous activity in the main olfactory bulb of the rat

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The lateral olfactory tract (LOT) contains the axons of mitral and tufted cells as well as centrifugal fibers that terminate in the main olfactory bulb (MOB). This study evaluated the effect of blocking axon conduction in the LOT by topically applying 2% lidocaine with a small ball of cotton. LOT blockade was assessed by recording field potentials (fp's) in the MOB evoked by stimulating LOT caudal to the block. Direct effects of lidocaine on the bulb were assessed by recording fp's evoked by stimulating LOT rostral to the block and/or by stimulating the olfactory nerve. The mean spontaneous activity (SA) of single units was recorded in each layer (Glomerular Layer (GL), External Plexiform Layer (EPL), Mitral Cell Layer (MCL), Granule Cell Layer (GCL)) before and after lidocaine application. Each site of single unit recording of SA in each layer of the MOB was confirmed by a dye spot. Overall, there was no change in the mean rate (paired t-test: 0.89 ± 11.2 Hz, p=0.6); however, there was considerable variability. In the GL, 6 units decreased in activity by a mean of 54.2 ± 27.7% and 7 units did not change. In the EPL, 4 units decreased in activity by a mean of 49.2 ± 32.2%, 2 increased by 32.7 ± 18.3% and 6 did not change. In the MCL, 7 units decreased in activity by a mean of 69.3 ± 18.8%, 8 increased by 43.4 ± 13.7% and 2 did not change. In the GCL, 3 units decreased in activity by a mean of 51.9 ± 25.3%, 2 increased by 33.6 ± 18.4% and 5 did not change. We conclude that tonic release of excitatory and/or inhibitory signals from centrifugal inputs to the MOB modulates spontaneous activity of many bulbar neurons. Ongoing experiments will attempt to determine the specific source(s) of this input and the bulbar circuits that are affected. Acknowledgements: University of Cincinnati Research Council

#P103 **WITHDRAWN**

#P104 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

PAC1R is Present and Functional before the Maturation of Granule Cells in Mouse Olfactory Bulb

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The GABAergic granule cells (GC) in the olfactory bulb (OB) develop from Dlx2 expressing neuroblasts derived from stem cells within the subventricular zone (SVZ). The neuroblasts migrate to the OB and enter the granule cell layer (GCL). From there, the neuroblasts either stop migrating and become immature neurons or continue migrating to the glomerular layer of the OB. The successful migration of neuroblasts from the SVZ to the GCL is a critical component of postnatal OB development. Pituitary Adenylate Cyclase-Activating Polypeptide (PACAP) and its G-protein coupled receptor (PAC1R) are involved in modulating the Ca^{2+} activity of developing OB neurons[1]. Ca^{2+} activity in the CNS is thought to be critical for the establishment and survival of

developing neuronal circuitry prior to sensory input. We used Dlx-2 tdTomato (Dlx-2T) transgenic mice to identify the small (4-8 um dia) GCs. This red dye uses the *Rosa26-Cag* promoter to continuously label cells that have expressed the *Dlx-2* gene at the neuroblast stage. We performed confocal Ca^{2+} imaging on live Dlx-2T OB slices from P2-P5 mice loaded with green membrane permeant Ca^{2+} indicator dye (Fluo-4 AM). We confirmed that 40 nM PACAP evokes either simple bursts or long term Ca^{2+} oscillations in identified GCs. We determined the stage of neuronal development of the Dlx-2T cells by using GABA, which is excitatory in immature neurons under our recording conditions. While at least half of the red Dlx-2T cells respond to GABA alone, we discovered that some PACAP-responding cells respond to GABA too, meaning they are neuroblasts in the process of becoming mature neurons. The appearance of PACAP-induced Ca^{2+} activity before GCs are mature suggests a role for PACAP in turning neuroblasts into mature GCs. Acknowledgements: University of Utah Graduate Research Fellowship, Ruth L. Kirschstein National Research Service Award NIDCD 1F31DC011686-01A to MAI, NIDCD R01 DC002994 to MTL

#P105 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Kv1.3 Channel Activity and GABAergic Signaling are likely Mediators of Glucosensing in Mitral Cells

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Olfaction is not static and is modulated by consumption of meals and metabolic disease states. The firing properties of mitral cells, the principle neurons of the olfactory bulb, are modulated by metabolic factors released from peripheral tissues and the central nervous system. We previously reported that mice with diet-induced obesity exhibit altered mitral cell intrinsic firing properties and insulin resistance of the olfactory bulb. We hypothesized that extracellular glucose levels may also be detected by a potassium channel predominantly expressed in mitral cells, Kv1.3. Using a heterologous expression system, Kv1.3 voltage-activated peak currents were rapidly modulated by D- but not L-glucose in a bell-shaped dose-dependent fashion. To examine the changes of mitral cell firing patterns in response to different glucose concentrations ranging from 0 to 22 mM, mitral cell evoked action potential (AP) firing frequency, AP cluster and pause duration, and AP shape and timing were recorded via slice electrophysiology in postnatal (day 15-30) mice. The most prominent biophysical change was in firing frequency that was inhibited in 12 of 23 mitral cells in response to higher glucose. Modulation was not reversible following subsequent bath substitution to the original glucose concentration. Addition of synaptic blockers (NBQX, gabazine, and AP5) prevented the glucose modulation, suggesting that mitral cell intrinsic membrane properties are not glucose sensitive. Systematic substitution of blockers revealed the involvement of GABAergic synaptic transmission in the development of glucose sensitivity. Glucose sensing was lost in mice with gene-targeted deletion of Kv1.3, which could be attributed to loss of channel signaling or persistently low fasting glucose in these mice. Acknowledgements: R01 DC003387, F31 DC010097, and T32 DC00044 from the NIH/NIDCD

#P106 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Role of Intraglomerular Inhibition in Shaping Responses to Dynamic Olfactory Input

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Odorant-evoked activity in the mammalian olfactory bulb (OB) is dynamically shaped by sniffing behavior, with individual sniffs eliciting bursts of activity across OB neuron populations. Mitral/tufted cells (MCs) – the projection neurons – generally maintain this sniff-patterning even at high sniff frequencies, while olfactory receptor neuron (ORN) inputs attenuate and show less patterning. Here, we investigate the glomerular circuitry that shapes inhalation-driven dynamics in MCs. First, we tested the role of glomerular inhibition using optogenetics. We injected a Cre-dependent virus containing the proton pump Archaerhodopsin into the dorsal OB of GAD2-Cre mice, targeting GAD65+ periglomerular (PG) interneurons. After three weeks, we obtained extracellular recordings from MCs below the infected region while controlling sniffing in the anesthetized animal and using light stimulation to suppress activity in infected neurons. The most prominent effect of optical stimulation was an increase in odorant-evoked MC peak firing rates. However, there was little change in fine-scale temporal dynamics, suggesting that inhibition from infected interneurons may affect MC excitability but not be critical in determining temporal response patterns. We next constructed a computational model of a glomerular circuit, including an external tufted (ET), PG, and mitral cell, each as a single-compartment, Hodgkin-Huxley-style model, and using different connectivities between these cell types. As input to the model we used signals derived from ORN recordings imaged from awake, naturally-sniffing rats. Preliminary modeling results suggest that synaptic depression and ET cell bursting can strengthen MC patterning. Ongoing work will further explore the contribution of intraglomerular inhibition to the shaping of MC responses. Acknowledgements: F31DC010312 (NIDCD NRSA), BU Center for Neuroscience Seed Grant, and R01DC011423-01 (NIH CRCNS)

#P107 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

A novel array design that incorporates tetrode recordings with optogenetic stimulation

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With recent growth in the field of optogenetics arises the constant need for improvements in multi-electrode array designs that combine electrophysiological recording and optogenetic stimulation. We present a design that allows tetrodes to be precisely targeted to regions of the brain that are stimulated by an LED-coupled optical fiber. This design focuses on simplicity and precision in stimulation and surgical implantation. Our design employs a tapered glass pipette that provides containment for the LED-coupled optical fiber as well as guide tubes for tetrodes. This design is ideal for use in freely moving mice, as the array is small and light enough to be easily tolerated during behavioral experiments. We provide technical specifications for this array design, including the extent of light spread from the glass cannula. We also provide data demonstrating the use of this array in the mouse olfactory bulb to stimulate olfactory sensory neuron terminals expressing humanized Channelrhodopsin-2 (hChR2), and to record from mitral and tufted cells receiving this sensory input. Acknowledgements: NIDCD R01DC009640 (TB), R21DC010911 (TB), the Whitehall Foundation and the Brain Research Foundation (TB), State of Colorado Bioscience Discovery Evaluation Grant (TL), Colorado Clinical Translational Science Institute (TL), the Boettcher Foundation's Webb-Waring Biomedical Research Program (GF), NIDCD R01DC00566 (DR), P30DC04657 (DR), F32DC011980 (DG)

#P108 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Odor representations selectively imaged from inhibitory interneurons and output neurons of the mouse olfactory bulb

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To understand how olfactory information is represented and processed across the olfactory bulb (OB) we are using the genetically-encoded calcium sensor GCaMP3 to image activity among genetically- and anatomically-specified populations of OB neurons, including GABA-ergic periglomerular (PG) interneurons and mitral and tufted (MT) cells projecting to piriform cortex. GCaMP3 expression in these neurons was achieved using Cre recombinase-dependent viral vector injection in mice expressing Cre in either GAD65-positive neurons (GAD2-cre) or protocadherin21-positive neurons (pcdh21-cre). We recorded optical signals using epifluorescence imaging across the dorsal OB and two-photon imaging yielding cellular-level resolution of activity within glomeruli and as deep as the mitral cell layer. Evoked GCaMP3 signals were large and showed clear coupling to inhalation. Odorant response maps imaged from both MT and PG cells appeared similar to those imaged from sensory neuron inputs, showing a rough chemotopy organized into functional domains, discrete foci reflecting glomerular boundaries and a strong concentration-dependence. This result suggests that the topography of odor representations is not drastically remodeled by OB processing. A second major observation was a strong dependence of MT and PG cell signals on anesthesia: odorant-evoked PG cell responses increased as depth of anesthesia decreased, while those of MT cells decreased and became nearly undetectable in the awake mouse. The transition from strong to weak MT responses could occur over a time-course of seconds. These results are consistent with a critical role for PG cell inhibition in shaping OB output and with the idea that both local and output neuron populations may be strongly modulated during behavior. Acknowledgements: NIDCD

#P109 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Modulation of the spatial representation of odors by an olfactory associative learning in the mouse olfactory bulb

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Plasticity of primary sensory cortices is essential for learning and memory. In the olfactory bulb (OB), a central structure supporting the first step of odor coding, odor stimulation evokes spatio-temporal patterns of activity. While the temporal aspect emerges from the functional loop between mitral cell and granular interneurons, the spatial component is formed by the activation of groups of glomeruli, anatomo-functional units of the OB, where olfactory neuroreceptors make synapses with the mitral cells. In vivo intrinsic optical signal imaging is a technique based on changes of endogenous optical properties of the brain tissue during activation and is commonly used to map odor-induced spatial activity in the dorsal OB. While modulations of the temporal component of the olfactory information have been studied through electrophysiological recordings, changes in spatial maps following learning in adults were not fully explored. The aim of this study is to visualize, using intrinsic optical imaging, changes in these odor maps following learning. Mice were implanted with a chronic cranial window centered on the OB and activity was recorded under anesthesia for a set of odors which will be used for training, plus a control/neutral odor. After few days of recovery, mice were trained to solve an odor discrimination task (go-nogo task) where one odor is associated with reinforcement and one odor is not associated with a reward (paired condition). In another group the odors were randomly associated with the reinforcement (unpaired condition). After mice had reached the criterion, maps for these three odors were recorded in the same conditions as initially, in order to compare the response profile before and after learning. We observed no reorganization of spatial maps or change in the intensity of odor responses in the paired group. However in the unpaired group, while the spatial maps were not modulated by the odor stimulation, we saw a decrease of responses following presentation of odors uses during training. No change was observed for the control odor. Taken together, our data indicate an impact of

the olfactory experience on the spatial representation in the olfactory bulb. Acknowledgements: Agence Nationale de la Recherche ANR-09-JCJC-0117-01

#P110 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Odorant Exposure Can Decorrelate Primary Odor Representations and Improve Odor Discrimination in Adult Mice

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Adaptive plasticity can permit the optimization of sensory function for a given environment. Last year we reported that chronic odorant exposure substantially altered the pattern of synaptic input from olfactory receptor neurons (ORNs) to olfactory bulb glomeruli (Moberly et al. 2011, *AChemS P108*). Here we optically imaged from the olfactory bulbs of mice that express the fluorescent exocytosis indicator synaptopHluorin in ORN terminals (Bozza et al. 2004) to compare patterns of ORN input between the structurally similar odorants hexanal (HEX) and heptanal (HEPT) before and after seven days of exposure to an unrelated odorant (butyl acetate, BA). We found that the spatial patterns of HEX- and HEPT-induced neural activity became decorrelated in BA-exposed mice but not in home cage controls. We then tested for changes in odorant discrimination abilities using a cross-habituation task (see Mandairon et al 2006). During baseline testing wild-type mice did not discriminate between HEX and HEPT, nor between (+)- and (-)-limonene or pentanol and butanol. When tested again with the same three odorant pairs after one week of exposure, BA-exposed mice spontaneously discriminated between HEX and HEPT and between (+)- and (-)-limonene, whereas home cage controls continued to cross-habituate between odors. These data demonstrate that exposure to a single odorant can enhance contrast between primary olfactory representations of odorant pairs that are chemically unrelated to the exposed odorant and that this decorrelation can lead to a gain of olfactory function. Together, the present findings also provide novel support to the conventional model that odor quality is represented by the spatial pattern of odorant-evoked ORN afferents. Acknowledgements: This work was supported by grant R00 DC009442 from the National Institute on Deafness and Other Communication Disorders to JPM

#P111 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Odour Specificity and Response Characteristics of Bulbar Neurons Linking Olfaction to Locomotion

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The peripheral olfactory organ of the sea lamprey is comprised of the main olfactory epithelium and an accessory olfactory organ. Olfactory information from the main epithelium and accessory organ transits through a uniglomerular medial region of the olfactory bulb to command neurons in the hindbrain driving locomotion; while non-medial regions of the olfactory bulb receive olfactory information exclusively from the main olfactory epithelium and primary output neurons project to forebrain structures where information is further integrated. In this study we used an *ex-vivo* nose-brain preparation to investigate the neural responses of the medial and non-medial subsystems of the olfactory bulb to a variety of odours using local field potential and multi-unit recordings. Response profiles of local field potentials were monophasic or multiphasic in shape and were consistent within a given recording location, independent of odour category. The amplitude, response latency, and half-width of field potential responses were examined for each odour in both the medial and non-medial regions of the olfactory bulb. In addition, changes in spike frequency were examined for multiunit recordings revealing both excitatory and inhibitory responses to amino aids, sex pheromones, and migratory pheromones depending on the recording location within the olfactory bulb. Taken together these responses suggest that the medial region is responsive to basic amino acids, lamprey sex pheromones and migratory pheromones and has the ability to evoke locomotor responses while the other regions of the olfactory bulb are responsive to a specific subset of odours suggesting that the olfactory bulb of the sea lamprey exhibits chemotopy. Acknowledgements: Funding provided by the Great Lakes Fishery Commission and the Natural Sciences and Engineering Research Council of Canada.

#P112 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Inhibitory Inputs onto Granule Cells in the Accessory Olfactory Bulb

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Granule cells (GCs) in the olfactory bulb (OB) receive abundant GABAergic inputs from the basal forebrain as well as from local inhibitory neurons. Inhibition at dendrodendritic synapses between GCs and principal cells in the OB is thought to be important for synchronous oscillations and olfactory discrimination. In addition, in the accessory olfactory bulb (AOB) regulation of inhibition plays an important role in the formation of odor memory in female mice during mating. Yet, regulation of the inhibitory input onto GCs and its function on dendrodendritic synapse activity is not known in the AOB. Here, using an in vitro slice preparation we characterized inhibitory inputs onto GCs of the AOB. We found that GCs exhibited spontaneous inhibitory postsynaptic currents (sIPSCs) with a mean frequency of 0.34±0.08 Hz and an amplitude of 14.6±1.3 pA (n=20). These currents were GABAergic as they were completely abolished in the presence of GABAzine (5μM) a $GABA_A$ receptor blocker. GABA sIPSCs exhibited a rise time bimodally distributed, centered at 2.0 and 7.9 ms, however, both populations had a similar averaged decay time (85.5±33 and 99.4±34 ms, t-test, $p>0.7$). Addition of TTX (0.5μM) and ionotropic glutamate receptor blockers APV (100μM) and CNQX (10μM) did not significantly change the frequency of IPSCs (0.35±0.08 Hz, n=20; t-test, $p>0.6$) suggesting that GABA IPSCs recorded in GCs were action potential-independent and were independent of fast excitatory glutamatergic transmission. Having distinct sources of inhibitory inputs onto GCs might be beneficial to produce fine-tuning of inhibitory transmission at dendrodendritic synapses under different behavioral conditions. Acknowledgements: Work supported by a NIDCD R01-DC-009817 grant to R.C.A. and Becas Chile fellowship to A.N.

#P113 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Higher anxiety is associated with better odor recall performance in apolipoprotein E ε4 negative adults, but not ε4 positive adults

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The ε4 allele of the apolipoprotein E (apoE) gene is associated with increased risk for Alzheimer's Disease, and adults who possess the ε4 allele exhibit olfactory performance deficits. Recent research suggests that anxiety may interact with the apoE gene to affect verbal learning and memory in older adults. The current study explored this gene-environment interaction within the olfactory modality in 32 young (18-26 years) and 32 older adults (60+ years). It was hypothesized that the apoE gene would mediate the effect of trait anxiety on olfactory episodic memory such that higher anxiety would be associated with better recall in ε4- adults, but not ε4+ adults. Short and long delay free and cued olfactory recall of 16 odors was measured following procedures of the California Odor Learning Test (COLT). Multiple hierarchical linear regression analyses were conducted to determine the impact of age group (young adults, older adults), apoE ε4 status (positive, negative), and trait anxiety (State Trait Anxiety Inventory - Trait; STAI-T) on short and long delay odor memory. Age group and apoE ε4 status were entered in the first block, while the STAI-T score, and the 2-way interaction terms were entered in the second block. Adding trait anxiety to the model significantly improved prediction of short and long delay recall performance. The 2-way interaction of apoE status and STAI-T was significant in all recall conditions, and indicated that higher trait anxiety was associated with better recall for older and younger ε4- adults, but not for ε4+ adults. Thus, ε4+ adults, regardless of age, are not receiving the same performance benefits from anxious arousal that are observed in ε4- adults. Acknowledgements: Supported by NIH Grants R01 AG004085 and R01 DC002064 to C.M. We thank the members of the UCSD Shiley-Marcos ADRC for genotyping, and the support of the NIH Grant P50 AG005131 to the ADRC.

#P114 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

The Influence of Fragrance on Salivary Alpha-Amylase and Cortisol Reactivity to Acute Stress. A Pilot Study

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Acute stress or "fight or flight" stress response is initiated when a person is exposed to a temporary trigger and the effect lasts as long as the trigger is present. The trigger could be public speaking, a competitive exam, a job interview, being stuck in traffic, house cleaning, etc. Salivary Alpha-Amylase (sAA) and Cortisol (CORT) are widely used as biomarkers for stress. A change in sAA can be correlated to a stress response activated at the locus cereleus norepinephrine/sympathetic nervous system (LC–NE/SNS). A change in CORT can be correlated to a stress response at the hypothalamic–pituitary–adrenal (HPA) axis. The purpose of this study was to investigate the influence of fragrance on sAA and CORT reactivity to acute stress. Female panelists age 30-45 were recruited for this study. Stress was induced using a timed 10 minute mathematical/word test in a small group competition setting. Fragrance was introduced for 6 seconds every minute during the 10 minute stress test. Saliva was collected before and immediately after the stress test, and analyzed for sAA and CORT. The increase of sAA in the presence of fragrance was significantly less than the control ($p<0.1$). A similar result was also seen with CORT ($p<0.05$). The results of this study suggest that the presence of fragrance during a stress task may have a positive influence by blunting the effect of the stressor and that both the sympathetic and the HPA axis may be involved. Supported by TAKASAGO Int'l Corp, Rockleigh, NJ.

#P115 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

The Influence of Verbal Processes on the Relationship Between Odor Naming and Memory

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Consistent odor naming has been found to be an excellent predictor of odor recognition memory in some studies but a poor predictor in others. One explanation for these discrepant results is that some testing procedures allow participants to employ a verbal strategy to recognize odors as old or new during retrieval by remembering the names given to the odors. The response old is given when an odor name used during encoding is also used during retrieval. When an odor name is not used during encoding, the recognition memory response is new. The aim of the current studies was to determine which of four procedures were conducive to use the verbal strategy. In the baseline procedure, participants smelled 10 odors, selected an odor name from 4 name alternatives, and were told to remember each odor for a subsequent memory test. Following a 10 minute retention interval, 20 odors were presented - 10 from the encoding phase and 10 new odors. Participants were asked to select the name from 4 alternatives and indicate whether the odor had been presented previously (old odor) or was new. The 3 remaining studies altered the above procedure by 1) separating completely the odor recognition memory task from the odor naming task, or 2) reversing the presentation order of the odor naming and recognition memory evaluation during the retrieval phase, or 3) using only odor names during encoding and using 16 odor alternatives during the retrieval phase. The predictive power of consistent odor naming and the use of the verbal strategy were the greatest when the odor names were provided both in the encoding and retrieval phases of the procedure. It was concluded that the ability of consistent naming to predict odor recognition memory is linked to the use of the verbal strategy in the dual odor naming/recognition memory task.

#P116 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

Swiss identity smells like chocolate: Accessible social identities shape olfactory perception

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There is some evidence that olfactory perception differs between cultural groups. However, people from different culture differ not just by their familiarity with different odors, but simultaneously in a variety of other dimensions, such as their social identity (e.g., nationality), rendering it unclear what is behind such differences. In this research, we isolated the effect of social identity on olfactory perception. To do so, we varied the relative accessibility of Swiss identity, using priming techniques, across participants from the same cultural background (i.e., Swiss). We contrasted these participants to a group of non-Swiss participants exposed to the same identity priming procedure. We measured the perception of two odors: chocolate, for which Switzerland is world famous, and sweet popcorn, a similarly high-caloric food item with no particular association to Switzerland. Swiss participants primed with Swiss identity perceived the chocolate odor as more intense than when primed with non-identity ($p < .001$), and than non-Swiss participants in the same identity priming condition ($p < .001$). There were no significant effects of condition on chocolate pleasantness or familiarity ratings [F_s (3,74) = 0.23, 0.25, p_s = .872, .860]. For popcorn, there was no significant effect of experimental condition on intensity, pleasantness, or familiarity perceptions [F_s (3,74) = .96, .47, .66, p_s = .415, .706, .580]. Taken together, this shows that making a particular social identity accessible can selectively enhance the intensity of odors relevant to the primed identity, even in the absence of familiarity and pleasantness differences. Our results suggest that beyond culture, social psychological concerns, such as the accessibility of a particular identity, can impact olfactory perception. Acknowledgements: This research was supported by the National Center of Competence in Research for the Affective Sciences, financed by a grant from the Swiss National Science Foundation (51NF40-104897), hosted by the University of Geneva, and by a research grant from Firmenich, SA, to David Sander and Patrik Vuilleumier.

#P117 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

Retronasal identifications of vapor-phase 18-carbon fatty acids

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The long-chain 18-carbon fatty acids linoleic, oleic, and stearic acids, presented retronasally in vapor-phase, are discriminated from blanks and each other (Kallas & Halpern, Chemo. Percept. 4:16-25, 2011). However, ability to linguistically identify them individually or as a group is unknown. Literature sources suggested 'oily' or 'fat' as likely identifications. METHODS. 1st, a Focus Group produced 32 descriptors for the 3 long-chain fatty acids plus phenylethyl alcohol (PEA) and geraniol, each presented retronasally in vapor-phase. 2nd, Check-All-That-Apply (CATA) measures on these 32 descriptors gave 9 identifiers for the 5 stimuli, each selected for a stimulus by ≥3 CATA participants: flowers, lemon, margarine, new plastic, oily, olive oil, peanut oil, rubbery, and sunflower. 3rd, using these identifiers, 22 participants selected 1 of the 9 identifiers from a computer-based display during 4 retronasal vapor-phase presentations of the 5 randomized stimuli. RESULTS. Modal identification (and 2nd & 3rd most frequent identifications) for geraniol was 95% lemon (2% oily, 1% flowers), PEA 67% flowers (11% rubbery, 10% oily), linoleic acid 23% rubbery (18% oily & 18% new plastic, 14% olive oil), oleic acid 21% oily (19% rubbery, 16% new plastic and 16% sunflower), stearic acid 43% rubbery (22% new plastic, 18% oily). Identifications for fatty acids differed from those for geraniol and PEA, $p < 0.0008$, but fatty acid identifications did not differ from each other, $p \geq 0.48$, Wilcoxon Signed-Rank tests. CONCLUSIONS. Retronasally presented linoleic, oleic, and stearic 18-carbon fatty acids received identifications that differed from other vapor-phase stimuli but not from each other, suggesting that retronasal vapor-phase 18-carbon fatty acids can be identified as a group but not separately. Acknowledgements: Support from a Susan Linn Sage Professorship

#P118 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Concentration at Detection as an Inappropriate Index of Chemosensory Potency

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The objective is to clarify the bases of a QSAR for odor and irritation potency. Abraham et al. demonstrated applicability of a linear free energy relationship (LFER) to chemesthetic/irritatiion potency. The equation, with descriptors for excess molar refraction, dipolarity/polarizability, hydrogen bond acidity and basicity, resp., and lipophilicity could account for potency to humans and various rodents (rsq about 0.95). The generality seemed consistent with the simplicity of chemesthesis phenomenologically and mechanistically. When solved for odor, the variables accounted for less variance (rsq about 0.75 to 0.80), a possible reflection of greater complexity phenomenologically and mechanistically. This outcome occurred previously, and did so here with data of precision and more than 200 materials ("Nagata set"). The outcome tempted the conclusion that chemesthetic potency depends just upon selective factors related to transport, whereas odor potency depends also upon specific factors such as molecular complementarity (e.g., shape). Research on input-output functions for individual materials suggests another possibility, viz., the two LFERs account for the same amount of variance. Chemesthetic output vs. an input of concentration invariably exhibits expansion whereas olfactory output vs. input of the same variable of concentration invariably exhibits compression. When normalized for this, the Abraham equation can do as well for odor as for chemesthetic detection. If residual variance of 5% is acceptable, then we have no reason to improve the Abraham model for olfaction, except some calculational refinements. These should include a measure of potency other than simple concentration, which introduces systematic variation in the chemesthetic-olfactory comparison. Acknowledgements: Supported by NIH grants R01 DC002741, R01 DR005003, and R01 DC050602.

#P119 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Response time for odor localization and identification

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When assessing the chemical senses, researchers often measure subjects' ability to identify or localise odors. One method of testing both tasks is the application of dichotomous stimuli. However, a problem one encounters with this method is the long testing time required to distinguish between different levels of performance; this is especially true if one takes into consideration the long inter stimulus interval which is needed to prevent adaptation and habituation. In this study we investigated if response times could be used as an alternative measure to assess odor localisation and identification. We delivered two mixed olfactory/ trigeminal odors (benzaldehyde - almond odor; eucalyptol - eucalyptus odor) to one nostril in a pseudorandomized order; the other nostril received an odor free airpuff. In half of the trials we asked the 23 normosmic participants to localise the odors (i.e., to detect the stimulated nostril); in the other half of the trials they were asked to identify the odors (i.e., to indicate whether they had received the almond odor or the eucalyptus odor). Subjects responded as fast as possible by pressing one of two buttons, allowing us to record both response times and response accuracy. Subjects reached a higher accuracy for odor identification than for odor localisation (driven by the almond odor); there was no effect on response times. We further observed response times to be correlated to response accuracy for the identification task, but not for the localisation task. Response times provide parametric data and are much faster to acquire, since less repetitions are needed. Our data therefore suggest that measuring response times may be an alternative economic approach to assess subjects' ability to identify odors; this however seems not to be true for odor localisation. Acknowledgements: CIHR postdoctoral fellowship to JF

#P120 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Olfactory Environment Influences Close Relationships through Multiple Methods of Measurement

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The current study examined whether disrupting the olfactory environment would impact the interaction of pairs of close friends through examining questionnaires, psychophysiology, and raters' perceptions of the videotaped interactions. One hundred pairs of female undergraduate close friends participated in two fifteen minute videotaped interactions. The first session was established as a baseline interaction for all participants. In the second session for half of the pairs, one member of the dyad was given a different perfume to wear; for the other half one participant was given a different watch to wear as a non-olfactory control condition. In questionnaires, only fragrance-wearing participants in the unfamiliar fragrance condition reported lower levels of enjoyment in the second session compared to the first, $p = .004$. Further, perceptions of closeness decreased for both participants when the olfactory environment was disrupted, $p = .011$. Analyses of psychophysiology data revealed that there was a trend for a session x condition interaction for beats per minute (BPM), $p = .057$. In the fragrance conditions, participants continuing their regular fragrance routine exhibited a decrease in BPM which was not observed in the unfamiliar fragrance condition. Analysis of raters' perceptions demonstrated that there was decreased meaningfulness, intimacy, and active engagement during the change in fragrance for both dyad members, all $p < .05$. Lastly, no changes in questionnaires, psychophysiology, or ratings of videos were observed in the non-olfactory control condition. Such findings suggest that exposure to the unfamiliar fragrance during the second session dynamically and rapidly affected close relationships.

#P121 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

The Effects of Aroma of Jasmine On Major League Baseball Players

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Objective: To determine whether the aroma of jasmine can affect the batting of major league baseball players. Methods: 6 Major League Baseball players participated in this IRB exempted study. All underwent the QSIT. In a consecutively alternating order, subjects underwent testing while wearing unodorized cotton wristbands followed by similar bands preimpregnated with jasmine at suprathreshold, but not trigeminally irritating levels. Subjects were instructed to wear bands and sniff once before batting at a standard pitch (provided by the same pitcher, selected for pitching consistency). After 5 pitches, the bands were switched, and the process was repeated. Following this, the subjects rated the hedonics of the odorant, and the players, coaches and pitcher rated, the batting. Batters, batting coaches, pitcher, and coaches were blinded as to which band contained the odor, the nature of the odor and the intent of the experiment. The same pitcher and coaches rated each batter. Assessment of batting was based on an integration of: mechanics of swing including trajectory, ball flight, bat speed, correctness of swing and bat swing in zone. Batters rated the subjective feeling of the swing and perception of batting ability. Results: While all claimed normal ability to smell on QSIT, 2 scored 0/3, 2 scored 2/3, and 2 scored 3/3. All reported positive hedonics towards the odor and better performance of hits using the odor. The pitcher and batting coaches independently rated better performance with the odor. No effect of order was found. Conclusions: Jasmine could have potential utility for enhancing athletic ability in baseball and other endeavors requiring precise hand-eye coordination, including microsurgery, musical performance, or in rehabilitation and physical therapy.

#P122 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

Effect of Lavender Odor on Reaction Time of 7th and 8th Graders

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Purpose: In adults, odors have been demonstrated to effect athletic performance possibly through improved reaction time (Raudenbush, Corley, & Eppich, 2001; Raudenbush, 2001). Alternatively, malodors have been demonstrated to impair reaction time (Rotton, 1983). The impact of odors on reaction time in children has not been established. This study attempted to determine if lavender would impact upon reaction time in children. **Procedure:** Nineteen 7th and 8th graders (15 girls, 4 boys) underwent reaction time testing with the method of Eckner (Eckner, Kutcher, & Richardson, 2010; Eckner, Lipps, Kim, Richardson, & Ashton-Miller, 2010). After two practice sessions, 8 measurements of distance dropped were recorded and averaged. All underwent reaction time testing while wearing an unodorized surgical mask (3M Aseptex Molded Surgical Mask), which served as a blank control, and while wearing a surgical mask impregnated with one drop of Custom Essence Lavender Natural de-44549 (Sommerset, NJ). **Results:** For the entire subject group, the reaction time while wearing the blank control mask was 0.235 seconds, whereas while wearing the odorized mask was 0.233 seconds; a difference of less than 1%. For the subgroup of subjects where the blank control was tested first (n=5), reaction time with control was 0.224 seconds and with odor was 0.223 seconds, a difference of less than 1%. For those who liked the aroma (n=11), reaction time with control and odor were identical, 0.221 seconds. Reaction time in the subgroup with disliked the odor (n=8) with control mask was 0.255 seconds, whereas with the odorant was 0.250 seconds, a difference of <2%. **Conclusion:** This study demonstrated that lavender has no effect on reaction time in early teenage children.

#P123 POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY

K14+ progenitors yield Glial-like and Receptor cells, not neuron-like Presynaptic cells of taste buds

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In adult mammals, taste buds turnover continuously. The basal layer of lingual epithelium adjacent to taste buds was shown to contain Keratin14 (K14)+, Sox2+ bipotential progenitor cells that generate both taste buds and keratinocytes. We asked whether all three functional cell types of adult taste buds are derived from this same set of progenitors. We performed lineage tracing by crossing K14-CreERT mice to Rosa26-YFP mice to indelibly mark (after tamoxifen-induction) all cells derived from K14+ progenitors. We induced the appearance of YFP in progenitors through tamoxifen-dependent Cre-mediated recombination and examined the numbers of YFP+ taste buds and cells over the following 60 days. In fungiform papillae and the palate, we found that K14+ progenitors generate keratinocytes within 3 days, but taste cells only a week following induction. From 12 to 30 days following induction, the fraction of taste buds that included YFP+ cells gradually increased to ≈50% and then remained at a plateau. Next, we double-immunostained for YFP and markers for mature taste cell types (NTPDase2, PLCβ2 and 5-HT for Glial-like, Receptor and Presynaptic cells respectively). We found that K14+progenitors initially give rise exclusively to Glial-like cells. Several weeks after induction, the K14+ lineage also yields Receptor cells. A maximum of 21% (of 216) YFP+ cells within taste buds were found to be PLCβ2+ at day 30 of post induction. In contrast, 5HT expressing cells were never YFP+. We conclude that K14+ progenitors for Glial-like/Type I cells and Receptor/Type II do not reside within taste buds, but migrate in from surrounding epithelium. Presynaptic/Type III cells in the adult may arise from an entirely different progenitor population. Acknowledgements: Supported by NIH/NIDCD R01DC6308 (NC)

#P124 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Hedgehog-responding cells in taste papillae are progenitors of lingual taste bud cells

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Sonic hedgehog (Shh) signaling regulates taste papilla development. In adult mouse fungiform papilla, Shh is specifically localized within taste buds. The transcription factor, *Gli1*, a reliable reporter of hedgehog (Hh) signaling activity, is expressed primarily in papilla epithelial cells that surround taste buds (but not within taste buds), in basal cells of the papilla epithelium, and in a population of mesenchymal cells in the papilla connective tissue core. This suggests that Shh that is produced by taste cells may signal to surrounding papilla cells for regulation of taste bud maintenance. To investigate the roles of Hh-responding cells in the maintenance of taste buds, we used a *Gli1-CreER^{t2}/R26R* mouse line for cell lineage tracing analysis. Tamoxifen injection was used to induce *lacZ* gene expression in *Gli1*-expressing cells and derived cells. Postnatal tongues were analyzed from 1 day to 3 months after tamoxifen injection, with X-Gal staining in whole tongue followed by cryostat sectioning. After tamoxifen injection, in addition to the *Gli1*-expressing cells described above, labeled cells are found within taste buds. Taste buds are fully or partially labeled. Labeling in taste bud cells is sustained at 3 months after tamoxifen injection whereas label in the fungiform papilla epithelium disappears. Immunoreactions for a pan-taste cell marker, Keratin 8, demonstrated that the X-Gal labeled cells within taste buds are K8 positive. Our results indicate that *Gli1*-expressing cells in the papilla epithelium surrounding taste buds are progenitors of taste cells, and that Hh signaling is important for the maintenance of taste buds. Acknowledgements: NIH NIDCD Grant DC000456 (CMM) and NIAMS AR045973 (AAD)

#P125 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Chemotherapy Drugs Induce Apoptosis and Decrease the Number of Progenitor Cells in the Taste Epithelium

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Taste abnormalities associated with chemotherapy are contributing factors toward development of food aversion and decreased caloric intake in cancer patients. Previous studies reported that up to two thirds of patients treated with chemotherapy experience taste alterations. The goal of this study is to understand the underlying mechanisms of chemotherapy-associated taste dysfunction. We investigated the effects of three chemotherapeutic agents, 5-fluorouracil (5-FU), cisplatin, and paclitaxel (PTX), on peripheral taste tissues. These drugs belong to different categories of anticancer agents and have been reported to affect taste in cancer patients. 5-FU (150 mg/kg), cisplatin (7.5 mg/kg), and PTX (115 mg/kg) were injected intraperitoneally into C57BL/6J mice. Taste tissues were collected at 24 and 48 h after drug injections. To investigate effects of these drugs on taste progenitor cells, we performed double immunostaining using antibodies against Ki67 and KCNQ1. Ki67 is a cell proliferation marker which can be used to identify progenitor cells in the taste epithelium. KCNQ1, a voltage-gated potassium channel protein, is a taste cell marker. To investigate whether these drugs induce cell death in taste tissues, we performed immunostaining using antibodies specific to activated Caspase-3 or Caspase-6. Both caspases are executioner caspases which, when activated, carryout proteolytic cleavage of many proteins critical for cell survival. Our results show that all three chemotherapy drugs significantly decreased the number of Ki67-positive taste progenitor cells and increased the number of apoptotic cells in the circumvallate epithelium. These results suggest that taste progenitor cells and taste bud cells are susceptible to the cytotoxic effects of chemotherapy drugs. Acknowledgements: Supported by a grant from the Pennsylvania Department of Health.

#P126 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Endogenous Gustatory Response and Properties of Immortalized Human Taste Cell Lines from Lingual Epithelium

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Stably proliferating human taste cell lines will be a powerful tool to gain new insights into human taste reception and signal transduction mechanisms as well as to develop new technologies for industry applications. We used biopsy samples from human lingual epithelium containing taste buds from fungiform, foliate and circumvallate papillae to obtain primary human taste cells. Isolated cells were transduced with Adenoviruses carrying immortalization gene cassettes comprising previously established immortalization genes. We obtained several proliferating cell populations suitable for characterization using molecular biology tools as well as for evaluation with HTS-compatible cell-based assays to quantitatively assess endogenous gustatory response of human taste cells. Two cell lines were chosen for gene expression analysis of select taste reception and signaling genes. Despite immortalization treatment, both cell lines revealed gene expression profiles resembling those of differentiated taste cells as well as those of progenitor cells residing in the taste bud. RT-PCR analysis of genes encoding taste receptors, ion channels and other potentially relevant factors revealed for instance that 15 of 25 human TAS2R bitter taste receptor genes as well as the Oxytocin receptor gene are expressed. Intriguingly, Fluo-4 Calcium assays revealed that our immortalized cell lines responded strongly with Calcium signaling when challenged with appropriate bitter compounds or Oxytocin. However, the cells were insensitive to compounds representing other basic taste modalities such as sweet, umami, salty and sour. These experiments provide evidence that we successfully established proliferating human taste cell lines, which maintain their endogenous programming and dedication to bitter taste perception.

#P127 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

β-defensin 1 expression in the peripheral taste system

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β-defensin 1 is one of many antimicrobial peptides that protect barrier epithelia from environmental pathogens. Expression of the peptide has been reported in porcine lingual epithelium. However, little is known about the expression of β-defensin in taste receptor cells and its regulation by inflammatory stimuli. We observed β-defensin immunoreactivity in taste receptor cells within fungiform taste buds, as well as the extra-epithelial layer of the anterior lingual epithelium. We administered the proinflammatory endotoxin, lipopolysaccharide (LPS; 0.1 mg), by injection to the ventral tongue of adult rats. Rats were also given overnight access to LPS (200 µg; 20 ml diH2O) in drinking water. Both treatments increased punctate β-defensin staining in taste buds, though injected LPS was more effective. β-defensin positive neutrophils were also more prominent after LPS injection, as expected. Work in progress will test the regulation of β-defensin expression by taste stimuli and the role of the antimicrobial peptide in taste function. Acknowledgements: NIDCD DC005811

#P128 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Regulatory roles of the BMP receptor Acvr1 in lingual mesenchyme in the development of tongue and gustatory papillae

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Development of the tongue and taste papillae requires interactions between the epithelium and mesenchyme and involves molecular signaling. Among multiple signaling pathways, stage- and tissue-specific effects of BMP signaling are profound. We have recently demonstrated a progressively dense distribution of neural crest derived cells (NCDCs) in tongue mesenchyme, just under the epithelium and in the mesenchymal core of taste papillae, suggesting important roles of mesenchymal NCDCs in interactions among epithelial and mesenchymal cells for taste papilla development. To test for roles of BMP signaling in mesenchymal NCDCs in taste organ formation, we used a *Wnt1-Cre* mouse line that expresses Cre recombinase, primarily in tongue mesenchyme, in a neural crest-specific manner. By crossing with mouse lines that conditionally express a constitutively activated (ca) form of type I BMP receptor *Acvr1* or conditional knockouts (cKO) of *Acvr1*, we were able to generate *caAcvr1* and *Acvr1* cKO in lingual mesenchymal NCDCs. In *Wnt1-Cre/caAcvr1* mouse embryos, there is a dramatic alteration of the developing tongue. The tongue is small and misshapen. Fewer fungiform papillae are seen on the surface of the tongue, and they are less obvious than those in littermate controls. In *Wnt1-Cre/Acvr1 cKO* mice, tongue shape and patterns of fungiform papilla placodes are altered at E12.5 when papilla placodes would typically emerge on a spatulate tongue. Furthermore, tongue formation is impaired in 2 day cultures of branchial arches of *Wnt1-Cre/Acvr1 cKO* embryos compared to littermate controls. Thus, our data suggest that appropriate levels of the type I BMP receptor Acvr1 in lingual mesenchymal NCDCs are important in lingual epithelial-mesenchymal interactions for the formation of tongue and taste papillae. Acknowledgements: NIDCD, NIH Grant DC009055 to HXL

#P129 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Characterization of Y Receptors Expression in Salivary Glands (SG) and Modulation of Feeding Behavior by SG Gene Delivery

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NPY family genes are represented by well-characterized hormones Neuropeptide Y (NPY), Peptide YY (PYY), Pancreatic Polypeptide (PP) and their cognate receptors. These genes are widely expressed in the brain as well as in the periphery where they mediate multiple metabolic functions. Recently, we have shown the presence of PYY in saliva and the expression of its preferred receptor, Y2R in lingual epithelia. We now extend our finding to all main NPY family members and characterize their expression in von Ebner's (VEG) and submandibular (SMG) salivary glands. A single layer of the cytokeratin-5 cells lining the VEG were shown to be Y1R/Y2R-positive, suggesting a role for Y receptors in proliferation of progenitor cells. In addition, acinar and mucous cells in VEG express Y1R. In SMG, acinar cells were positive for Y1R, myoepithelial cells for Y2R, while cells in excretory and intercalated ducts expressed Y4R. The wide variety of cells expressing genes of the NPY family suggests their functional significance in mediating diverse physiological functions. To test a possible role of salivary YR-signaling in energy metabolism, we constructed a recombinant Adeno-associated viral vector encoding gene for pre-pro-PYY. The vector was administered bi-laterally into the SMG duct of germline PYY KO mice or in diet-induced obese mice. In a long-term study, a sustained, two-fold increase in salivary PYY_{3-36} was achieved resulting in a significant reduction in food intake and body weight, thus re-opening the potential of PYY_{3-36} for the treatment of obesity. Taken together, these experiments characterize, for the first time, the expression of all NPY family members in at least 2 types of salivary glands suggesting multiple functions in the proliferation of epithelia cells, mucosal secretion, and energy metabolism. Acknowledgements: PI's startup

#P130 **POSTER SESSION III: OLFACTION DEVELOPMENT & CNS; HUMAN PSYCHOPHYSICS; TASTE PERIPHERY**

Effect of Maternal Diet on the Fat Taste Transduction Pathway of Male Offspring

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Recent studies on the effects of maternal obesity have shown that overnutrition in female rats during pregnancy and lactation can lead to adverse physical conditions, such as diabetes or cardiovascular disease, in the offspring. The peripheral taste system is involved in the initial stages of nutrient intake and we have found that diet can modulate expression levels of signaling molecules and ion channels in the peripheral taste system which may eventually modulate food choices. We have previously shown that linoleic acid activates the fatty acid receptor GPR120 in mouse taste cells leading to activation of PLCß2, an IP_3-mediated rise in intracellular calcium and activation of TRPM5 (Liu et al. *J Neurosci* 31:8634, 2011). In the present study, we investigated the changes in expression of taste signaling molecules in 3-4 week old male pups born and weaned to OM and S5B female rats fed a 60% (60kcal/100kcal) fat or control diet, as well as male offspring from their female littermates, using quantitative real time PCR. Expression of several putative fatty acid receptive proteins, including CD36, GPR120 and delayed rectifying K (DRK) channels, were assayed. Our results show an increase in expression of CD36 and the primary fatty acid-sensitive channel, KCNA5 (Kv1.5), which appears to be passed on to the next generation. Alternatively, expression of the fatty acid-insensitive channel, KCNC1 (Kv3.1), decreases in both generations. GPR120 expression however, increases in rats born and weaned on a high fat diet, then decreases in the next generation. While preliminary, our results support the idea that maternal nutrition can modulate specific chemosensory pathways that underlie nutrient transduction. Acknowledgements: Supported by NIH R01DK059611

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#P132 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Resistance to Aversion Conditioning to a Semiochemical in the Rat

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Semiochemicals are a class of small organic molecules that mediate a wide variety of species-specific "innate" behaviors. While semiochemicals and their attendant behavioral responses have been extensively catalogued and characterized, little work has been done to explore the qualitative differences between semiochemicals and other odiferous compounds at the behavioral level. For instance, it is not known whether or not semiochemicals are subject to the same rules of associative learning as other odor cues. We therefore tested the hypothesis that Long-Evans rats are impaired in their ability to learn about the semiochemical responsible for the acquisition of a food preference in rodents (carbon disulfide, CS_2). Here, we show that rats exhibited an impaired taste-potentiated odor aversion to CS_2 but not to a neutral food odor (benzaldehyde, $p = 0.03$, $n = 16$) despite showing normal learning to the co-presented gustatory stimulus ($p = 0.33$, $n = 16$). Thus it appears that CS_2 belongs to a qualitatively distinct category of odor compounds.

#P133 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Could sniffing variations improve olfactory perception?

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Different authors have considered sniffing not only as the odorant molecules vector but also as an integral part of the olfactory percept (Mainland and Sobel, 2006). While sniffing has been shown to be highly dynamic (Youngentob et al., 1987), the precise role of its variations in frequency and flow rate in olfactory perception remains the question to be answered. As first suggested by Schoenfeld and Cleland (2005), variations would improve olfactory capabilities by optimizing the deposition of odor molecules through the olfactory epithelium (OE). To test this hypothesis, we needed to record sniffing variations, using non-invasive method to not disturb sniffing. For this purpose, we adapted the double discrimination task developed by Uchida and Mainen(2003) in a whole-body plethysmograph. Here, we present our preliminary results. They suggest that 1) specific sniffing variations help in olfactory perception and 2) sniffing parameters vary as a function of odorant chemical properties. If our first results are confirmed, this would place sniffing as a specific motor act similar to how eye movements serve to allow acute visual perception. Acknowledgements: This work was supported by a grant from "Agence Nationale de la Recherche" (#ANR-07-NEURO-030).

#P134 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Diet-induced Obesity Differentially Disrupts Olfactory-based Learning and Memory Paradigms in Wildtype and "Super-smeller" Mice

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Gene-targeted deletion of a predominant *Shaker* channel in the olfactory bulb (Kv1.3) results in a "Super-smeller" phenotype. Since Kv1.3-/- mice also exhibit resistance to diet-induced obesity, we hypothesized a correlation between the ability to detect odors and body weight. Wildtype (WT) and Kv1.3-/- (KO) mice were maintained on a Purina control chow (CF, 13% fat), moderately-high fat diet (MHF, 32% fat), or a high-fat diet (HF, 60% fat) for 6 months prior to being placed in a Knosys liquid-based olfactometer

for operant conditioning. WT mice challenged with higher fat diets became hyperglycemic whereas fasting glucose levels and body weight remained low in KO mice, only elevating to CF levels of WT mice when placed on the HF regime. Regardless of body weight, mice maintained on higher fat diets required twice as many learning trials to achieve 80% accuracy determined by the animal licking 6 of 10 short time bins following the presentation of an odorant to receive a water reward (Stage 3). Once the task was learned, HF challenged WT mice had a reduced accuracy in go-no-go trials to recognize the trained odorant, difficulty in discriminating at asymptotic levels of performance between two structurally dissimilar odors, and only one could relearn a task following switch of the conditioned odorant (S+) with the unconditioned odorant (S-). HF challenged, but obesity resistant, KO mice had no difficulties recognizing the trained odorant, demonstrated increased discrimination between two odorants over that of CF KO mice, but showed a slower time to initially relearn a task (i.e. S+/S- switch) compared to WT mice. These data suggest that high-fat diet contributes to impaired olfactory-based learning whereas related changes in body weight additionally affect the accuracy of olfactory discrimination. Acknowledgements: This work was supported by NIH R01003387-SUMM by the NIDCD, a Bess Ward Scholarship from FSU, a Johnson Award from TriBeta National Biology Society, and an equipment grant from the FSU Program in Neuroscience.

#P135 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Olfactory sensitivity and odor structure-activity relationships for aliphatic carboxylic acids in CD-1 mice

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Using a conditioning paradigm, the olfactory sensitivity of CD-1 mice for a homologous series of aliphatic n-carboxylic acids (ethanoic acid to n-octanoic acid) and several of their isomeric forms was investigated. With all 14 odorants, the animals significantly discriminated concentrations ≤0.03 ppm (parts per million) from the solvent, and with four odorants the best-scoring animals even detected concentrations as low as 3 ppt (parts per trillion). Analysis of odor structure-activity relationships showed that the correlation between olfactory detection thresholds of the mice for the unbranched carboxylic acids and carbon chain length can best be described as a U-shaped function with the lowest threshold values at n-butanoic acid. A significant positive correlation between olfactory detection thresholds and carbon chain length of the carboxylic acids with their branching next to the functional carboxyl group was found. In contrast, no such correlation was found for carboxylic acids with their branching at the distal end of the carbon chain relative to the functional carboxyl group. Finally, a significant correlation was found between olfactory detection thresholds and the position of the branching of the carboxylic acids. Across-species comparisons suggest that mice are more sensitive for short-chained (C_2 to C_4) aliphatic n-carboxylic acids than other mammalian species, but not for longer-chained ones (C_5 to C_8). Further comparisons suggest that odor structure-activity relationships are both substance class- and species-specific.

#P136 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Changes in odor-guided learning mirror changes in cortical dopamine function.

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The orbital frontal cortex (OFC) and piriform cortex are highly interconnected structures that are thought to be involved in encoding the predictive value of environmental stimuli. Each of these cortical areas displays experience-dependent plasticity, which may be modulated by mesocortical dopamine (DA). The importance of DA in associative learning appears to change during development; adolescent rats demonstrate a greater behavioral sensitivity to drugs that act on DA receptors compared with juvenile and adult rats, require more trials to extinguish cocaine place-preference than adults, and exhibit higher susceptibility to reinstatement in studies of cocaine-seeking behavior. Changes in DA receptor expression throughout the lifespan may underlie these age-dependent differences in learning the predictive value of environmental cues. Previously, we described changes in DA receptor expression during adolescence. Here, we confirm these findings with quantitative PCR and immunocytochemical data, and show that adolescent rats exhibit significantly slower learning on an odor discrimination task compared with juvenile and adult rats. This impairment was alleviated by administration of a low dose of the DA receptor agonist SKF-32393. These results suggest that DA plays a role in learning the predictive value of environmental stimuli, and that developmental changes in DA receptors may underlie age-related differences in odor-guided associative learning.

#P137 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Effects of Cholinergic Receptor Inhibition on Olfactory Fear Learning and Generalization in Mice

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Fear conditioning has long been used as a powerful model for the study of the neural mechanisms behind learning and memory. Here we use this model to investigate the role of cholinergic neurotransmission in olfactory learning. Under control conditions, mice receiving pairings of an olfactory stimulus with aversive foot shock display robust fear towards the trained odorant as measured by stereotypical freezing behavior. We next applied systemic injections of cholinergic antagonists prior to pairing an odorant with aversive foot shock and measured freezing to the trained odorant as well as similar odorants the following day. Injections of the nonselective nicotinic antagonist mecamylamine before training had no effect of subsequent freezing levels. However, pre-training injections of the muscarinic antagonist scopolamine significantly reduced freezing to the trained odor in a dose-dependent manner. Additionally, scopolamine also reduced freezing to other similar odorants compared to control mice. While there was an overall reduction in freezing levels to all odorants in scopolamine treated animals, the amount of generalization remained similar in both control and scopolamine groups. Overall, these results suggest that

while blocking muscarinic neurotransmission during acquisition of olfactory association leads to a general reduction in the learning, it does not affect generalization of this learning. Acknowledgements: R03 DC009853

#P138 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

The Role of Chemical Cues in Precopulatory Reproductive Isolation in House Mouse Superspecies Complex *Mus musculus* s.lato: from Behavior to Receptors

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The present study aimed to investigate the role of chemical cues in precopulatory reproductive isolation in closely related *Mus* species. Test subjects were two sympatric species which do not hybridise under natural conditions: house mouse *M. musculus* and mound-building mouse *M.spicilegus*. To monitor plasma testosterone and corticosterone we used ELISA technique. To visualize activated neurons in vomeronasal organ (VNO) receptor tissue, in the main (MOB) and accessory olfactory bulb (AOB) in response to stimulation with odors, Fos protein immunohistochemistry was used. To assess behavior, the following behavioral techniques were utilized: standard two and four preference tests, habituation-dishabituation tests. In all tests individuals discriminated con- and heterospecific odors. Both males and females investigated significantly ($p<0.01$) longer opposite sex urine samples of conspecifics versus heterospecifics. Males responded to exposure to estrus female samples of conspecifics with elevated plasma testosterone ($p<0.01$). However, we did not observe plasma testosterone response in males when heterospecific female urine was used. In males of different species, Fos-IR was recorded in MOB, AOB and in VNO epithelium in response to stimulation with urine samples from receptive con- and heterospecific females. In *M. musculus*, in response to stimulation with conspecific receptive female urine we observed Fos-IR in apical and bazal zone of VNO. Using the very same design of experiments in *M.spicilegus*, we observed Fos-IR in VNO apical zone only. There were no activated cells in VNO receptor epithelium in response to stimulation with receptive heterospecific female urine. Our data support the hypothesis that chemical cues play a critical role in reproductive isolation of closely related *Mus* species. Acknowledgements: Russian Foundation for Basic Research #10-04-01599 to VVV

#P139 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Reciprocal use of sniffing during rodent social interactions

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Sniffing is a specialized respiratory behavior considered critical for odor perception and is displayed by a variety of animals, especially during social interactions. Due to this, sniffing is widely considered a mechanism for gathering information during social encounters. However, the display of sniffing in 'non-olfactory' contexts and the lack of knowledge regarding sniffing within the social milieu bears to question the true meaning of sniffing during social interactions. Here we explored the purpose of sniffing during social encounters by simultaneously monitoring intranasal dynamics from rats during interactions through use of a nasal thermocouple connected to a head-mounted wireless transmitter. We found that rats modulate numerous parameters of sniffing, including frequency and amplitude, both before and during contact with a conspecific. As predicted, the display of high-frequency sniffing (4-10Hz) was more pronounced during social interactions than when a rat was in solitude. Interestingly, we found that rats commonly modulate their sniffing upon being sniffed. Namely, upon the high-frequency snout-to-snout sniffing of one rat, the conspecific being sniffed often reduces its sniffing frequency to ~2Hz. This 'reciprocal' display of sniffing however was not observed when the same rat sniffed the conspecific's flanks or anogenital region, suggesting a unique role for reciprocal sniffing in snout-to-snout investigation. Our work provides an initial description of social sniffing and establishes evidence that in addition to being used to acquire odor information, sniffing may also be a form of active communication. Due to these findings, the possibility that active sampling methods may also be forms active 'communicating' should be considered. Acknowledgements: Supported by NSF grant ISO-1121471 to D.W.W.

#P140 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Modulations of Emotional Attention Processes by Androstadienone

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Androstadienone (AND, Δ4,16-androstadien-one), a human steroid found in sweat, is considered as a putative human pheromone. Recent studies have proposed that AND could enhance attention toward emotional information. Which cerebral mechanisms are more particularly involved in the modulation of emotional attention by AND remains unexplored. In this study, electrical brain potentials were recorded while male and female participants performed a visual emotional dot-probe task known to trigger emotional attention processes. Meanwhile, they were exposed to AND and control odors in a within subject design. In this dot-probe task, participants indicate the location of a target (a triangle) that replaces one of two simultaneously presented cues. One cue is emotionally significant (baby or angry face), and the other is

neutral (neutral face). In a valid trial, the target is in the location of the emotional cue; in an invalid trial, the target is in the location of the neutral cue. Results shown that behavioral efficiency and event-related P1, time-locked to target onset, were significantly increased in valid trials as compared to invalid ones, independently of the odor, indicating early attentional capture by emotional stimuli. Moreover, a significant validity effect was also found in the subsequent N1 component, but only for female participants in AND condition. These results support the hypothesis that AND could influence female brain processes responsible for early attentional capture by emotional stimuli. Acknowledgements: This research was supported by the Swiss Centre for Affective Sciences, financed by a grant from the Swiss National Science Foundation (51NF40-104897), hosted by the University of Geneva, and also funded by a research grant from Firmenich, SA, to David Sander and Patrik Vuilleumier.

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#P141 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

The smell of altruism: the putative human pheromone 4,16-androstadien-3-one makes people more generous in a gender dependent manner

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A long series of studies showed that the putative human pheromones influence cognitive processes such as attention, emotional states and sexual behavior. For example, 4,16-androstadien-3-one (AND) improves attention on emotional information in women [1]. Our research expands the study of the effects on pheromones on a different high-level cognitive process: economic decision-making. In particular, we investigate if and how the exposure to AND affects the decision to adopt fair behavior (*e.g.*, donation of money during a Dictator Game, a measure of altruism). We know that AND increases mood in women [2] and we expect that it drives them to adopt fair behaviors (*e.g.*, higher amounts donate with the AND stimulation than in the control condition). The experiment has a within subject design with 2 conditions of odor stimulation (650µM AND in Limonene, Limonene only). The participants entered a non-scented room and rated their mood on a 16 affective states scale [3]. A bottle of fragrance was presented to the participants and they had to rate it on intensity, pleasantness, unpleasantness, familiarity and sensuality [4]. Then they filled the second mood questionnaire. Then the Dictator Game was presented (42 trials). The participants had to divide €8 with a person, shown in a picture [5]. At the end, participants rated their mood. The results show a main odor effect ($Wald\chi^2(1)=3.85$, $p<.050$), an odor by mood ($Wald\chi^2(1)=4.27$, $p<.039$) and a sex by mood interaction on the donations ($Wald\chi^2(1)=8.08$, $p<.005$). When women were exposed to AND there was an increase in mood and donations (from M=€3.42 to M_{AND}=€3.68). In conclusion, our findings support the hypothesis that AND influences high cognitive processes such as decision making. Acknowledgements: Valentina Perrotta gratefully acknowledges the financial support of the Provincia Autonoma di Trento. Michele Graffeo acknowledges the financial support of the Marie Curie grant post doc 2009 – Outgoing (project PEOCC), from the Provincia Autonoma di Trento. REFERENCES: [1]

#P142 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

The smell of disgust and fear: specific emotional chemosignalling of fear and disgust in humans

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Humans can communicate the emotion of fear from a sender to a perceiver via chemical signals (Zhou & Chen, 2009), a process which has been referred to as emotional contagion. But how specific is this contagion: Can perceivers also *discriminate* between two distinctive negative emotional states such as fear and disgust? This question was answered by examining the function of chemosignals in a framework furnished by embodied social communication theory (Semin, 2007). We hypothesized that specificity of emotional contagion is maintained during the transmission of the sender's chemosignals to the perceiver at the perceptual and physiological level. Sweat was obtained from male donors watching disgusting and fearful film clips. In a double-blind experiment, we examined in a sample of 36 females facial reactions, sensory regulation processes, and visual search in response to pooled disgust sweat pads, fear pads and odorless pads in a within-subjects design. We demonstrated that fear chemosignals generated a fearful facial expression (facial electromyography: medial frontalis activity, $p<.01$) and *sensory acquisition* (increased sniff magnitude and eye scanning) while disgust chemosignals evoked a disgusted facial expression (levator labii activity, $p<.001$) and *sensory rejection* (decreased sniff magnitude, detection sensitivity, and eye scanning). The participants could not consciously discriminate between the sweat samples. It was concluded that specificity of emotion during emotional chemosignalling was maintained at both the perceptual and physiological level. These findings suggest that emotional chemosignals do not transmit just a general negative emotional state, but that there is specificity both at the level of the chemosignal as well as the level of perception of that signal. Acknowledgements: Supported by a Utrecht University Neuroscience and Cognition grant to Smeets and Semin

#P143 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Olfactory Cued-reactivity and Craving in Nicotine-dependent Smokers

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Objectives: Previously identified smoking-related and control olfactory cues were utilized in a laboratory test to elicit craving in nicotine-dependent adult smokers. **Methods:** 16 healthy, normosmic, non-treatment-seeking, nicotine-dependent, adult smokers were systematically exposed to a variety of odors [fresh tobacco (TOB), cigarette smoke (CIG), coffee (COF), freshly mowed grass (GR), lavender (LAV), burned rubber (BR), and propylene glycol (PG)] following 12 hours of CO confirmed abstinence. Skin conductance response (SCR), heart rate (HR), and subjective ratings of craving were obtained. **Results:** In this preliminary analysis, CIG elicited a 47% and TOB a 36% increase from baseline in SCR, whereas odorless PG elicited only a 19% increase from baseline. These CIG and TOB odor-elicited increases, compared to the increase following PG, approached statistical significance (t_{15}=1.64, p=0.06; t_{15}=1.44, p=0.08; respectively). The other odors (COF, GR, LAV, and BR) did not demonstrate this trend. No odor-elicited changes in HR were found. Subjective ratings for the item "Right now, the intensity of my craving to smoke is" (11-point scale, 0=none, 10=irresistible) were significantly increased following TOB (mean=7.9, SD=1.6) compared to PG (mean=6.4, SD=2.7, p=0.003) and marginally increased from PG following CIG (mean=7.1, SD=2.5, p=0.07), GR (mean=7.4, SD=2.6, p=0.07), and LAV (mean=7.3, SD=2.2, p=0.08). **Conclusions:** Not surprisingly, contact with the smell of fresh tobacco and cigarette smoke elicits the subjective report of craving in smokers. To our knowledge, this is the first study to also demonstrate an objective psychophysiological response to smoking-related olfactory cues in nicotine-dependent smokers. Ongoing data collection and analyses include olfactory fMRI-assessed smoking cue reactivity. Acknowledgements: This research was supported by MUSC's South Carolina Clinical and Translational Research Institute (SCTR) grant UL1 RR029882 and by NIMH grant K01MH090548.

#P144 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Changes in 6-n-Propylthiouracil (PROP) Bitterness in Smokers During a Brief Smoking Abstinence Trial with Nicotine Replacement Therapy (NRT)

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Nicotine replacement therapy (NRT) substantially improves quitting success for smoking. However, nicotine bitterness may serve as a barrier to oral NRT adherence, especially among those more sensitive to bitter taste. We assessed the influence of the PROP bitter-taste phenotype on use frequency of nicotine lozenges and inhalers during a 2-wk, randomized cross-over trial for smoking abstinence. We also determine if PROP bitterness was altered by smoking abstinence with NRT. PROP tasters (n=57) and non-tasters (n=63) were recruited into the study at baseline. Participants rated the intensity of PROP- and NaCl-impregnated filter papers using the LMS and were grouped according to the method of Zhao (2003). PROP screening was repeated at the end of the trial. Subjects were 57 females and 63 males, 32.1 ± 10.3 yr of age who were predominantly Caucasians (66%) and African-Americans (28%), and smoked 15.4 ± 5.7 cigarettes/day. Overall, participants used lozenges and inhalers with equal frequency (~4.5 ± 2.3 times/d). No interaction between NRT type and taster phenotype was found. However, in a sub-analysis, non-tasters used an average of 0.65 more lozenges/day than inhaler cartridges/d (p=0.04). At baseline, there were 48% non-tasters and 52% tasters; at the end of the trial, the breakdown was 21% non-tasters and 79% tasters (p<0.01). Mean PROP ratings rose from 35.9 ± 3.3 to 53.2 ± 2.9, and NaCl intensity ratings rose from 30.3 ± 2.1 to 42.3 ± 2.1 (p<0.01 for both).This trial found no specific advantage of pairing taster status with either intermittent or continuous oral nicotine delivery. However, general taste responsiveness increased after 2-wk of smoking abstinence with nicotine replacement. These data raise interesting questions about the short-term recovery of chemosensory function during NRT. Acknowledgements: Supported by R21 DA024765-01 to KLA

#P145 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

A Short Olfactory Identification Test Designed for In-Home Use is Associated with Cognitive Function in Older Adults

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Although it is established that errors in odor identification are associated with cognitive impairment within clinically at-risk and laboratory populations, it is not known whether there are similar associations in the aging US population as a whole. To longitudinally test this hypothesis in a nationally-representative probability sample of older adults in the US, we developed a short test of olfactory identification, which could be administered by lay interviewers within a long battery of survey items and biomeasures. We tested the feasibility and efficacy of our measures in 120 older adults (57 male, 63 female) between the ages of 46 and 89 (mean = 71, SD = 8.4). All participants successfully completed both a five-item odor identification test (Sniffin' Sticks, choosing among four word-picture options) and the Montreal Cognitive Assessment (MoCA), designed to assess eight distinct cognitive functions and mild cognitive impairment (the highest cooperation rates among all measures administered in the larger survey: range 85-100%). At least 4 of 5 odors were identified by 73% of participants. Controlling for age and gender, a 0.5 decrease in the mean number of correctly identified odors (range 0-5) was associated with a 9-point decrease in the MoCA ($p = 0.041$). Rose and leather (68%, 73% correct) were more difficult to correctly identify than orange, fish, or peppermint (85%, 85%, 86% correct). Our short field measures could detect associations similar to those found in studies conducted in more formal settings, and are effective for home-based population survey research needed to investigate the relationship between olfactory identification and specific aspects of cognitive decline in the aging US population. Acknowledgements: The National Social Life, Health and Aging Project Wave 2 (R37 AG030481). DWK is supported by The Center on Aging Specialized Training Program in the Demography and Economics of Aging, which is funded by the National Institute on Aging (NIA) (T32000243). JMP was supported by the Institute of Translational Medicine at The University of Chicago (KL2RR025000).

#P146 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Racial Disparities in Olfactory Function in Older Adults in the United States

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Age-related olfactory loss (presbyosmia) is an important public health problem that substantially decreases quality of life. Variation in presbyosmia within the general population is poorly understood with little or no published epidemiological data regarding racial differences. Seeking to determine how race is associated with olfactory loss in older adults within the United States, we identified demographic, social and health-related factors associated with olfactory function collected by the National Social Life, Health and Aging Project (NSHAP), a cross-sectional US nationally-representative probability sample of community-dwelling older adults (57 – 85 years of age). NSHAP assessed the ability to verbally identify five odors presented with Sniffin' Sticks odor pens. We used ordinal logistic regression to estimate racial differences in odor identification, controlling for factors known to influence olfaction. African Americans and Hispanics had markedly worse olfactory function (controlling for age and gender) compared to whites ($P<0.001$ and $P=0.009$, respectively), comparable in magnitude to differences associated either with gender or aging 8.7 years. Controlling for education, financial status and cognitive decline eliminated this disparity among Hispanics, but the difference for African Americans remained; this was true even after controlling for additional potential mediators such as physical and mental heath, including tobacco and alcohol use ($P=0.001$, both models). In conclusion, after careful control for important confounders, significant racial disparities exist in presbyosmia, a novel finding. We speculate that environmental exposures, genetic susceptibility or cultural practices may drive these significant health-disparities in olfaction during aging. Acknowledgements: Supported by AG030481, KL2RR025000

#P147 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

The Effect of Alzheimer's Disease and Parkinson's Disease on Olfaction: A Meta-Analysis

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Impaired olfactory function is one of the earliest clinical features in both Alzheimer's disease (AD) and Parkinson's disease (PD). We performed a meta-analysis on articles available on the PubMed database to determine what aspects of olfaction are affected in these two diseases and whether different patterns of impairment emerged.

We included 81 studies in applying strict inclusion criteria such as: 1. Patients had a clinical diagnosis of AD or PD; 2. Patients were compared to a healthy control group; 3. Patients and controls were age-matched; 4. Olfactory function was assessed by means of a psychophysical olfactory test; 5. Mean and standard deviation of the tests were reported. Mean effect sizes indicate that AD and PD patients' performance is strongly impaired on all olfactory functions. Indeed, effect sizes through Cohen's d's for AD and PD were respectively 2.05 and 1.52 on identification, 0.92 and 1.29 on detection thresholds, and 2.59 and 1.00 on recognition. Both groups presented with stronger impairment on odor identification and odor recognition tasks than on odor detection threshold tasks ($p < 0.05$). However, PD patients exhibited stronger impairments on detection thresholds than AD patients ($p = 0.043$). These results suggest that PD patients are more impaired already on low-level perceptual olfactory tasks, while AD patients are more impaired on higher-order olfactory tasks relying on specific cognitive processes such as long-term memory. In conclusion, our results suggest that odor identification and recognition tests may help differentiate AD and PD from normal olfactory age-related decline. Johannes Frasnelli is supported by a postdoctoral fellowship of CIHR.

#P148 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Brainstem autonomic dysfunction in neurodegenerative disorders

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Hypothesis and Aims: We hypothesise that the well-documented disturbances of the balance between cholinergic and monoaminergic neurones in neurodegerative disorders extends to the brainstem. We therefore investigated the modulatory effects of respiratory neurons on cardiac vagal motor neurons during deep breathing exercises in healthy controls and in patients with neurodegenerative disorders. Methods and Results: Non-invasive real time and continuous monitoring of cardiac vagal tone (CVT) was done at baseline in supine position during quiet breathing and during deep breathing exercises in 6 healthy controls, 5 male and 1 female aged 24-40 years to establish the type of central autonomic modulation during deep breathing. Eight patients with neurodegenerative disorders, all were suspected of suffering from multiple system atrophy (MSA). Four males aged 71-73 and 4 females aged 60-67 years were studied. Eight more patients within these age ranges but without neurodegenerative disorders were also studied. There were 4 males aged 67-74 and 4 females aged 59-69 years in this group. The results were analysed and compared. The CVT was measured using the NeuroScope and expressed in units of a linear vagal scale (LVS). The local ethics committee of the Imperial College, London, approved the study. Conclusion: We have shown here that the cholinergic dependant central respiratory modulation of cardiac vagal motor neurones is impaired in neurodegenerative disorders. It suggests that cholinergic interneurones may be affected in the lower brainstem in neurodegenerative disorders more than it is currently known. This is new data and requires further investigation whether this cholinergic dysfunction is related to the early loss of taste and smell in neurodegenerative disorders. Acknowledgements: Breakspear Medical Group, Hemel Hempstead, Hertfordshire, London UK.

#P149 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Evidence of Hypergeusia in Burning Mouth Syndrome Patients

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Burning mouth syndrome (BMS) has been defined as burning pain in the tongue or oral mucous membranes, usually without accompanying clinical findings. Symptoms of BMS often include taste phantoms. There are numerous reports in the literature of increased taste thresholds for the anterior tongue in patients with BMS. A hypothesis for the etiology of BMS has thus been proposed suggesting that BMS results from disinhibition of nociceptive input from the trigeminal nerve following damage to the chorda tympani branch of the facial nerve (Grushka and Bartoshuk, 2000). Similarly, taste phantoms may result from disinhibition of gustatory input from the glossopharyngeal nerve. As part of a larger case-control study, BMS cases and pain-free controls were given a brief suprathreshold taste assessment battery that included anterior tongue and whole-mouth testing. Participants were 20 female BMS patients (age 33 to 76 yrs) and 32 female pain-free controls (age 33 to 68 yrs). Participants completed questionnaires including items on the experience of persistent salty, sweet, sour, bitter, or metallic taste sensations. Participants used the general Labeled Magnitude Scale (gLMS) to rate the intensity of tastants (1 M sucrose, 1 M NaCl, 0.032 M citric acid, 0.001 M quinine HCl) applied to the lateral, dorsal surface of the anterior tongue as well as sampled whole-mouth. 10 of 20 BMS cases and *only* 1 of 32 controls reported experiencing taste phantoms ($p<0.001$). BMS cases gave higher gLMS ratings than did controls for whole-mouth NaCl, citric acid, and quinine HCl (p's <0.025). The observed whole-mouth hypergeusia is consistent with a disinhibition hypothesis. However, unexpectedly, ratings of tastants applied to the anterior tongue were comparable in cases and controls, or were slightly elevated in cases. Acknowledgements: Supported by federal funds from the National Institute of Dental and Craniofacial Research, 3R21DE018768-02S1 (PI, Mark Drangsholt) and by Grant UL1RR025014 from the NIH National Center for Research Resources.

#P150 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Taste disorders in patients of a specialized Smell & Taste Clinic

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Aim of this retrospective study was to determine the frequency of taste disorders, their courses and symptoms in patients of the Smell and Taste Clinic in Dresden. Material and Methods: All patients underwent a through physical ENT examination including detailed assessment of smell and taste function. Results: A total of 451 out of 4679 patients (presenting them for the first time) exhibited taste disorders (9.6 %). The three most frequently causes were idiopathic (31%), postoperative (16%) and posttraumatic (15%). Patients with idiopathic and postoperative taste disorders complained mainly about hypogeusia and pargeusia; in comparison patients with posttraumatic taste disorders exhibited a relatively higher degree of partial, local or complete ageusia. When exploring all patients with regard to specific hypogeusia/ageusia this was most common for sweet (n=7), followed by sour (n=5) and salty/bitter (n=3/2). Almost the reverse pattern was seen for parageusias which were most frequent for salty/bitter (n=12/9), and much less common for sweet and sour (n=2/3); metallic parageusias were mentioned by 5 patients. Conclusions: Taste disorders seem to be a little bit more frequent than previously thought; compared to olfactory disorders, however, less is known about the course of the disease.

#P151 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Cerebral processing of gustatory stimuli in patients with dysgeusia, with and without burning sensations

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Aim of the investigation was to determine differences in the central-nervous processing of gustatory stimuli between patients with dysgeusia, patients with dysgeusia plus burning sensations, and healthy controls. Twelve subjects with normal gustatory function an 20 patients suffering from dysgeusia as well as 13 patients with burning mouth syndrome(BMS) participated. A detailed history was taken, followed by an ENT examination and psychophysical testing. Patients also participated in a functional magnetic resonance imaging(fMRI) session in a 1.5 T scanner. Four different liquid stimuli were presented at suprathreshold concentrations. The fMRI analyses were performed by means of SPM8. Across all participants severel clusters of activation were mainly found in orbitofrontal or insular regions. As already shown previously, in general patients exhibited higher activation compared to the control group. Results of the SPM8 analysis showed no major difference between the patients with qualitative and quantitative taste disturbance. These results indicate that, in terms of central nervous processing of pain, BMS and dysgeusia exhibit more similarities than previously thought.

#P152 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Guidelines for Quantifying Fungiform Papillae Densities in a Community-Based Laboratory

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Utilizing more than 50 volunteer citizen-scientists, we are conducting research on how PROP taster status correlates with genetic ancestry and body composition. After analyzing 2,000 samples, we were dismayed to find no correlations, not even the well-supported correlation between fungiform papillae density and taster status. Despite seemingly clear guidelines of what is to be considered a fungiform papilla (mushroom shaped, elevated structures that stain lighter in color than the surrounding papillae), in our community-based laboratory, we realized we needed stricter guidelines so that more than 50 different people can count the same photograph of a blue-stained tongue consistently. Our goal is to quantify the density of papillae in any given photograph within 10% of each other. We established a hierarchy of guidelines in order to count more consistently. Additionally, we included a cut-off size of 0.5mm for fungiform papillae; anything smaller is considered to be a filiform papillae. Here we present the impact of this classification system on our outcomes and our consistency.
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#P153 POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY

Differences in adaptation rate to sucrose and saccharin in the mouth reflect differences in heat sensitivity

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Prior studies have shown that among sweeteners, sucrose and other carbohydrates adapt less rapidly than do some artificial sweeteners, such as saccharin. We recently observed that adaptation to sucrose sweetness is highly temperature-dependent: i.e., it is more rapid and complete when the tongue tip is dipped into a room-temperature solution (ca. 22°C) compared to a 37°C solution. This finding implies the slower rates of sweetness adaptation for sucrose in the mouth are due in part to the warmer temperature of the mouth, which in turn implies that the more rapid adaptation of saccharin sweetness in the mouth reflects a lesser sensitivity to heat. This hypothesis was tested in 2 experiments that measured sweet taste adaptation at different temperatures and in different conditions: In exp. 1, 20 Ss used the gLMS to rate the perceived sweetness of 22° or 37°C solutions of 0.42M sucrose or 0.0032mM saccharin that were sampled by either dipping the tongue into the solution ("Dip") or sipping the solution into the mouth ("Sip"). Adaptation was measured over 0, 3, 7, or 15 sec. Saccharin sweetness adapted significantly more rapidly than did sucrose

sweetness in the Sip condition but not in the Dip condition, where adaptation was rapid for both stimuli. In exp. 2, 20 Ss again rated perceived sweetness in the Dip condition when the sucrose and saccharin solutions were either 22° or 37°C. The results confirmed the similar rapid adaptation rates for both stimuli at 22°C and further showed that saccharin sweetness also adapted rapidly at 37°C. These results support the hypothesis that the rate of adaptation to saccharin sweetness is independent of temperature, and thus raise the possibility that saccharin and sucrose interact with the TAS1R2-TAS1R3 heterodimer in ways that are differentially sensitive to heat. Acknowledgements: Supported by NIH grant RO1-DC005002

#P154 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

The Effect of Solution Temperature on Adaptation and Recovery of Sucrose Sweetness

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In a recent study we observed that the sweetness of sucrose sensed by dipping the tongue tip into a room temperature solution (ca. 22°C) adapted almost completely after only a few seconds, yet sweetness was largely restored when the tongue was retracted back into the mouth. After a follow-up experiment demonstrated that sucrose adaptation was temperature dependent, i.e., sweetness adapted more rapidly when the tongue was dipped into a 22°C solution compared to a 37°C solution, we hypothesized that the increase in sweetness when the tongue was retracted into the mouth was due in part to re-warming of the sucrose solution and the tongue. The present experiment tested this hypothesis by determining whether sweetness adaptation that occurs when the tongue tip is dipped into a 22°C solution can be reversed by immediately dipping the tongue tip into a 37°C solution. Twenty-six Ss used the gLMS to rate the sweetness intensity of a 0.42 M sucrose test solution at 22° or 37°C when it was sampled for 3 sec after 0-, 3-, 7- or 15-sec exposures to the same sucrose solution (self-adaptation) at one of the same 2 temperatures. The results supported the hypothesis: the measured amount of adaptation depended more on the temperature of the test solution than on the temperature of the adapting solution. Specifically, after 15 sec, measured adaptation was always significantly less when the test solution was 37°C than when it was 22°C, irrespective of whether the adapting solution was 37° or 22°C. Experiments are continuing that are aimed at testing the hypothesis that persistence of the sweetness of sucrose and other sugars is maximal at or near normal oral temperature. Acknowledgements: Supported by NIH grant RO1 DC005002

#P155 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Amifostine Alleviates Cyclophosphamide Induced Taste Disturbances

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Cyclophosphamide (CYP) is a commonly prescribed chemotherapy drug. It is a DNA alkylating agent that indiscriminately attacks proliferating cells. Like other chemotherapy drugs, CYP also has adverse side effects such as taste disturbances which can lead to malnutrition and poorer recovery. Amifostine (AMF) is an approved cyto-protective adjuvant used in combination with radiation therapy or chemotherapy (Kemp et al., 1996). AMF has been shown to be effective in preventing radiation-induced side effects like mucositis, nephrotoxicity, xerostomia, etc., but it has never been tested for chemotherapy-induced disruptions of taste. Our previous work with male C57BL/6J mice, using behavioral methods, indicated that CYP (IP, 75mg/kg body wt) causes a two-phase taste disturbance. The first phase lasts up to 4 days after injection, followed by the second phase occurring during days 9-12 after injection. The first phase was due to the cytotoxic effect of CYP on fungiform taste buds and von-Ebner glands while the second phase was due to disruption in the taste cell replacement cycle (Mukherjee & Delay, 2011). We hypothesized that AMF will alleviate the CYP-induced taste disturbances. We used behavioral and IHC methods to test our hypothesis. Sucrose detection threshold tests indicated that pre-treatment with AMF (SC, 100 mg/kg body wt) 30 min prior to CYP injection reduces the elevation in detection threshold of sucrose caused by CYP. It also protected against the loss of fungiform papilla and prevented the disruption of the fungiform taste buds observed 4 days after CYP injection. AMF also partially protected the proliferative pool of cells in the lingual epithelium and taste buds thought to be responsible for normal taste sensory cell replacement. Acknowledgements: This work is funded by NSF grant IOS-0951016 and by Ajinomoto 3ARP.

#P156 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Salt Taste Perception in Mice with a Tissue-Specific Conditional Targeted Mutation of the ENaCα Gene

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Mice with the ENaCα subunit selectively eliminated in taste tissues (ENaC-KO mice) lack the amiloride-sensitive component of chorda tympani nerve responses to sodium salts (Bosak et al., 2010; Chandrashekar et al., 2010). To elucidate contribution of the ENaC-dependent mechanism to perception of salt taste, we examined behavioral taste responses to salts in these mice. In the two-bottle preference tests, water-replete ENaC-KO mice had elevated NaCl preferences for weaker NaCl concentrations. In the brief-access tests, water-restricted ENaC-KO mice had weaker NaCl avoidance

of stronger NaCl concentrations. The increased NaCl preferences and decreased NaCl aversion in ENaC-KO mice indicate that the ENaC-dependent mechanism is involved in perception of aversive taste of NaCl. NaCl taste sensitivity was assessed by measuring behavioral NaCl taste thresholds in mice with conditioned taste aversion (CTA) formed to suprathreshold concentrations of LiCl. ENaC-KO mice had elevated NaCl taste thresholds, which indicates that the ENaC-dependent mechanism of salt taste is more sensitive than the ENaC-independent mechanism retained in ENaC-KO mice. Taste quality perception was examined using CTA generalization between Na/Li and K salts. ENaC-KO mice conditioned to avoid LiCl had stronger CTA generalization to KCl than control mice. This indicates that the ENaC-dependent mechanism is important for the ability to distinguish between Na/Li and K salts and therefore is involved in perception of the Na/Li-specific taste. Results of our study illustrate differences between the ENaC-dependent and ENaC-independent salt taste mechanisms. The latter is less sensitive and is involved in positive hedonic responses and in detection of taste shared among Na/Li and K salts. TMN and NPB contributed equally to this study.

#P157 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Changes in preference for amino acids by addition of glycogen in C57BL/6 mice

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Various edible parts of shellfish contain the polysaccharide glycogen and if its content is high, glycogen is thought to enhance the palatability of the food. Although glycogen is tasteless and does not directly contribute to the taste, it may have various interactive effects enhancing the taste of amino acids. In this study, we investigated changes in preference for 12 amino acids at 100mM [except for aspartic acid (Asp) at 30mM] by addition of glycogen in C57BL/6 mice using the 2-bottle preference test. No significant preference for 0.1% glycogen alone was observed. The total intake for methionine (Met) and taurine (Tau) was not significantly different to distilled water (DW), while that for Asp, arginine (Arg), lysine (Lys) and isoleucine (Ile) was significantly less and glycine (Gly), alanine (Ala), serine (Ser), leucine (Leu), proline (Pro) and valine (Val) was significantly more than DW. After addition of glycogen, the total intake of Met changed to being less than DW and it for Ile showed no difference to DW. However, preference for Gly, Ala, Ser, Val and Ile significantly increased and Asp significantly decreased after addition of glycogen. On the other hand, preference for Arg, Leu, Lys, Met, Pro and Tau did not significantly change after addition of glycogen. These results suggest that addition of glycogen has varied effects on the palatability of amino acids. Acknowledgements: Fisheries Research Agency (Yokohama, Japan) research grant

#P158 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Pharmacological Modulation of Serotonin Reuptake and 5HT1A Receptors Has No Effect on Psychophysically Determined Detection Thresholds of Taste Compounds by Rats

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Serotonin (5HT) and 5HT1A receptors are found in taste buds. Paroxetine (PAR), a selective serotonin reuptake inhibitor, has been shown in humans to increase reported sensitivity to sucrose and quinine, whereas WAY100635 (WAY), a 5HT1A-receptor antagonist, has been shown in rats to inhibit chorda tympani responses to NaCl, sucrose, and quinine. In the present report, we used a 2-response taste detection task to measure the effect of serotonergic drugs on the thresholds at which rats (n=3-8/tastant) could discriminate decreasing concentrations of sucrose, NaCl, citric acid, or quinine from water. After establishing psychometric functions for each animal, 5 concentrations of each taste stimulus were chosen to represent the dynamic portion of the taste-response curve, and performance of the rats at these concentrations after vehicle and drug injections was measured. We first tested PAR (7 mg/kg ip), then WAY (0.3 mg/kg sc), and then implanted each rat with a jugular catheter to test WAY again (1 mg/kg iv). When analyzed via ANOVA, overall performance of the rats across all concentrations dropped slightly when they were presented with: 1) quinine after being injected with PAR ip or WAY sc, 2) NaCl after PAR ip or WAY iv, and 3) sucrose after WAY iv. Despite these differences, which, though significant, were minor at best, no differences between drug and vehicle conditions were seen in the asymptote or EC50 (threshold) of the psychometric function in the curve parameter analysis. In contrast to findings in humans, our results suggest that drugs that modulate 5HT activity have little impact on taste detectability in rats, at least at these doses in this task. In a rat model, serotonin's paracrine action in the taste bud may work in a manner that does not impact overt behavior involved in taste detection. Acknowledgements: This work was supported in part by NIDCD NRSA 1F32DC010517 to CMM.

#P159 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Adding Sucrose to Increase Bitter Taste Palatability in Hamsters

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Golden hamsters (*Mesocricetus auratus*) show an aversion to bitter stimuli and a preference for sweet stimuli. Generally the aversion to bitter stimuli is partially reversed by adding sucrose. Some bitter stimuli are not rendered palatable by addition of sucrose, which suggests that mechanisms for bitter detection can vary between stimuli. We used 2-bottle 48-hr preference tests (R-L bottle positions reversed after 24 hr) to measure intake of 12 solutions compared to water. Solution to water preference ratios (indifference = 0.5) were determined for 1mM quinine.HCl, 30µM cycloheximide, 0.2mM chlorhexidine, 30mM caffeine, 10mM

salicin, water, and for each of these combined with 0.5M sucrose. Each of 12 hamsters received each stimulus once in a Latin square design. Data were analyzed by ANOVA and post-hoc tests ($p = 0.05$). All 5 bitter stimuli presented alone were rejected at the concentrations used (preference ratios 0.15 to 0.25). Sucrose alone was preferred (preference ratio 0.7). Addition of sucrose improved the palatability of quinine, chlorhexidine and salicin (preference ratio 0.6 to 0.75) but had no effect on the palatability of cycloheximide or caffeine. These results suggest that cycloheximide and caffeine have different mechanisms of detection or physiological responses than the other bitter stimuli. It is noteworthy that cycloheximide and caffeine can have potent non-sensory effects that could explain their resistance to sucrose amelioration. Consistent with this interpretation, consumption of cycloheximide, a known inhibitor of protein synthesis and an unconditioned stimulus for aversion learning, was reduced in the second 24-hr period as compared to the first; and learned aversions to caffeine, a stimulant, are known for failing to generalize to the bitter prototype quinine in hamsters. Acknowledgements: Supported by UConn SDM Alumni Research Fellowship and NIH grant DC004099.

#P160 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Contribution of Taste to Carbohydrate-Induced Obesity in C57BL/6 Mice

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We asked whether taste contributes to carbohydrate-induced obesity in C57BL/6 (B6) mice. Taste was manipulated by studying B6 mice that lacked T1r3 or Trpm5. T1r3 is part of the T1r2+T1r3 sugar receptor, and Trpm5 mediates signaling for several G protein-coupled receptors in taste cells. Previously, we established that the taste of Polycose (a glucose polymer) stimulates intake in B6 and T1r3 knock-out (KO) mice, but not in Trpm5 KO mice; whereas the taste of sucrose stimulates intake in B6 mice, but not in T1r3 KO or Trpm5 KO mice. In Experiment 1, we maintained the B6, T1r3 KO, and the Trpm5 KO mice on one of 3 diets for 38 days: lab chow plus water (control diet), a 34% Polycose solution (Polycose diet), or a 34% sucrose solution (sucrose diet). The B6 and T1r3 KO mice overconsumed the Polycose diet, exhibited high feed efficiency (i.e., weight gained/kcal ingested) and became obese. Although the B6 and T1r3 KO mice overconsumed the sucrose diet, only the B6 mice exhibited a high feed efficiency and became obese. In contrast, the Trpm5 KO mice consumed relatively small quantities of both carbohydrate diets, and gained limited (but significant) amounts of weight. In Experiment 2, we tested the hypothesis that the T1r3 KO mice failed to become obese on the sucrose diet because it lacked a highly palatable taste. We predicted that adding a low (i.e., 1%) but highly palatable concentration of soybean oil to the 34% sucrose solution would induce obesity in T1r3 KO mice. The T1r3 KO mice became obese on the oil+sucrose diet without ingesting extra calories. These findings indicate that nutritive solutions must be highly palatable to cause obesity in mice, and that palatability produces this effect in part by enhancing feed efficiency. Acknowledgements: This research was supported by grants from the NIH (DK-31135, DC03055 and DC03155) and the Amgen Foundation.

#P161 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Proteomic analysis of ciliary membrane proteins

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To study ciliary membrane proteins (i.e. ion channels, receptors, Ca^{2+} pumps, and signal transduction components such as cyclases) involved in the modulation of ciliary motility and sensory transduction, we compared by LC-MS/MS the *Paramecium tetraurelia* proteins that could be found in isolated cilia, the purified ciliary membrane and the ciliary membrane in the detergent phase after Triton X-114 phase separation. Proteins that were identified by at least two unique peptides from each of these preparations were filtered to false discovery rates of less than 0.7%. Identified proteins were then ranked by spectral counts and the top 300 most abundant proteins were used for inter-preparation comparisons. After Triton X-114 phase separation, we found that 64% of the proteins in the detergent phase were transmembrane or membrane associated compared to 26% in the ciliary membrane preparation. The voltage-gated Ca^{2+} channel, small conductance Ca^{2+} dependent K^+ channel, adenylyl cyclases, plasma membrane Ca^{2+} ATPases and Na^+/K^+ ATPases involved in the ciliary ion homeostasis, Ca^{2+} dependent protein kinases, and Rab GTPases involved in the signal transduction were identified. Many of the identified protein kinases and Rab GTPases have a putative myristylation or prenylation site, respectively. To validate our results, we confirmed using immunostaining and Western blots that these channels and other signaling proteins are localized in the cilia. The Triton X-114 phase separation proved to be a useful method for separation of enrichment of integral ciliary membrane proteins for analysis. Acknowledgements: Deconvolution microscopy was completed with the help of NIH grants GM59988 and P20 RR016435-06. Mass spectrometry was carried out in the VGN Proteomics Facility (P20 RR16462).

#P162 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Direct measurement of electrical signals in a sensory primary cilium

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Most cells in the body possess a single primary cilium. These cilia are key transducers of sensory stimuli, and defects in cilia have been linked to several diseases. Evidence suggests that some transduction of sensory stimuli by the primary cilium depends on ion-conducting channels. However, the tiny size of the cilium has been a critical barrier to understanding its electrical properties. We report a novel method that allows sensitive, repeatable electrical recordings from primary cilia. The cilia of cultured renal epithelial cells were selected for study. Defects in renal cilia are implicated in cystic kidney diseases including autosomal dominant polycystic kidney disease (ADPKD). Adherent IMCD-3 cells were grown on small, spherical beads that could be easily moved within the recording chamber. In this configuration, an entire cilium could

be pulled into a recording microelectrode. In 47% of 838 attempts, suction resulted in a membrane-pipette seal of resistance ≥1 GΩ. Single channels could be recorded while the cilium remained attached to the cell. When the pipette was raised into the air, the cell body was pulled off. The pipette retained the cilium and could then be immersed in various solutions that bathed the cytoplasmic face of the membrane. 34% of excised cilia showed a 92-pS cationic channel that preferentially conducts K^+ and Ca^{2+}. This channel is strongly activated by cytoplasmic Ca^{2+} and by depolarization. 77% of cilia showed a second cationic current activated by higher levels of cytoplasmic $Ca^{2+}$and by depolarization. Such channels likely initiate and/or amplify electrochemical signaling by the primary cilium. In cases where primary cilia underlie the transduction of a stimulus into an electrical signal, the method reported here should allow a direct means of investigation. Acknowledgements: This work was supported by National Institutes of Health grant R21 DK091917 and by the University Research Council and the Department of Cancer and Cell Biology of the University of Cincinnati.

#P163 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Measuring Ca^{2+} Kinetics within Cilia of Olfactory Sensory Neurons

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The olfactory system's task is to transduce chemical signals into electrical signals that can be transmitted to the brain. The front end of the olfactory system is the olfactory sensory neuron (OSN). OSNs are able to achieve good signal-to-noise amplification and have highly adaptive behavior but the exact mechanism by which these neurons perform their functions is not well understood. It has been proposed that Ca^{2+} ions behave as modulatory second messengers for Ca^{2+}-gated Cl^- channels within the long receptive cilia of the OSN. Indeed, it has been shown that Ca^{2+} organizes into spatially localized microdomains, but the kinetics of Ca^{2+} remain elusive to measure directly. The radial size of a steady-state concentration microdomain is governed by how far the species may diffuse before being sequestered by intracellular buffers. In this work, high Ca^{2+}-affinity chelators (i.e. BAPTA) are used to inhibit the size of the purported microdomains within the cilia of the mouse olfactory epithelium by quickly buffering intracellular Ca^{2+} at the mouth of the Ca^{2+} permeable cyclic nucleotide gated (CNG) channels. Changes in response are measured by recording the electric field potential of the epithelium (electro-olfactogram) while the CNG channels are stimulated. The size of the microdomain should be proportional to the number of Cl^- channels that are activated, so a decrease in microdomain size should predict a decrease in signal levels. The results from these experiments indicate that inhibiting the size of the Ca^{2+} microdomains with an exogenous buffer decreases the response from the olfactory epithelium. This provides evidence for the existence of Ca^{2+} microdomains during sensory stimulation that may act as a spatially modulated second messenger system during transduction. Acknowledgements: NIDCD (DC006070)

#P164 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Off-Flavors in Foods and Beverages Cause a Potent Blockage of the Olfactory Signal Transduction

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In the human history, people have been annoyed by natural generation of off-flavor substances in foods and beverages. Those substances induce exogenous unpleasant smells even with a very low concentration (ppt level). Although not yet scientifically demonstrated, it has also been pointed out that off-flavors reduce the pleasant flavors contained in foods/beverages. One of the most powerful off-flavors is 2,4,6-trichloroanisole (TCA), that is especially know for inducing the cork taint of wines. In the present study, we show with human psychophysical tests that TCA actually reduces flavors of wines with very low concentration. Furthermore, it was shown that TCA blocked cyclic nucleotide-gated (CNG) channels potently, when examined in the newt sensory cilium. Surprisingly, the blockage of CNG channels by TCA was much more potent than by olfactory masking agents, and even than by a well-known pharmacological blocking agent, l-cis-diltiazem; TCA blocked CNG channels even with sub-fM level. To explain such super-efficiency, the TCA effect showed the time-integration and slow recovery from the blockage, presumably representing the integration of the substance into the hydrophobic site. Because of a similar working concentration, we speculate that the induction of unpleasant smells by such off-flavors is achieved also by the same pathway. In addition, we argue about the molecular architecture to invent novel masking agents.

#P165 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

PI3K-dependent Antagonism as a Basis for Broad Opponent Coding in Mammalian Olfactory Receptor Neurons

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Our recent findings have implicated phosphoinositide (PI) signaling, in particular PI3-Kinase (PI3K) signaling, in mediating inhibitory odorant input to mammalian olfactory receptor neurons (ORNs). Limited data indicate that chemically dissimilar odorants, e.g. octanol and citral, display strong PI3K-dependent antagonism; citral, otherwise an antagonist, changes to an agonist upon inhibiting PI3K. To better understand the generality of this phenomenon we performed larger scale screening using panels of odorants representing different chemical classes, including aldehydes, alcohols, esters, and selected single odorants (cineole, 2-heptanone, whiskey lactone, 2-isobutyl-3-methyl pyrazine, phenylethylamine). Odorants were screened on dissociated native rat ORNs before and following pre-incubation with PI3K-specific blockers (AS252424, TGX221). Many odorants from different chemical classes that otherwise were weak or non-agonists for the ORN being tested increased their agonistic strength in a PI3K-

dependent manner. In contrast, odorants that otherwise were relatively strong agonists for the ORN being tested were PI3K-independent. Two very dissimilar complex odorants, Symrise-100 and Henkel-100, both showed PI3K-dependent enhancement of the response to the mixture, providing further support for there being an extensive repertoire of PI3K-dependent ligands. Collectively, these findings argue that many different odorants are PI3K-dependent antagonists in mixture and as such create a broad basis for opponent coding in mammalian ORNs. Acknowledgements: NIDCD DC001655, DC005995

#P166 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Comparison of the intrinsic odor response and response imposed by aerodynamics in the rat olfactory epithelium

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The olfactory epithelium intrinsic response is determined primarily by the specificity of olfactory receptors. Epithelial odorant access is controlled by air flow rate and sorption onto upstream surfaces in the intact nose so that responses for many water soluble odorants are strongest in the dorsomedial region of high air flow rate. We compared the EOG distribution (the relative response size in the medial vs.lateral regions) to the Henry law constant (HLC), which describes air/water partitioning of compounds (values from EPI suite at EPA.gov, with units of atm-m^3/M). For a broad range of HLC (from 5.15, the value for decane, to $2.0x10^{-5}$, near the value for benzaldehyde) the response distribution correlates with the log(HLC) in two intact nose experiments ($R= -0.82$, $p<.001$, $N=45$ odorants) and ($R= -.74$, $p<.001$, $N=38$). This was also seen in our published study of the intrinsic response with an opened epithelium ($R= -.79$, $p<.001$, $N=34$). For values of HLC between $2.75x10^{-5}$ and $6.5x10^{-7}$, the correlation for intact experiments is weaker ($R= .50$, $p<.05$, $N=21$ & $R= .30$, NS, $N=13$) and reversed. This range includes alcohols, carboxylic acids, vanillin, ethylacetoacetate, and pyrazine. Similar results occurred with other measures of odorant solubility or polarity. New open epithelium recordings with six extremely soluble odorants from this group confirm that their intrinsic response does not strongly favor the region of high airflow in either the intact or open epithelium. These results show that the relationship between physical chemical properties and response distribution in the rat epithelium is nonlinear, probably due to extreme upstream sorption of some odorants. The result may explain some (but not all) of the apparent discrepancies between epithelial recordings and observations in olfactory bulb. Acknowledgements: Supported by NIH grant DC 008648

#P167 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Electroolfactorgram recording from the human olfactory epithelium during natural nasal respiration

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The olfactory system presents a unique opportunity to directly record neural activity in humans in vivo. Olfactory receptor neurons (ORNs), a form of PNS-CNS transition neurons outside the skull, located in the olfactory epithelium, enable in vivo recording of olfactory responses from awake behaving humans. Till now, the work frame for EOlfG research was recording during short respiration cessation to avoid the ORNs response to the airflow overshadowing the olfactory evoked response. Because the sniff is an integral part of the olfactory perception, its absence may alter or even abolish the ORNs response. Here we set out to develop a method for EOlfG recording during natural human nasal respiration. EolfG's were recorded at 1 kHz from a normosmic healthy subject (M, age = 25) using Ag/AgCl electrode coated with Teflon tubing (0.8 mm OD) filled with Ringer-agar (1%). Using a computer-controlled olfactometer we delivered an odorant (L-bronyl Acetate, CAS 5655-61-8) into the recorded nostril via Teflon tubing (inner diameter = 2.15 mm), maintaining steady mechanical and thermal conditions (5.5 SLPM, 37 °C, 80% RH). Stimulus duration was 0.5 s, and inter-stimulus-interval was 25 s. The experimental paradigm contained four blocks; each consisted of five-odorant presentations during respiration cessation and five presentations during natural respiration. We found that a simple high-pass filtering with the corner frequency of 1 Hz enabled on-line visualization of the EolgG recorded during natural breathing. Moreover, a more advanced signal processing method almost completely reconstructs the olfactory portion of the recorded EOlfG, which enables the recording of in vivo ORNs activity and perception simultaneously in naturally breathing humans. Acknowledgements: Supported by ERC Ideas 800250

#P168 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

HMGB-1 expression in the normal and injured peripheral taste system

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High-mobility group protein (HMGB)-1 is a ubiquitous nuclear protein that acts as a danger signal when released from injured or infected cells. We explored HMGB-1 expression in the normal peripheral taste system and after chorda tympani nerve (CT) sectioning. HMGB-1 is robustly expressed in the cytosol of most taste receptor cells, and in macrophages responding to CT injury. At day 1 post-sectioning, HMGB-1 expression is reduced in denervated vs. contralateral or sham taste buds. This suggests that degenerating taste receptor cells secrete cytosolic HMGB-1. Released HMGB-1 may then act through the toll-like receptor (TLR)-4 present on taste receptor cells and modulate taste function. We determined whether lingual application of recombinant HMGB-1 peptide (to mimic the physiological release of HMGB1 after injury) alters CT responses. We measured baseline CT responses in

anesthetized, control SD rats. HMGB-1 peptide (dose and vehicle) or vehicle alone was then applied to the dorsal surface of the tongue, and CT responses to the same stimuli recorded. HMGB-1 application had no significant effect on CT response magnitudes. We are currently testing whether local injection of HMGB-1 affects taste function, and the role of the peptide during taste bud degeneration and regeneration. Acknowledgements: NIDCD DC005811

#P169 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Taste on steroids: estrogen receptors are expressed in type 2 taste cells

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Sex steroids can access the taste epithelium through three potential routes: in the bloodstream, in saliva, or de novo within the taste cells themselves. Among the sex steroids, 17β-estradiol affects the broadest range of tissues in the body and plays a central role in the function and maintenance of numerous sensory and metabolic tissues. Estradiol exerts its effects through three different receptors: ERα, ERβ, and GPER. Whether taste cells express any of these receptors and thus directly respond to estradiol signaling was previously unknown. Earlier work had suggested that taste behaviors are affected when estradiol is absent, as evidenced by psychophysical studies in women before and after menopause or in female rats following gonadectomy. Using immunohistochemistry and RT-PCR, we have found that type 2 taste cells in mice express ERβ and GPER but not ERα. Further, ERβ is coexpressed more often with T1R3 than with TRPM5, suggesting a role for this receptor in the function of sweet- and umami-sensing cells. We are currently determining whether estradiol treatment changes the ERβ expression pattern in type 2 cells. Also, we will test whether estradiol exposure modulates T1R mRNA expression levels. Acknowledgements: This work was supported by NIDCD/NIH funds (R01 DC03055 and T32 DC00014). Imaging was conducted in Monell's Histology and Cellular Localization Core supported by NIDCD/NIH (P30 DC0011735) and NSF (DBI-0216310).

#P170 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Angiotensin II modulates taste sensitivities in mice

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Modulation of gustatory function critically influences food preference, food intake and metabolic homeostasis. Even so, the mechanisms for modulating taste sensitivity are poorly understood. Here, we report that angiotensin II (AngII), which plays important roles in the maintenance of sodium and water homeostasis, modulates salt and sweet taste sensitivities in mice. The chorda tympani nerve recording demonstrated that AngII suppresses amiloride — sensitive taste responses to NaCl. Surprisingly, AngII enhances sweet taste responses, without affecting responses to KCl, sour, bitter and umami tastants. These effects of AngII on gustatory nerve responses are blocked by AngII type1 receptor (AT1) antagonist. Behavioral tests showed that lick rates (per 10sec) for NaCl and sweeteners are significantly reduced by AT1 antagonist in water deprived mice. Expression analyses revealed that AT1 are co-expressed with αENaC (amiloride - sensitive epithelial sodium channel α-subunit: a salt taste receptor) or T1r3 (a sweet taste receptor component) in a subset of taste cells. These results suggest that taste organ is a new peripheral target of AngII, and the specific modulation of amiloride - sensitive salt and sweet taste sensitivities may play an important role in regulating sodium and water intakes. Acknowledgements: Grant-in-Aids 18791370 (N.S.), 18077004 (Y.N.), 18109013 (Y.N.) for Scientific Research from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

#P171 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Comparative Analysis of Taste-related Gene Expression in Taste Papillae, Gut and Cell Lines

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G-protein-coupled taste receptors and their downstream signaling components have been reported to be expressed not only in the oral cavity but also in other tissues and cell lines. However, the exact expression profiles of these genes in these tissues and cells are not fully understood. In this study, we used conventional quantitative real-time PCR and custom-made ABI TaqMan Low Desity Arrays (TLDA cards) to determine the expression levels of these genes, which include those for all 3 mouse T1r receptors, 35 T2r receptors, α-gustducin, Gβ3, Gγ13, PLCβ2, TrpM5, 6 REEP proteins and 4 RTP proteins, GLP-1, peptide YY, neurotensin, and orphan receptors GPRC5A, GPRC5B, GPRC5C, GPRC5D and GPRC6A. Mouse fungiform papillae, circumvallate and foliate papillae, small and large intestines, STC-1, GLUTag and MIN6 cells were used to prepare RNA samples, which were reverse transcribed into first-strand cDNAs using random primers. The results from the quantitative assays indicated that only four of the 35 *Tas2r* genes were expressed in the fungiform whereas the expression of all 35 T*as2r*s was detected in the back of the tongue. The three cell lines expressed a small subset of *Tas2r*s, a few of which were found in all three cell lines. The expression of *Tas2r* genes was also detected in mouse duodenum, jejunum, ileum, colon and rectum, with the most abundance in the jejunum. The expression profiles varied among the different intestinal segments; and within a particular segment, a few genes were more strongly expressed than others. Validation of these expression patterns using in situ hybridization and immunohistochemistry is in progress. Identification of the expressing cells for these taste-related genes can provide insightful information underlying the function of these genes in these tissues. Acknowledgements: Partially supported by a grant from GlaxoSmithKline, and NIH grant R01 DC007487 to L.H., and NIH-NIDCD Core Grant P30 DC011735 to R.Margolskee and NSF Equipment Grant DBI-0216310 to N. Rawson.

#P172 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Differential Expression of TNF Receptors in Subtypes of Taste Cells

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The taste bud is a collection of a heterogeneous population of cells, all cooperating and developing so as to maintain a homeostatic normalcy. Aged taste cells degenerate and are replaced by young cells differentiated from basal cells. A healthy taste system depends on the balance of various cell types. The survival and death of cells are tightly regulated by many factors, among which is tumor necrosis factor (TNF). TNF plays its role by binding to its receptors TNFR1 and TNFR2. TNFR1 contains a death domain and often induces cell apoptosis. TNFR2, lacking a death domain, can promote cell survival under some conditions. While our recent studies demonstrated that taste bud cells can produce TNF, the role of TNF in the taste system remains unclear. Indeed we even lack a knowledge base of the expression of TNFRs in taste cells. Here we report TNFRs expression in subtypes of taste cells in fungiform (FF), foliate (FP), and circumvallate (CV) papillae. In FF, TNFR1 is more prevalent in type III cells than in type I and type II cells; TNFR2 is, however, much more preferentially expressed in type I cells. In FP, TNFR1 is moderately expressed by all three types of cells; TNFR2 is sparse in type II cells, prevalent in type III cells, and moderate in type I cells. In CV, TNFR1 and TNFR2 are both more preferentially expressed in type II cells than in type I and type III cells. This expression pattern of TNFRs strongly suggests that TNF produced by type II taste cells (previous report) could act on taste cells via both autocrine and paracrine mechanisms. The differential expression levels of TNFRs in subtypes of taste cells among the three forms of taste papillae may be related to the different life spans of taste cells. Acknowledgements: The study was supported by NIH/NIDCD grants DC010012 (H. W.).

#P173 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Connexin-30 and Connexin-32 Immunoreactivity in Rodent Taste Buds

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Studies indicate that ATP is one of the primary neurotransmitters in taste transduction. ATP release occurs from taste cells via specific hemichannels, such as pannexin/connexin hemichannels (Huang et al., 2007; Romanov et al., 2007). We hypothesize that Type II and possibly Type III cells release ATP at sites containing pannexin/connexin hemichannels. We have previously observed connexin-43-LIR in a subset of Type II cells. Our recent data indicate that connexin-30-like immunoreactivity (-LIR) and connexin-32-LIR are also present in taste buds. Our preliminary data suggest that connexin-30-LIR immunoreactivity is present in a small subset of taste cells in rodent taste buds. Connexin-30-LIR cells are spindle-shaped with large nuclei and are most likely Type II cells. In this study, we examine the presence of connexin-30-LIR and connexin-32-LIR in rodent taste buds through immunocytochemical analysis and DAB immunoelectron microscopy. We observed no colocalization of connexin-30-LIR with 5-HT-LIR or syntaxin-1-LIR taste cells. Our preliminary data indicate that connexin-32-LIR is present in nerve fibers. Our results show colocalization between connexin-32-LIR and syntaxin-1-LIR nerve processes. Thus, our results indicate that both connexin-30 and connexin-32 are present in rodent circumvallate taste buds; however, only connexin-30 is expressed in a small subset of taste cells while connexin-32 is present in the nerve fibers. Acknowledgements: This work is supported by NIH grants DC00285 and P30 DC04657

#P174 **POSTER SESSION IV: CHEMICAL SIGNALING & BEHAVIOR; PSYCHOPHYSICS; CHEMOSENSATION & DISEASE; OLFACTION PERIPHERY; TASTE PERIPHERY**

Glutamate Elicits Inhibition in Mouse Taste Buds

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Gustatory afferent fibers innervating taste buds store neurotransmitters such as glutamate, but little is known about the function of these transmitters. Recent studies suggest that glutamate may be an efferent transmitter (Vandenbeuch et al., 2010; Huang et al., 2012). However, to date, the effect of glutamate on signal processing in taste buds is not well understood. In this study, we characterized ionotropic synaptic glutamate receptors present on taste cells. These receptors appear to underlie the postulated efferent transmission. Specifically, we loaded mouse vallate taste cells with Fura 2 and tested their responses to a low (synaptic) concentration of glutamate (100 μM). We also measured taste-evoked transmitter (ATP) release from taste buds and taste cells. The findings are that a significant fraction of Presynaptic (Type III) taste bud cells (~50%) respond to glutamate, but that only few Receptor (Type II) taste cells (4%) are activated by this transmitter. Presynaptic cells were also stimulated by NMDA (100 μM) and kainic acid (KA, 100 μM). At these concentrations and with these compounds, glutamate, NMDA, and KA activate ionotropic glutamatergic synaptic receptors, not glutamate taste (umami) receptors. Consistent with these results, applying glutamate, NMDA, or KA caused taste buds to secrete 5-HT, a Presynaptic taste cell transmitter. Importantly, glutamate-evoked 5-HT release inhibited Receptor (Type II) cells and reduced their ability to secrete transmitter (ATP). We conclude that the net effect of glutamate as an efferent transmitter in taste buds is inhibitory—i.e., glutamate acts via serotonergic mechanisms to reduce taste-evoked transmitter release. Acknowledgements: 5R01DC007630

#P175

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Activation of the trigeminal system by different odorants

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Mammalian nasal chemosensation is predominantly mediated via the olfactory (OS) and the trigeminal system (TS). The TS is provided by the trigeminal nerve, representing a cranial analog of the dorsal root ganglia. Somata of trigeminal neurons are localized within the two trigeminal ganglia (TG) at the base of the skull. Since the OS and the TS are closely linked together, most odorants are detected by both systems. Interestingly, anosmics can still discriminate between different groups of odorants. Until today, the underlying mechanisms of this phenomenon remain elusive. In order to search for stimulus-specific spatio-temporal dynamics of neuronal activity within the TG of narcotized adult male wistar rats, we used voltage-sensitive-dyes to monitor neuronal activity upon nasal stimulation with different volatile substances. Most of these substances induced the strongest activity within posteromedial areas of the ganglion. Additionally, we observed the shortest onset latencies in these regions. The intensity of the monitored signals appeared to be highly dependent on the stimulus used and the concentrations used. Interestingly, the monitored activity seemed to spread from these posteromedial regions to more anterior and lateral parts of the ganglion. Here, the somata of neurons innervating other facial regions are localized. These findings might point on a cross-excitation between different cells within the TG (e.g. neuron-neuron, or neuron-glia). The existence of a cross-excitation between cells within the TG has been previously assumed, based on data obtained from cultured trigeminal neurons or TG-slices. Our data indicate for the first time that this cross-excitation might appear not only *in vitro* but also *in vivo*.

#P176

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Gustatory modulation of the responses of trigeminal subnucleus caudalis (Vc) neurons to noxious stimulation of the tongue in rats

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Psychophysical evidence supports interactions between the taste and trigeminal systems in man. Tastants attenuate irritation elicited by oral application of capsaicin in adults, and anesthesia of the chorda tympani (CT) enhances the oral burning sensation elicited by capsaicin. Our aim was to test the hypothesis that CT activation suppresses responses of Vc neurons to noxious oral stimuli. Single-unit recordings were made from neurons in superficial lamina of dorsomedial Vc in pentobarbital-anesthetized rats. We recorded responses to noxious electrical (0.5ms pulse trains, 15 V), chemical (pentanoic acid, 200 µM) and thermal (55°C water) stimulation of the tongue. Each electrical or pentanoic acid stimulus was immediately preceded by 30 sec superfusion of the tongue with either water (control) or tastant (either 0.3 M sucrose, 0.1M NaCl, 0.05 M glutamate [potassium salt], 0.01M citric acid, or 0.001M quinine, or a mixture of all tastants). Electrically- and chemically-evoked responses preceded by water or tastant were compared (Wilcoxon). The effect of heat was tested by comparing Vc neuronal responses to water vs. tastant, both heated to 55°C. Electrically-evoked responses were significantly reduced when preceded by the tastant mixture ($p=0.012$) or by individual application of NaCl or glutamate ($p<0.05$ for both). Sucrose, citric acid and quinine had no effect. Similarly, pentanoic acid-evoked responses were significantly attenuated when preceded by application of NaCl and glutamate ($p<0.05$ for all). There was no difference between Vc responses to heated water vs. tastants. Thus, certain tastants (i.e., NaCl and glutamate) selectively inhibit responses of Vc neurons to electrical and chemonociceptive tongue stimuli, via peripheral and/or central interactions currently under investigation. Acknowledgements: National Institutes of Health grants [DE013685 and ARO57194]

#P177

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Eugenol and carvacrol increase lingual heat responses in trigeminal subnucleus caudalis (Vc) neurons and activate capsaicin-sensitive trigeminal ganglion neurons in rats

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Eugenol and carvacrol from clove and oregano, respectively, are agonists of TRPV3 which is implicated in innocuous warmth and possibly heat pain transduction. TRPV3 agonists induce oral irritation that rapidly desensitizes, accompanied by a short-lasting heat hyperalgesia in humans. We investigated the responses of Vc neurons with lingual receptive fields in the rat. Eugenol (1%) directly activated 9/20 (45%) units and carvacrol (1%) directly activated 13/19 (68%) of heat-sensitive units. Eugenol increased neuron responses to noxious heat by almost 70%. Carvacrol increased noxious heat-evoked responses by 37%. Of 78 Vc units tested, 42% responded to 1% menthol, 47% to 10% cinnamaldehyde, and 75% to lingual application of 0.01% capsaicin. We also presently investigated if trigeminal primary afferent neurons responded to eugenol or carvacrol and other TRP channel agonists. Using ratiometric calcium fluorometry with Fura2-AM, we found that 200 µM eugenol and 100 µM carvacrol activated 20-30% of cultured trigeminal ganglion (TG) neurons but only activated 7-20% of dorsal root ganglion (DRG) neurons. TG and DRG neurons also responded to bath application of 250 µM menthol (TRPM8,~25%), 100 µM mustard oil (TRPA1,13-38%) and 1 µM capsaicin (TRPV1,52-62%) with large overlapping populations. The largest overlapping populations were those responding to eugenol and capsaicin (70, 76%) or carvacrol and capsaicin, (85, 93% for TG and DRG cells, respectively). This overlap provides a basis for a potential peripheral site of TRPV3 agonist modulation ofTRPV1-mediated noxious heat sensitivity of trigeminal afferents. Peripheral sensitization may account for the enhancement of Vc heat-evoked responses, and human heat hyperalgesia, by TRPV3 agonists although central sensitization cannot be ruled out. Acknowledgements: NIH DE013685 and AR057194

#P178 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Methyl syringate, a low-molecular-weight phenolic ester, activates the chemosensory cation channel TRPA1

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We have previously shown that methyl syringate, a component of the *Kalopanax pictus* Nakai (Araliaceae), a wild vegetable widely used in Korea for its unique somatosensory properties interact with TRPA1 in calcium imaging analyses using a human TRPA1 expressing cells. We now further analyzed the action of methyl syringate in cell-based assay and whole-cell patch-clamp recordings in the extracellular Ca^{2+}-free condition at a holding potential of -60 mV in hTRPA1 stably expressing cells. In cell-based assay, methyl syringate (1mM) significantly increased intracellular Ca^{2+} in a dose-dependent manner (EC_{50}= 565.2 μM), which was completely blocked by HC-030031, a specific TRPA1 antagonist. This was 90- or 10-fold low in comparison to AITC (EC_{50}= 6.246 μM), the most potent TRPA1 agonist among all natural products, or CALD (EC_{50}= 64.01 μM), a pungent compound present in cinnamon oil, respectively. When methyl syringate (1-3 mM) was applied to AITC-sensitive cells for 15 s, inward currents were clearly evoked in a dose-dependent manner. Further, the *I-V* relationship indicated that methyl syringate (3 mM)-induced currents have the characteristics of TRPA1-mediated currents with a reversal potential of ~0 mV and a slight outward rectification. These results demonstrate that methyl syringate activates human TRPA1, providing a mechanistic rationale for the unique somatosensory properties of *K. pictus*.
Acknowledgements: Supported by a Korea Food Research Institute (KFRI) grant E0105101

#P179 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Comparison of functional characteristics between the TRPM8 ionchannel of *Mus musculus* and *Gallus gallus*

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Transient receptor potential (TRP) channels can be activated by a huge variety of endogenous and exogenous chemical compounds and by physical stimuli like touch and temperature. In the present study, we focused on the TRPM8 receptor of *Gallus gallus* (cTRPM8) and *Mus musculus* (mTRPM8) and compare the functional characteristics of these two ortholog receptors.
The mammalian TRPM8 channels are well characterized. It is known, that the mammalian TRPM8 receptor can be activated by temperatures below 25°C, and by natural as well as synthetic chemical compounds like menthol, eucalyptol, icilin or the second messenger PIP2. We measured temperature and menthol responsiveness of sensory neurons from dissociated dorsal root ganglia and transfected HEK-293 cells. It is known, that avians and mammals have different basal body temperatures (39°C and 37°C, respectively). Furthermore, variations in the amino acid sequence of both species, e.g. in the coiled-coil domain which is necessary for the activation of the receptor, could be responsible for functional differences. We aimed to investigate functional properties of the ortholog receptors and compared the differences in detection of cool temperatures or after menthol stimulion between the two species. Therefore, we used the patch-clamp and Ca^{2+}-imaging technique to characterize the activation temperature and the response behavior after stimulation with menthol. We found that the cTRPM8 has an approximately 3°C higher activation Temperature than the mouse ortholog. Furthermore the cTRPM8 leads to a lower intracellular Ca^{2+} increase by stimulation with menthol and cooling than the mTRPM8.
Acknowledgements: DFG (WE2298/4-1), International Max Planck Research School in Chemical Biology (IMPRS-CB)

#P180 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Genetic Variation in Bitter Receptor Genes is Associated with Cough Threshold in Human Subjects

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Cough is a protective response that clears mucus, irritant chemicals, and other xenobiotics from the airways. Individuals differ in cough sensitivity, which impacts the ability to respond appropriately to airborne threats. We report a preliminary investigation of the relationship between individual differences in cough reflex sensitivity and polymorphisms in the genes that encode chemosensory receptor proteins expressed in the airways. Genes of interest included those that encode TRP channels known to play a role in generating chemically evoked cough (TRPA1, TRPV1) and bitter receptors (TAS2R) known to modulate other respiratory responses. Cough thresholds, i.e., the minimum concentration of capsaicin needed to trigger at least 2 coughs, were measured in 65 healthy subjects (adolescents and their mothers). Saliva samples were collected from each subject; DNA was extracted and genotyped at 20 markers within or near the *TRPV1*, *TRPA1*, and *TRPM8* genes, as well as members of the *TAS2R* gene family. Preliminary analyses revealed that two variant sites within a bitter receptor cluster on chromosome 12 (centering on *TAS2R20*) were related to cough thresholds (*rs10845279*, $\chi^2_{(1)} = 7.18$, $p = 0.03$; *rs12226920*; $\chi^2_{(1)} = 6.47$, $p = 0.04$). These results suggest that people with particular genotypes differ in response to inhaled capsaicin. It remains to be seen whether these effects generalize to other irritant compounds and to other airway threats such as bacteria, viruses, or toxins.
Acknowledgements: The project described was funded, in part, by a grant from the Pennsylvania Department of Health, Award Number R01HD37119 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, and 1P30DC011735-01 from NIDCD. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institute of Child Health and Human Development or the National Institutes of Health. The Pennsylvania Department of Health specifically disclaims responsibility for any analyses, interpretations, or conclusions.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Effects of Jasmine and Peppermint Scent Administration on Physiological and Psychological Stress Reactions in Enclosed Spaces

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Enclosed spaces can cause significant anxiety and stress responses in individuals, which may hinder their ability to perform certain tasks. The present study assessed the effects of jasmine and peppermint scent administration on physical and psychological stress reactions in enclosed spaces. Eighty-five participants completed the protocol on two separate occasions. For each participant's first visit, they completed questionnaires related to mood (Profile of Mood States) and anxiety (State Trait Anxiety Inventory) prior to and after spending 20 minutes in a sensory deprivation tank. During this time, objective physiological measures of heart rate, galvanic skin response, and respirations were recorded. For the participant's second visit, they repeated the experimental protocol in the presence of no scent (control condition), jasmine scent or peppermint scent. Participants receiving jasmine scent on their second visit showed decreased heart rate, galvanic skin response, and psychological stress/anxiety scores than did the control group who did not receive any scent, $F(1,55) = 4.08$, 4.05, and 3.31, $p<.05$, respectively. These results are particularly salient in terms of reducing stress and anxiety in participants undergoing enclosed medical procedures, such as an MRI.

#P182

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Faster Olfactory Detection in High vs. Low Anxious Healthy Adults

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The perceptual and attention systems allow us to be aware of and react rapidly to a dangerous situation. Despite the evolutionary utility of such mechanisms, excessive sensitivity to potential threats can be problematic when the presumed threats do not represent any danger. Hence, anxious people exhibit increased sensitivity to moderately threatening or ambiguous visual or auditory stimuli reflected by faster reaction times. Evidence of such bias is rare for olfaction, since only a few studies have investigated the influence of emotional states on olfactory perception. They reveal some effects of anxiety on olfactory performance; still the nature of these effects is not clear yet, as edibility and pleasantness of the odor may be two critical features to take into account. The main objective of the present study was thus to investigate whether olfactory perception varies as a function anxiety levels during the detection of two odors (pleasant food, unpleasant food). We secondly investigated possible bias for the unpleasant odor in high anxious subjects. We submitted 38 healthy adults to an odor detection task and measured their anxiety levels. Highly anxious subjects detected both odors significantly faster than less anxious subjects ($F=6.98$, $p= .01$). In fact, trait anxiety levels significantly correlated with reaction times to both, pleasant ($r= -.39$, $p=.01$) and unpleasant ($r= -.39$, $p=.01$) odors. Our results show anxiety levels, but not odor pleasantness, to influence olfactory detection. Acknowledgements: This study was supported by the FRSQ (VLB), CIHR (JF), NSERC (FL).

#P183

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Strong and Poor Predictors of Odor Recognition Memory Performance: An Item Analysis of the California Odor Learning Test

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Olfactory recognition memory has demonstrated value as a predictor of cognitive deficits, particularly in older adults. However, olfactory recognition memory is a complex cognitive process, with an integral component being odor identification. Odor Identification involves retrieval of a meaningful, previously encoded, odor label from memory when presented an odor stimulus. The current study explored the recognition task of the California Odor Learning Test (COLT)—an analog to the California Verbal Learning Test, developed to evaluate normal and pathological changes in odor memory arising from age. Subjects were 168 adults (Mean age = 66.23 SD = 10.89). Item difficulty and discrimination indices were computed for List A items of the COLT that were presented during the odor learning trials. The mean discrimination index is .3563 (SD = .0963 Range= .1220-.4872). Based on the item's discrimination index, items were separated into quartiles. A one-way between subjects ANOVA was performed to analyze the differences in the discrimination indices among quartiles $F(3,13) = 19.046$, $p <.001$. Bonferroni post hoc analyses revealed difference in discrimination indices between the highest quartile and the lowest quartile $t(1,18) = -.228$ $p <.001$. Therefore items in the highest quartile versus the lowest quartile are significantly better at discriminating between participants who do well on odor recognition memory versus participants who do poorly. Acknowledgements: Supported by NIH grant AG04085-24 and DC02064-14 to Claire Murphy and P50AG005131 to the UCSD ADRC.

#P184 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Speaking of Smells: The Relationship Between Describing Odors and Memory Recognition

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Since the phenomenon of "verbal overshadowing" suggested verbalizing a perceptual experience may interfere with the ability to accurately recall a memory, the present study examined the effect describing an odor at the time of encoding had on olfactory memory. To examine the relationship between odorant description and memory, during the training phrase, 39 subjects were placed into one of three groups and exposed to 8 target odorants from a 20 odorant "Sniffin Sticks" set. In Group 1 subjects verbalized a self-generated description of each odor, in Group 2 subjects circled a description of each odor from 4 alternatives appropriate for that particular odorant, and in Group 3 subjects smelled each odor without providing any verbal description. After participating in an unrelated task for 15 minutes, subjects were presented the entire 20 odorants (12 distracters), one at a time, and asked if they remembered smelling that particular odorant during the training phase. After the completion of this phase of the experiment, subjects were again presented the 20 odorants and asked to name each one. Finally, the odorants were presented a third time and subjects were asked to choose the correct name from an odorant list. Subjects in Group 2 had significantly less recognition ability as compared to Groups 1 and 3 (75% versus 88% correct). However subjects in Group 2 also had many fewer (17% versus 34%) false positives - incorrectly identifying that a distracter was in the target set. Apparently having subjects pick an odorant description made it more difficult to remember target odorants but also produced fewer false memories whereas self-generating a verbal description of an odorant or simply trying to remember the odorant odors produced a "better" olfactory memory but also produced more false positives. Acknowledgements: The St. Lawrence University Fellows Program and the Biology Department provided some of the funding for this work.

#P185 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Differences in olfactory event-related potentials (OERPs) among apolipoprotein ε4 positive and negative individuals in an odor memory retrieval task

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The current study investigated olfactory event-related potentials (OERPs) among healthy and individuals at risk for Alzheimer's disease (AD) as they completed an odor memory task. At risk individuals were determined by genotyping, using the strongest genetic risk factor associated with AD, the ε4 allele of apolipoprotein E (ApoE ε4). OERPs were recorded from the FZ, PZ, and CZ midline scalp electrode sites in 60 participants among 3 different age groups: young (10 F, 10 M, mean= 21.35 years), middle (10 F, 10 M, mean= 50.35 years), and old (10 F, 10 M, mean= 68.95 years). Each age group contained an equal number of ApoE ε4+ and ApoE ε4- subjects. The odors were presented for 200 msec with an inter stimulus interval of 30 secs by a computer-controlled olfactometer. Subjects were instructed that they were performing a memory task and completed three sessions: session 1 was an exposure trial for encoding, session 2 was a retrieval trial using odors, and session 3 was a retrieval trial using odor labels. We focused here on the retrieval trial using odors for recognition. The odor retrieval trial produced OERPs for the following response types: hits, misses, correct rejections, and false positives. The results indicated a significant interaction between response type, electrode site, and ApoE status in N2 latency ($p<.05$). The N2 latencies were significantly longer in ApoE ε4+ subjects for hits, misses, and false positives than ApoE ε4- subjects, across all electrode sites. There was also a significant N1 amplitude effect with response type ($p<.05$). Correct rejections and false positives both had significantly higher amplitudes than misses. The results indicate that OERPs during memory retrieval with odors have the potential to differentiate between ApoE ε4 positive and negative individuals. Acknowledgements: Supported by NIH grant # DC00262-14 from the National Institute on Deafness and Other Communication Disorders. We thank Paul Gilbert for his statistical expertise and Jessica Bartholow, Roberto Zamora, Ariana Stickel, Derek Snyder, Kyle Sigel, Jean-Loup Bitterlin, Kristina Constant, and Sanae Okuzawa for helping with data collection, entry and analysis.

#P186 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Relationships between Confidence Accuracy and Odor Familiarity: The Effect of Apolipoprotein-E Status

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Metamemory, or the ability to monitor, judge, and control our memories, is an important aspect of cognition because it helps to determine cognitive and behavioral self-regulation involved in overall judgment and decision-making (Marquie & Huet, 2000). Deficits in metamemory abilities have been found to accompany both healthy aging and Alzheimer's disease (AD), and various models link related phenomena, such as high-confidence false recognition, to declines in executive functioning associated with normal aging and AD (Cosentino, 2007). Many studies have linked the accuracy of metamemory judgments to levels of familiarity (Chua et al., 2009), however, few studies have examined this relationship in aging populations. Accordingly, the main goal of the current study was to examine the relationship between familiarity and confidence accuracy in healthy aging individuals compared to those with AD. Data were included from 158 patients diagnosed with possible or probable AD, and were compared with data from 138 non-demented elderly controls ($n = 296$). Since prior research suggests that memory-based olfactory tests are equally, if not more sensitive than more semantic, visual tasks when examining cognitive decline in normally aging individuals and those with AD, in particular (Murphy et al., 1999), recognition memory was assessed using a signal-detection based olfactory recognition memory task. Univariate analyses revealed a significant interaction between Apo-E status and familiarity levels for those in the AD group, $F(5,158) = 2.8$, $p < .05$, but not for the control group. This interaction accounted for approximately 15% of the variance in confidence accuracy for those diagnosed with AD. Applications and implications are discussed. Acknowledgements: Supported by NIH grant # AG04085 from the National Institute of Aging to CM.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

IMPLICIT AND EXPLICIT MEASURES OF EMOTIONS IN RESPONSE TO ODORS

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Implicit consumer tests of product emotions are under-investigated but become increasingly popular in an effort to increase market success of new introductions. Reactions to odors varying in valence and intensity were measured implicitly with facial expressions (automatically analyzed with FaceReader,) and explicitly with the Product Emotion Measurement Instrument (PrEmo,) and pleasantness ratings in 26 human participants. The odors, presented for 1 sec (ISI 60 secs) with an olfactometer (Burghart OM2) were orange (pleasant) and fish (unpleasant) presented at three concentrations ranging from clearly detectable to strong. Each stimulus was presented five times in a random order to verify systematic effects of exposure on emotions. PrEmo results varied primarily with the odor's valence (99% explained variance) with positive emotions (e.g., joy, satisfaction, desire) associated with orange and negative emotions (e.g., disgust, dissatisfaction, fear) associated with fish. Facial expressions also reflected the odor's valence (71% explained variance) and ranged from neutral (orange) to sadness/disgust/anger (fish) but showed additional differentiation with respect to odor intensity (15% explained variance). Individual differences were large with respect to exposure effects on facial expressions; one sub-group became more and more sensitized with increasing exposure to the odors whereas other sub-groups became either desensitized or were unaffected. Pleasantness ratings did not show differential effects of exposure. In summary, the implicit and explicit tests appear both promising as valence measures. In addition, implicit facial expressions, although challenging to measure and analyse, may provide more detailed insights in consumer experiences that may be difficult to capture with explicit tests. Acknowledgements: Funding was provided by Hak& Partners B.V.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Impaired flavor nutrient conditioning in overweight and obese individuals

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Flavor preferences are dependent upon associative learning. One critical associative process is flavor-nutrient conditioning (FNC) whereby preference increases for a flavor paired with positive post-ingestive consequences. This form of learning depends on dopamine signaling. Since dopamine signaling is blunted in obesity we predicted that FNC would be impaired in those with higher body mass index (BMI). Twelve healthy weight (HW) (BMI 20-23) and 12 overweight/obese (OW/OB) (BMI 26-34) individuals participated in an experiment where the pleasantness, intensity, sweetness and wanting of novel flavors were evaluated before and after subjects consumed beverages containing one of the flavors paired with 112.5 calories (maltodextrin) and another paired with 0 calories. At pretest subjects rated the stimuli and performed triangle tests to screen out subjects who could detect the presence of maltodextrin. Following the pre-test subjects underwent 8 exposure sessions in which, on separate days, they drank either the caloric or non-caloric beverage in a fasted state. Hunger ratings were assessed before and after drink consumption. Stimulus ratings were then re-assessed in the post-test. A repeated measures analysis of variance with age as a covariate showed a significant 3-way interaction between time, stimulus and group. As predicted this effect arose because the HW but not the OW/OB group showed an increase in pleasantness ratings for the 112.5-calorie beverage pre- vs. post-conditioning. No other significant effects of BMI were present, indicating that the effect of BMI on conditioning does not depend upon the influence of calories on internal state ratings and that the effect is selective for the hedonic attributes of flavors. We conclude that FNC is impaired in OW/OB individuals. Acknowledgements: NIH/NIDDK R01 DK085579 PEPSI-CO.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Odor context influences aversive conditioning

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Odors have been shown to influence mood and cognitive functions through the emotions they elicit. The present study aims at investigating the effect of odor valence on low level affective processes. Two experimental groups (n=13 and n=14) underwent aversive conditioning between 2 sets of stimuli. One of the sets (conditioned stimulus CS+) was reinforced at 50% with a 100dB 200ms white noise, while the second set was unreinforced (CS-). An odor (pleasant or unpleasant) was presented as a context during the 3 phases of conditioning. Participants were asked to rate the level of anger of the faces, as well as the pleasantness, familiarity, intensity of the odors and the subjective feelings elicited by the olfactory stimulation. Skin conductance, heart and respiratory rate were simultaneously recorded during the session. Group x Conditioning Phase x Conditioning Status x Odor Context MANOVA performed on Behavioral results showed a different rating pattern according to the pleasantness of the context odor, conditioning being more efficient in a pleasant context, with a significant Group x C. Phase interaction [$F(2,50)=6,9154$, $p=0.00223$]. In addition, conditioning removed valence associated effects in heart rate, with a significant Group x C. Status interaction [$F(1,21)=4,4812$, $p=0.04638$], by conferring a negative valence to pleasant smells only. The results obtained support the idea that low level affective processes could be influenced by the valence of the olfactory environment, as shown by the increased effectiveness of aversive conditioning in a pleasant odor context. Acknowledgements: This research was supported by the National Center of Competence in Research for the Affective Sciences, financed by a grant from the Swiss National Science Foundation (51NF40-104897), hosted by the University of Geneva, and by a research grant from Firmenich, SA, to David Sander and Patrik Vuilleumier.

POSTER PRESENTATIONS

#P190

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

BMI and Age Predict Psychophysical Ratings of Food Stimuli

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The aim of the current study was to investigate the effect of BMI and age on psychophysical ratings of foods. Participants were younger (ages 18- 29) and older (ages 65- 87) adults. Differential BMI categorizations were used for the age groups: young participants with BMI ≥ 25 were categorized as high BMI, and older participants with BMI ≥ 28 were categorized as high BMI (Jacobson, Green, & Murphy, 2010). Participants ate ad libitum from a series of foods (i.e., pizza, apple, potato chips, chocolates) and were then asked to produce magnitude estimates of pleasantness, intensity, liking, and wanting, each reported on adaptations of the general Labeled Magnitude Scale (Bartoshuk, et al., 2004). 2 x 2 (BMI x age) between subjects ANOVAs were performed to examine potential differences in magnitude estimates for each of the foods. Only one significant difference was found for the main effects (i.e., high BMI participants rated the wanting of the chocolate significantly lower than did moderate BMI participants). However, the interaction between BMI and age revealed a number of significant relationships. Most notable were significant interactions on all psychophysical measures for the chocolate. In the moderate BMI group, older participants rated chocolate lower on all psychophysical measures than younger participants. However, when the high BMI group was examined, the reverse was true: older adults rated the chocolate higher on all psychophysical measures than did young adults. This finding suggests overweight older adults differ significantly from overweight young adults on reported pleasantness, intensity, liking, and wanting of a high sugar, high fat stimulus. The findings suggest the potential importance of disparate foci in assessing and managing obesity in young and older adults. Acknowledgements: Supported by NIH grant #AG04085-25 to Claire Murphy and NIMH Career Opportunities in Research (COR) Scholar Program grant #MH065183 to Thereasa Cronan.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Effects of Food Neophobia and Food Neophilia on Diet and Metabolic Processing

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Past research reveals that neophobic individuals (those individuals unwilling to try new foods) have significantly lower body weight compared to neophilic individuals (those individuals overtly willing to try new foods) or average individuals (after controlling for gender and age). It is a basic tenet in dietetics that dietary variety reduces the risk of nutrient deficiency, which is also positively correlated with body weight. If neophobics have a more restrictive diet, they may be at increased nutritional risk. In the present study, the reliability and dietary basis of this body weight difference is explored by collecting dietary information. Participants completed a food diary for three random days during a random seven-day period, and completed questionnaires related to eating habits and body satisfaction. On average, there was a statistical difference between food-neophobics, food-neophilics, and an average group related to consumption of overall nutrients and calories with age, height, weight, and sex taken as covariates. When the data were further analyzed, the three groups were found to differ significantly on dietary intake of 20 specific nutritional and caloric items, with food-neophobics typically having the lowest intake of specific nutrients and calories overall. This lackluster level of nutritional consumption is seen as a sign of decreased nutritional health and may affect food-neophobics overall health.

#P192

POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Preference for salt in foods without or with soy sauce in children and adults

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Strategies that reduce the sodium content in foods need to take into account the taste preferences of children since taste is the best predictor of food acceptance. One reported strategy to improve the palatability of salt-reduced foods is to add soy sauce. The aims of the present study were to 1) determine the most preferred level of saltiness in a variety of foods in which some of the NaCl was substituted with soy sauce and 2) to determine whether there are age-related differences in the level of salt most preferred in foods. To this end, 61 children between 5 and 10 years of age and their mothers were tested using forced-choice tracking procedures to determine the level of salt they most preferred in three types of food: soup, crackers and dressing. On one testing day, the foods presented were prepared with varying levels of NaCl (and no soy sauce) and on the other testing day, the salt levels remained the same but soy sauce was added to each of the recipes. Preliminary analyses revealed that children preferred higher levels of salt in soup and dressing than their mothers; these age-related preferences for salt were also evident for the foods that contained soy sauce. As a group, children and adults were more likely to prefer a lower level of salt when soy sauce was added to the recipe for one of the foods (crackers). Acknowledgements: The project described was supported by a grant from the Kikkoman USA R&D Laboratory, Inc.

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POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Cephalic Phase Blood Pressure Response to Oral Sodium Stimulus in Humans

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High sodium intake is correlated with and identified as a risk factor for hypertension (HTN) and cardiovascular disease (CVD). Human physiology typically responds with anticipatory reflexes to the taste of metabolically important stimuli such as the release of insulin in response to oral glucose exposure. In addition, a urine production reflex is obseverd in rats orally exposed to sodium solutions. We

hypothesized that humans will demonstrate a blood pressure (BP) response to oral sodium stimulation in anticipation of an ingested and absorbed salt load and concomitant increase in blood volume. Twelve subjects were tested after an overnight fast without water followed by a 2-minute oral swish with either a 1M NaCl solution or Distilled Water (DW). While maintaining a seated, resting state for 2 hours, BP was manually tested every 10 minutes with a sphygmomanometer on five separate trials of each solution on ten different days. Data indicate that a subset of participants reliably show an initial drop in Mean Arterial Pressure (MAP) within the first 30 minutes of rinsing with NaCl, but not with DW, followed by an increase in MAP. All other subjects indicate an overall lower MAP after rinsing with NaCl compared to DI. This lower MAP after rinsing with NaCl is consistent with the relaxation of vessel walls to accommodate the anticipated increase in blood volume. This is subsequently followed by a corrective increase in MAP when the salt bolus, which was tasted and not swallowed, does not appear in blood. These data suggest that there are anticipatory autonomic reflexes in the cardiovascular system to the tastes of salt and water. Future testing will explore other salty stimuli such as 1M KCl to address the specificity of cardiovascular reflexes to the taste of solutions. Acknowledgements: Funded in part by NIH DC 02995.

#P194 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

The Relationship of Papillary Density With Taste Intensity in the Beaver Dam Offspring Study

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The purpose of this study was to determine the distribution of fungiform papilla density and to examine the association of papillary number with taste intensity in the Beaver Dam Offspring Study. Digital tongue images were obtained using blue food coloring to highlight the papillae and subsequent grading provided the total number of fungiform papillae within a standard 6 mm circle. Whole mouth suprathreshold taste intensity was measured using filter paper disks and a general labeled magnitude scale (gLMS). Papillary density and taste intensity were evaluated as continuous and as categorical with 3 categories defined as the lowest decile (10%), deciles 2-9, and the highest decile of the density or intensity distributions. There were 2371 subjects (mean age = 48.8, range = 21-84 years), the mean number of fungiform papillae was 29.3 (standard deviation = 9.3, range = 0-60) and the median was 29.0 papillae. In age and sex adjusted models, papillae number decreased as age increased (-0.8 papillae for +5 years of age, $p < 0.001$) and was significantly greater among females than males (mean = 30.6 and 27.7, respectively; $p < 0.001$). There was a significant inverse association between salt intensity and papillae count (-1.1 units of intensity for +10 papillae, $p < 0.01$). Participants in the lowest decile (0–17 papillae) were significantly more likely to have intensities in the lowest decile for sweet [Odds Ratio (OR) = 1.6, 95 % Confidence Interval (CI) = 1.1,2.2] and bitter (OR = 1.8, 95% CI = 1.3,2.6). In summary, fungiform papilla density was found to be related to age, sex, and taste intensity. Acknowledgements: The project described was supported by R01AG021917 from the National Institute on Aging, National Eye Institute, and National Institute on Deafness and Other Communication Disorders. The content is solely the responsibility of the authors and does not necessarily reflect the official views of the National Institute on Aging or the National Institutes of Health.

#P195 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Testing Flavor Perception in Felines: A Sour Story

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pH is an important consideration in pet foods both for its impact on function and flavor. A common perception is that “cats prefer sour taste” although data are lacking to support this notion. Both astringency and sour taste are related to pH, but sourness is more directly correlated with titratable acidity, as well as other chemical attributes such as lipophilicity and molecular size. These sensory qualities are detected by distinct biological mechanisms. The purpose of this study was to develop methods for comparing intake of solutions by cats, to examine the sensitivity of cats to pH and to determine whether preference among various acidic solutions may be more directly related to pH, titratable acidity (sourness), or other chemical characteristics. Methods were approved by our Institutional Animal Care and Use Committee and included 4-bowl comparisons for screening among multiple solutions and two bottle tests of individual cats trained to consume from standard licking spouts similar to those used in rodent studies. Behavioral observations were made at specified intervals to characterize the ingestive and non-ingestive bowl- or bottle- oriented responses such as sniffing and rubbing. Preliminary data indicate that: 1) cats preferred water to any of the acidic solutions tested; 2) cats failed to discriminate two solutions at equal pH that varied in titratable acidity; 3) cats appeared to use both smell and taste to determine preference for acidic solutions. As these data are limited to intake and behavioral observations alone, further work using quantitative measures of lick rate and analysis of taste reactivity responses will be needed to better understand preference for and sensitivity to acids in cats.

#P196 POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Experience-based Enhancement of Preference for Dried-Bonito *Dashi* (a Traditional Japanese fish stock) in Various Rodent Strains

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The dried-bonito *dashi* is a traditional Japanese fish stock that improves palatability of various dishes, probably via enhancement of umami taste. We have found that preference behavior for *dashi* in ascending concentration series varies among rodent strains, suggesting contribution of some genetic factors for the preference. Here we compared preference for dried-bonito *dashi* in descending concentration series with that in ascending ones using 48-h two-bottle choice tests. The animals used were the adult male Sprague-Dawley rats, ICR mice, and C57BL/6 mice. The commercial *dashi* employed were the "*Hondzukuri Ichiban-dashi Katsuo*" (Ajinomoto, Japan) which was 5- to 10-fold dense-taste stock of hot-water extracted dried bonito. As the dry matter components was 4% (w/w) on a weight basis, the commercial *dashi* was considered as 4% solution. In the ascending concentration series, preference for *dashi* was observed between 0.4% and 4% solutions and the most preferred concentrations were between 1.2% and 2% solutions. However, the maximal preference varied among rodent strains with the order of Sprague-Dawley rats (preference ratio, 99%) > ICR mice (80%) > C57BL/6 mice (65%). In the descending concentration series, the concentration-preference functions of *dashi* shifted to the left for 100 to 1,000-fold and the slop was gentler compared to those in ascending ones in all strains. As a result, the preference was observed in wider concentration ranges (3-4 log units vs. 1 log unit). In C57BL/6 mice, the maximal preference enhanced greatly compared to ascending ones (95% vs. 65%). These results suggested importance of prior experience of *dashi* for the development of *dashi* preference. Experience-based enhancement of preference may involve postingestive consequences associated with *dashi* ingestion.

#P197 POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Inhibition of Human Umami Taste Perception By the Lipid Lowering Drug Clofibrate

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The T1R1-T1R3 receptor is believed to be a principal umami sensing taste receptor in humans. Umami taste is induced by monopotassium glutamate (MPG) and is enhanced by inosine monophosphate (IMP) and guanosine monophosphate (GMP). It is weakly inhibited by sodium lactisole, which binds to T1R3 in vitro. We have shown that clofibric acid, a lipid lowering drug structurally related to lactisole, also inhibits the sweetener receptor T1R2-T1R3 activity *in vitro* and *in vivo.* Here we wished to determine if this fibrate drug inhibits umami taste perception in humans. 12 participants rated the umami intensity of MPG across a broad range of concentrations. MPG was prepared neat, with 1.37 mM of the T1R1-T1R3 inhibitors Na lactisole and Na clofibrate, with 3mM of the T1R1-T1R3 enhancers GMP and IMP, and with combinations of these inhibitors and enhancers. Clofibric acid inhibited umami intensity for all subjects and was generally a more potent umami inhibitor than was lactisole. Whereas lactisole inhibited umami intensity only at low MPG concentrations, clofibrate inhibited umami intensity across the full range of MPG concentrations. When prepared with IMP or GMP, umami intensity was enhanced at low MPG concentrations but was unaffected at high MPG concentrations. IMP and GMP blunted the inhibitory effects of clofibric acid and lactisole at low MPG concentrations. Strikingly, clofibric acid enhanced umami taste at high MPG concentrations with IMP. In conclusion, the lipid lowering drug clofibrate inhibits perception of umami in humans and the addition of IMP or GMP tends to prevent this inhibition at low concentrations of MPG. Further, clofibrate reciprocally modulates the effects of the known T1R1-T1R3 enhancers, IMP and GMP, at high concentrations of MPG. Acknowledgements: Supported by NIH DC02995 to PASB

#P198 POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY

Diurnal variation of plasma leptin levels and taste recognition thresholds in over-weight and obese subjects

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Leptin is shown to selectively suppress sweet taste responses in lean, but not obese diabetic, mice. In humans, sweet taste recognition thresholds showed diurnal variation that parallel with variation of plasma leptin levels. Here, we investigated potential linkage between leptin and sweet taste in over-weight and obese (OW/Ob) humans. A total of 34 Japanese OW/Ob subjects (BMI > 25 kg/m^2) were used to determine recognition thresholds

for various taste stimuli at 7 different timepoints from 0800 h to 2200 h using a stair-case methodology. Plasma leptin and insulin were measured by an enzyme-linked immunosorbent assay. Blood glucose levels were determined by the glucose dehydrogenase method. In OW/Ob subjects with higher leptin levels (~20 ng/ml), diurnal variation of mean recognition thresholds for sweet stimuli (sugars and saccharin) became not evident. However, individual differences in diurnal variation of leptin and recognition thresholds for sweet and umami stimuli were negatively correlated with ratios of postprandial blood glucose increase vs. insulin increase. Basal leptin levels of OW/Ob subjects may already be higher than leptin's effective range on sweet taste modulation. Diurnal variation of leptin levels and sweet and umami recognition thresholds may be associated with overall efficacy of insulin on blood glucose among OW/Ob individuals.

#P199 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Oxytocin decreases sensitivity to sweet taste

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We have previously reported that oxytocin (OXT) elicits calcium responses from taste cells and that oxytocin receptor is expressed in glial-like taste cells (Sinclair et al, 2010). We asked if OXT alters behavioral responses to sweet taste *in vivo*. We measured lick rates of C57BL6/J mice (n = 21) in a Davis lickometer to a range of sucrose concentrations (in M: 0, 0.03, 0.1, 0.2, 0.3, 0.6 1.0). The naïve mice were exposed to sucrose once in the lickometer to familiarize them with the novel taste. They were then tested twice, injected 30 min. prior with either saline or OXT (0.1 mg/kg, i.p.). Mice injected with saline for the first test were injected with OXT for the second (n = 6) or vice versa (n = 15). OXT noticeably reduced licking for low-to-intermediate concentrations of sucrose: 0.3 M ($p<0.001$; ANOVA) and 0.2 M (not-significant trend). OXT slightly but significantly right-shifted the concentration-response ($EC50_{saline}$ = 0.38 M, $EC50_{OXT}$ = 0.43 M, $p<0.001$), indicating a decrease in sensitivity. Further, the Hill slope of the concentration reponse curve is higher for OXT (1.8 vs. 2.2, $p<0.05$), also indicative of a raised taste threshold. Male (n = 8) and female (n = 7) did not differ in their response to sucrose, whether they were injected with OXT or not. The dose of OXT injected (0.1 mg/kg i.p.) results in a plasma [OXT] of ~10 nM 30 min. after injection. A 100-fold higher dose of OXT did not alter licking responses to aversive stimuli (300 mM NaCl, 20 mM citric acid, 0.3 mM quinine). We previously reported that 10nM OXT evokes calcium responses in taste cells (Sinclair et al, 2010). These results suggest that OXT may modulate sweet taste sensitivity in behaving mice by acting on glial-like cells in taste buds. Acknowledgements: Supported by NIH / NIDCD grants R21DC010073 and R01DC006021 to N.Chaudhari.

#P200 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Methodological Aspects of the Cold-Pressor Test and the Analgesic Effect of Interoral Saccharin

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An inter-oral bolus of sucrose has been shown to increase pain tolerance in children, although this sweetness analgesia effect is somewhat spurious in adults. A key question concerning sweetness analgesia is whether its reward is mediated through the association of sweetness with calories or the intrinsic value associated with the palatability of sweet tastes. One way to address this question is to investigate the phenomenon with an artificial sweetener, such as saccharin. Although saccharin has been shown to increase pain tolerance in rodents (Foo & Mason, 2009), it has not been well investigated in human adults. Thirty participants were exposed to four cold-pressor tests over two days and were asked in each test to hold their hand in 4º C water for as long as they could tolerate the pain while holding a tastant in their mouths. The tastants were either water (presented each day) or a tastant [either .7M sucrose or .005M saccharin] and were presented in a counterbalanced order. After each test, participants rated pain intensity and tastant qualities. When effects of testing order were taken into account, sucrose did not show analgesic properties, but saccharin did, $t(26) = 2.01$, $p = 0.05$, and increased the amount of time that participants held their hands in the cold water significantly more than sucrose, $t(26) = 4.14$, $p < 0.01$. Despite the counterbalancing, presentation order within a session strongly affected both sucrose, $t(26) = -4.13$, $p < 0.01$, and saccharin, $t(26) = 4.45$, $p < 0.01$, with the second tastant in a session consistently resulting in greater pain tolerance. This finding suggests that some of the spurious nature of the sweetness analgesic effect may be due to subtle methodological issues, such as the order of the stimuli. Acknowledgements: This work was made possible through a grant from the Le Moyne College Research and Development Committee

#P201 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

The reduction of bitterness by sodium gluconate and the effects of bitter receptor genotype in adults

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The unpalatable flavor of a medicine can thwart the benefits of even the most powerful of drugs and those individuals, both young and old, who are genetically more sensitive to the bitterness may experience the most difficulty in medication compliance. As part of an ongoing study on the interaction between bitter blocking and genetics in children and adults, we present here preliminary data on ratings of the bitterness of urea, caffeine, quinine, propylthiouracil, and denatonium benzoate (DB) with and without the addition of a bitter blocker, sodium gluconate, in adults (N=64). Ratings were made using the gLMS and subjects were genotyped for 58

taste gene variants including those for the ability to taste propylthiouracil. The addition of sodium gluconate significantly decreased the bitterness ratings for urea, caffeine, quinine ($p<0.001$), marginally reduced ratings for DB ($p=0.096$) and did not reduce ratings for propylthiouracil ($p=0.59$). For propylthiouracil, the inability of the blocker to reduce bitterness was not a floor effect among genetically insensitive people [genotype x blocker; $p=0.63$]. A survey of the link between the bitter compounds other than propylthiouracil and genetic variants besides those within the TAS2R38 gene revealed an association between the bitter receptor TAS2R60 (rs4595035) and the bitterness of urea and quinine ($p = 0.02$), with an equal reduction in bitter-blocking for all TAS2R60 genotype groups. We conclude that (1) as previously reported, the effectiveness of sodium gluconate to reduce bitterness depends on the particular compounds tested, (2) bitter perception is related to receptor genotype more broadly than the relationship between propylthiouracil and TAS2R38 variants, and (3) sodium gluconate can reduce the bitterness of urea and quinine regardless of TAS2R60 genotype. Acknowledgements: This project was funded by R01 DC011287 and supported by P30 DC011735 from the National Institute on Deafness and Other Communication Disorders. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIDCD or the National Institutes of Health.

#P202 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Quantitative analysis for the masking effects to bitter taste

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On behavior tests for taste evalutaion with mice, lick number to the test solutions depends on their favorability. So, we analyzed the favorability of various concentration of denatonium benzoate bitter solution based on animal behavior. We also analyzed and quantified the favorability changes when sodium saccharin as sweet compound, mono-sodium glutamate as umami compound, or sodium chloride as salty compound was added to the bitter test solutions. As a result, the addition of 2.5 mM of sodium saccharin, 500 mM of mono-sodium glutamate, and 100 mM of sodium chloride showed the ability to suppress bitter taste as 44%, 69%, 47%, respectively. These results suggest that the bitter masking effects could be evaluated objectively by animal behavior, without having human sensory evaluation by well-trained panelists.

#P203 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Agonists and Antagonists of the Insect Odorant Receptor Co-Receptor Subunit

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Insect odorant receptors (ORs) are odorant-gated ion channels, consisting of two essential parts: an odorant binding subunit and a co-receptor subunit (Orco). VUAA1 (CAS: 525582-84-7) was recently identified as a novel OR agonist that acts directly on Orco (Jones et al., 2011, PNAS 108: 8821-5). To identify additional Orco ligands, we screened 22 compounds (termed Orco Ligand Candidates, OLCs), some structurally related to VUAA1 (4-Ethyl-1,2,4-triazol thioacetamide core with alterations to the pyridine and phenyl rings) and some similar to portions of the VUAA1 structure. We expressed heteromeric ORs, as well as individual Orcos, from several species in *Xenopus* oocytes and assayed receptor function by two-electrode voltage clamp electrophysiology. OLC3 (pyridine nitrogen moved to the 4 position) and OLC12 (pyridine nitrogen in the 4 position and a 4- isopropyl moiety on the phenyl ring) were identified as agonists, able to activate several ORs: DmelOr35a+DmelOrco, an OR from *Drosophila melanogaster*, as well as DmelOrco expressed alone; CquiOr10+CquiOrco, an OR from *Culex quinquefasciatus* (Southern House Mosquito), as well as CquiOrco expressed alone; OnubOr1+OnubOrco, an OR from *Ostrinia nubilalis* (European Corn Borer), but not OnubOrco expressed alone. We next identified several antagonists, each able to inhibit OLC12 activation of DmelOr35a+DmelOrco, DmelOrco, CquiOr10+CquiOrco and CquiOrco. Of particular interest was OLC15 (pyridine nitrogen in the 2 position and a 4-butyl moiety on the phenyl ring). Concentration-inhibition analysis of OLC15 inhibition of DmelOr35a+DmelOrco at different concentrations of OLC12 demonstrated a competitive interaction. Our identification of additional Orco agonists and antagonists provides new experimental tools for the study of insect ORs. Acknowledgements: NIH RO1DC011091

#P204 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

A systems-level analysis of odor coding in antenna of a herbivorous insect, the Asian Citrus Psyllid

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The Asian Citrus Psyllid (ACP), *Diaphorina citri*, has a specialized olfactory system, bearing less than a dozen putative olfactory sensilla on the antenna, which encourages a systems-level approach for complete characterization. Here, we present a systematic characterization of the responses of the main olfactory sensilla, the four Rhinarial Plate (RPs), to a panel of 120 odors using single-sensillum electrophysiology and the annotation of the Odorant Receptor (OR) and Ionotropic Receptor (IR) gene families. Roughly, half of the odors induced either activation or inhibition of specific Odorant Receptor Neurons (ORN). Each RP hosts three ORNs of which the A ORNs respond specifically to amines, acids and aldehydes, the hallmark of receptors encoded by IRs. The B and C ORNs respond primarily to aliphatic and aromatic odorants, with a variety of functional groups, that are hallmarks of receptors encoded by the OR gene family. We are able to identify two specific neurons that are broadly tuned to green leaf volatiles, and another that is narrowly tuned to odors of the citrus flush shoots, suggesting that these may participate in host-seeking behavior. On the other hand, we have also identified neurons that are activated by an ACP repellent. In regards to the annotation of genes encoding ACP ORs and IRs, sixteen genes have been identified so far, which is compatible with its limited olfactory system. Taken together, the electrophysiological responses of 12 ACP OSNs revealed a possible neuronal code controlling ACP attraction and repellence, which is being further tested via behavioral studies.

These findings will form the foundation for a systems-level understanding of odor coding that spans from the molecular to neuronal level. Acknowledgements: Citrus Research Board

#P205 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

An Odorant Receptor Mediating Attraction of Drosophila melanogaster to a Specific Enantiomer of a Food Derived Odorant

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Odorant receptors (ORs), a family of odorant-gated ion channels, mediate the attraction of *D. melanogaster* to a variety of fruits. Ethyl-3-hydroxybutyrate (E3HB), a component of fruit extracts that activates several *Drosophila* ORs, is chiral, with the S isomer preferentially produced by yeast through reduction of ethyl acetoacetate, also a component of fruit extracts. Because yeast growing on fruit is a primary food source for *Drosophila* and S-E3HB may serve as a marker for the presence of yeast, we asked whether flies could distinguish between the isomers of E3HB. In a preference assay, adult female flies showed an innate preference for the S isomer. In an aversive associative conditioning assay, we also found that flies could distinguish between the two isomers and be conditioned to prefer the R isomer by associating R-E3HB with sweet taste (sucrose) and S-E3HB with bitter taste (quinine). To determine which OR mediates this behavior we expressed in *Xenopus* oocytes several ORs (9a, 35a, 85a, 85b) previously shown to respond to racemic E3HB and assayed by electrophysiology (Orco was coexpressed). While Or35a showed a slight preference for the R isomer, and Or9a and Or85b showed no preference, Or85a displayed a >1000-fold preference for the S isomer. Next we asked whether Or85a was responsible for the ability of flies to distinguish isomers of E3HB. Using the UAS/GAL4 approach to selectively express tetanus toxin, we found that silencing Or85a expressing olfactory sensory neurons eliminated the ability to distinguish between isomers, while silencing Or9a expressing neurons did not affect the ability of the flies to distinguish between isomers. We conclude that Or85a plays an essential role in recognizing the presence of S-E3HB, a potential food source marker for *Drosophila melanogaster*. Acknowledgements: NIH RO1DC011091

#P206 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Temporal features of odor stimuli and the encoding of odor identity and intensity by Olfactory Receptor Neurons

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Odor stimuli are detected by Olfactory Receptor Neurons (ORNs) that project to segregated regions of the brain called glomeruli, where they make synaptic connections with second-order neurons. Different odorants elicit distinct patterns of activity in the population of ORNs as well as in the glomeruli, suggesting that odors are encoded in spatial combinatorial maps. Odors also elicit diverse temporal patterns of activity at several levels of the olfactory system but their origin and role in odor coding remains so far unclear. We performed single sensillum recordings from the *Drosophila* antenna simultaneously with measurements of the odorant concentration reaching the fly. We found that in several conditions stimulus dynamics depends on odor type before any interaction with the olfactory system occurs. Individual ORNs follow these differences in stimulus dynamics with such precision that a linear-nonlinear model can predict the response of one ORN to different odorants solely from measurements of the stimulus. This suggests that a single response function can be associated to a single ORN and mediates the response to a large set of different odors. Importantly we found that ORN adaptation capabilities maintain response dynamics remarkably similar across a large range of stimulus and background intensities. Hence, irrespective of the odor and receptor type, ORNs can capture information about stimulus dynamics independently from the intensity of the signal. Our results open the question of whether odor-specific dynamics might be used in discrimination tasks and affect odor tracking strategies. Acknowledgements: This work was supported by research awards from the Whitehall Foundation and the Raymond and Beverley Sackler Institute for Biological, Physical and Engineering Sciences to T.E., and by NIH grants to J.C.

#P207 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Linking Ecological Adaptations in Olfactory Physiology and Functional Genetics of Olfactory Receptors in a Polyphagous female Moth, *Spodoptera littoralis*

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Host plant selection is of continuous ecological and evolutionary interest with respect to understanding host specialization, speciation, and the steady emergence of insect pests in our agro-ecosystems. We have selected a polyphagous and widespread agricultural pest, the Egyptian Cotton Leaf Worm moth *Spodoptera littoralis*, as a research model to elucidate olfactory neural mechanisms related to host plant selection. We are characterizing olfactory receptor (OR) genes, recently identified in *S. littoralis*. The receptive range of each odorant receptor is determined via de-orphanisation experiments in a heterologous expression system. Individual olfactory receptor proteins are expressed in the vinegar fly *Drosophila melanogaster*, and their response profiles characterized by means of single neuron electrophysiological recordings. We study how ecological adaptations in olfactory genetics and physiology are linked in *S. littoralis*, and we will also determine how much the level of differentiation is between olfactory receptor populations of different moth species (sequence polymorphism, differential expression, and functional receptive range) to study how olfactory function and behavioral preferences may co-evolve. We show that the heterologous expression system works very well, and we have identified ORs that respond to odors

derived from the ecological relevant sources of this insect species. This study will be an important contribution in understanding the olfactory neural mechanisms used by insects to select their hosts Acknowledgements: Untill now, I do not have any grant/finace to travel to USA and present my work at AChemS 2012 meeting. Thats why I applied for travel grant from AChemS. If AChemS awards a travel grant to me, it will make possible for me to join AChemS 2012 Meeting.

#P208 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Investigating the structural basis for odorant recognition in an odorant receptor from the malarial vector, *Anopheles gambiae*

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Insect vector-borne diseases are a leading cause of morbidity and mortality among humans. Insects employ olfaction to find food, mates and egg-laying sites, making the acquisition of detailed knowledge of the structure of odorant receptors (ORs) important for developing more effective insect repellents. To identify structural features of the odorant binding site of an insect OR, we examined the odorant responsiveness of two highly homologous (82% amino acid identity) *Anopheles gambiae* odorant binding subunits. AgamOr13 and AgamOr15 were expressed in *Xenopus* oocytes (each in combination with AgamOrco) and assayed by two-electrode voltage clamp electrophysiology. These ORs displayed distinct odorant specificities, allowing us to develop an assay based on the ratio of responses of the two receptors to acetophenone and 4-methylphenol. Each residue in the predicted transmembrane and extracellular domains of AgamOr15 that differed from AgamOr13 was mutated to the residue present in AgamOr13, generating a panel of 34 mutated ORs. Screening this panel with acetophenone and 4-methylphenol identified A195I as a mutation that partially shifted the response ratio from that of AgamOr15 toward that of AgamOr13. Concentration-response analysis for activation of AgamOr13, AgamOr15 and AgamOr15,A195I by several odorants confirmed that the A195I mutation partially shifts the odorant specificity of AgamOr15 to that of AgamOr13. Our results implicate residue 195, located near the interface of the predicted second extracellular loop and the fourth transmembrane helix, as playing a critical role in odorant activation. We are currently examining residue 195 and its surrounding area to gain a better understanding of the role of this region in odorant recognition. Acknowledgements: NIH RO1DC011091, NIH T32NS007044

#P209 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Characterization and expression of lobster olfactory variants of ionotropic glutamate receptors

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The molecular basis of olfactory signal transduction in crustaceans, a major group of arthropods, is still uncertain, in particular the nature of the olfactory receptors. We have cloned and analyzed full length sequences of multiple orthologs of *Drosophila* olfactory variants of ionotropic glutamate-like receptors (IRs) from the spiny lobster olfactory organ. Odorant-induced responses from HEK cells heterologously expressing a combination of two IRs, 1 and 2, indicate that lobster IRs can form functional odorant receptors and suggests that, as in insects, they function as heteromers. Unlike the IR expression pattern in insect olfactory receptor neurons (ORNs), most, if not all, lobster ORNs express IR1 (ortholog of *Drosophila* IR25a), as confirmed by *in situ* hybridization. IR1 can be further localized to the transduction compartment (outer dendrites) of the ORNs by western blotting and immunocytochemistry. While IR1 appears to be a common subunit, other IRs are expressed in very few ORNs, suggesting specific receptor function. Characterizing the receptive range of lobster ORNs *in situ* using calcium imaging shows that single biologically-relevant odorants, e.g., amino acids, trigger calcium increase in only 0.3-6% ORNs, consistent with the IR expression pattern. In the context of long-standing evidence for odorant-activated metabotropic signaling in lobster ORNs, expression of IRs in the same cells argues that ionotropic and metabotropic signaling work in concert to effect lobster olfactory transduction. Acknowledgements: This work was supported by National Institute on Deafness and Other Communication Disorders (DC009730, DC005995 and DC001655).

#P210 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Environmentally Regulated Patterns of Olfactory Receptor mRNA Expression In Pacific Salmon

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Salmon are well known for their extraordinary homing migrations from oceanic feeding grounds back to their river of origin to spawn. These migrations are governed by olfactory discrimination of homestream odors that juvenile salmon learn (imprint to) prior to their seaward migrations. Our previous laboratory studies have suggested that one component of imprinting involves sensitization of the peripheral olfactory system to specific odorants and up-regulation of specific odorant receptor (OR) mRNAs. Therefore, we hypothesized that juvenile salmon exposed to tributary waters with distinct chemical constituents would display different patterns of OR expression. To test this hypothesis, we sampled two cohorts

of age 1+ juvenile spring Chinook salmon reared as part of a hatchery program in the Yakima River, Washington. One-year-old juveniles were sampled at their central rearing hatchery and then again just prior to release as smolts from three different sites where they were transferred for acclimation and release. Using quantitative PCR, we assessed mRNA expression levels of several ORs representing distinct subfamilies of ORs expressed in the olfactory epithelium. After several weeks of rearing at different sites, smolts reared in different waters displayed distinct patterns of OR expression. In a similar experiment, sockeye salmon siblings reared in two different water sources also displayed distinct patterns of OR mRNA expression. These results are consistent with our hypothesis that distinct odors present in the waters of different tributaries may influence mRNA expression in the olfactory epithelium. These findings may ultimately facilitate development of molecular tools for assessing imprinting and identifying critical chemical components in natural waters that are important for imprinting. Acknowledgements: Funding provided by NWFSC

#P211 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Functional Analysis of Nematode GPCRS in Yeast

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Given its ease of genetic manipulation, rapid growth, and eukaryotic secretory pathway, yeast is an attractive host system for the development of robust heterologous expression systems. Yeast has been successfully used for the heterologous expression of mammalian membrane proteins, specifically G-protein coupled receptors (GPCRs). Although the *Caenorhabditis elegans* genome was sequenced 13 years ago and encodes over 1,000 GPCRs, of which several hundred are believed to respond to volatile organic ligands, only one of these receptors, ODR-10, has been linked to a specific ligand, 2,3-butanedione. Here we report the tailoring of a *Saccharomyces cerevisiae* strain for the analysis of *C. elegans* olfactory receptor function. In this study, a yeast *gpa1D ste2D* double mutant was used to develop a strain that efficiently couples a nematode olfactory receptor with the yeast signalling pathway. We used three different reporter genes: green fluorescent protein (GFP), histidine (HIS_3) and MEL1 to verify activation of the signal transduction pathway by ligand-GPCR interactions. With this heterologously engineered yeast system, we will be able to accelerate the de-orphaning of *C. elegans* GPCR proteins. Acknowledgements: Australian Department of Defence for CTD and Department of Prime Minister and Cabinet and Attorney General's.

#P212 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

M3 Muscarinic Acetylcholine Receptor Potentiates Mammalian Odorant Receptors through Inhibiting ß-Arrestin2 Recruitment

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In mammals, activation of odorant receptors (ORs) expressed in the olfactory epithelium mediates the perception of smell. These ORs form the largest class of G-protein coupled receptors (GPCRs). The M3 muscarinic acetylcholine receptor (M3-R), which is co-expressed with ORs in the olfactory epithelium, couples to and enhances the G protein based cAMP response of ORs. This enhancement is further increased by M3-R agonists and reduced by M3-R antagonists. As the olfactory epithelium contains a population of cholinergic cells and is innervated by parasympathetic nerves that release acetylcholine, the potentiation of OR mediated cAMP response by M3-R suggests the layer of olfactory signaling regulation by the neurotransmitter. However, the mechanism of OR potentiation by M3-R is not well understood. In accordance with classic GPCR signaling, OR desensitization involves ß-arrestin2 recruited to the activated receptor.
We developed a split luciferase based assay system to measure ß-arrestin2 recruitment by activated ORs in live heterologous cells. In this system, dose-dependent ß-arrestin2 recruitment is observed for various ORs when stimulated by their cognate ligands. Using this assay, we show that M3-R reduces ß-arrestin2 recruitment for various ORs, raising the possibility that M3-R potentiates OR mediated G protein activation by inhibiting ß-arrestin2 recruitment and receptor desensitization. Activation of M3-R with agonist further inhibits ß-arrestin2 recruitment to the OR, while M3-R antagonist reduces the inhibition. When ß-arrestin2 is knocked down using siRNA, the potentiation of OR cAMP response by M3-R is attenuated. These results suggest that M3-R potentiates cAMP response of ORs, at least in part, through attenuating ß-arrestin2 recruitment by activated ORs. Acknowledgements: This work is supported by NIH.

#P213 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR AND PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Chemosensory processing of odorants in the skin

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In its essential role as a protective barrier the skin is exposed to multiple environmental factors. Keratinocytes represent the major cell type of the epidermal layer of the skin. They express a variety of different sensory receptors that enable to react to various thermal, mechanical and chemical stimuli and thus contribute to information processing in the skin. This study is dedicated to unravel the molecular and cellular mechanisms underlying odorant perception in the human skin. For this purpose, the physiological impact of odorant exposure was analyzed in cultured human keratinocytes using the calcium imaging technique. Several fragrances have been identified that induce transient calcium

signals when applied to human skin cells. Additionally, pharmacological characterizations of the odorant-induced calcium elevations revealed a substance-dependent involvement of a cAMP or IP_3 signaling pathway. Moreover, the effects of long term stimulation were analyzed concerning cell viability and keratinocyte proliferation. Furthermore, using Microarray studies and PCR analysis the expression of several olfactory receptors could be demonstrated which might contribute to odor perception of keratinocytes. Detailed investigation on the ability of keratinocytes to detect and convey chemical stimuli is important to understand how environmental influences are communicated within the skin.

#P214 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR & PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Characterization of ectopically expressed olfactory receptors in human liver

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Olfactory receptors (ORs) are responsible for the detection and processing of odor signals from the environment. Various studies show that the expression of ORs is not only restricted to the olfactory epithelium; they are also expressed in other tissues where their function is often not well understood. Until now, several studies demonstrate a functional expression and physiological role in human sperm, gut and prostate. The present study deals with the comprehensive identification and functional characterization of ectopic OR expression in human liver cells. Using a combination of Microarray, Next Generation Sequencing and quantitative RT-PCR experiments, specifically expressed ORs were identified that are up- or downregulated in healthy and diseased human liver tissue. In addition, Calcium Imaging experiments demonstrated that a citrus odorant evokes a cAMP-dependent intracellular Ca^{2+} increase in a human hepatocyte cell line. These results correlate with the detection of specific ORs on mRNA and protein level. Therefore, we postulate that ORs also play a functional role in liver tissue. These data constitute an essential contribution to the understanding of physiological and pathophysiological processes in the liver, and will provide new insights for clinical applications.

#P215 **POSTER SESSION V: TRIGEMINAL SYSTEM; BEHAVIOR & PSYCHOPHYSICS; ODORANT RECEPTORS & OLFACTION PERIPHERY**

Ectopically expressed olfactory receptors in primary human skeletal muscle cells

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Olfactory receptors (ORs) comprise the largest group of G protein-coupled receptors (GPCRs) and are responsible for the recognition of different odorant molecules. For many years ORs were believed to be exclusively expressed in the olfactory epithelium (OE). However, recently several studies demonstrated an ectopic expression of ORs in different tissues and cells throughout the body. Nevertheless, the physiological relevance in most of these tissues remains poorly understood, except for a few examples like spermatozoa and prostate cells. Using next generation sequencing and microarray approaches combined with real time qPCR we could identify several ORs expressed in primary human skeletal muscle cells (hSkMC). We also observed that the expression levels of some ORs changed according to the differentiation stage. In addition, we could also detect members of the transient receptor potential (TRP) channel family. In calcium imaging experiments, hSkMCs responded to stimulation with odorants by showing an intracellular calcium increase in a concentration dependent manner. Interestingly, the responses were also dependent on the developmental stage of the cells showing a significant difference between undifferentiated and differentiated cells. Furthermore, we could demonstrate an effect of odorant stimulation on the migration activity of hSkMCs.

#P216 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

The olfactory system of closely related wild-bee species - neuroanatomical correlations to social organization and floral preference

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Among Hymenoptera, many ecologically successful species evolved a eusocial lifestyle. However, there are also many solitary wasp and bee species. Several studies emphasize that eusocial Hymenoptera - like honeybees and ants - possess a complex brain including a high number of functional units (glomeruli) in the antennal lobe and large mushroom body calyces. Brain complexity may have evolved as the result of a eusocial lifestyle or in response to other selective pressures and, therefore, be a precondition for the evolution of eusociality. We analyzed specific neuroanatomical traits in selected wild-bee species and correlated the results with both social lifestyle and floral preference. We investigated halictid bee species (Halictidae) with different grades of sociality, but polylectic floral preference and solitary polylectic and oligolectic mason bee species (*Osmia*). We employed confocal microscopy scanning and 3D-reconstruction for quantitative analyses and focused on the antennal-lobe structure (number and size of glomeruli). In halictid bees, we found between 156 and 161 glomeruli in *Lasioglossum* species and between 171 and 183 glomeruli in *Halictus* species. No significant difference in glomerular number between solitary and eusocial species was found. The investigated *Osmia* species showed a significantly lower number of glomeruli (100-137 glomeruli) and a large interspecies variance. The strictly oligolectic species *Osmia adunca* showed the lowest number of glomeruli, while all polylectic *Osmia* species showed larger glomerular numbers. Our results give first hints that a more complex antennal-lobe structure is not the result of a eusocial lifestyle. Furthermore, the results indicate that floral preference seems to have a larger impact on the antennal-lobe complexity than social lifestyle. Acknowledgements: DFG KE-1701 1/1

#P217 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Linking sensory input to behavioral output using Drosophila olfactory system

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Olfaction is a crucial modality for many animals, and mediates behavioral responses to food, mates and predators. Olfaction begins with odor molecules binding to and activating olfactory receptor neurons (ORNs). Each ORN expresses a single (or small number of receptors) out of large family of receptor, which defines its odor response profile. Most odors activate many ORN-types and activities in multiple ORN-types are integrated to guide behavior. In recent years, great progress has been made in understanding odor processing at the periphery. In contrast, relatively little is known about the relation between activity in ORN and behavior. This is largely due to the fact that it is difficult to control odor stimulus in freely moving animals and without stimulus control it is difficult to link odor responses to behavior. In this study, we describe a novel behavioral arena in which a fly's walking behavior can be measured under precisely controlled stimulus conditions. We use this arena in combination with single-cell recording and fly genetics to ask two fundamental questions in olfaction: 1) What are changes in a fly's walking behavior that accompanies its attraction to odor? and 2) What is the contribution of a single ORN-type in eliciting odor-evoked behavior? Attraction to an odor can be decomposed into two parameters: First, the fly dramatically increases the time it spends inside the odor-zone each time it enters in. Second, the time it takes for the flies to return to the odor-zone after it loses the odor also dramatically decreases. Interestingly, odor induced changes in the two parameters are dependent on the identity of the odor. Behaviors elicited by activation of a single ORN-type are dramatically different from those odors that activate many receptors and will be discussed.

#P218 ***This abstract has been moved to Poster Session II, page 54.***

#P219 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Histamine Enhances Antennal Lobe Pulse Tracking and Lowers False Positive Responses in Behavioral Detection Threshold Tasks in the Moth *Manduca sexta*

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Recent studies show that the antennal lobe (AL) of the moth, *Manduca sexta,* tracks periodically structured stimuli at natural wing beat frequencies (10-30Hz). Odor detection is also enhanced when pulsed at these frequencies. This may be mediated by a bilateral pair of histamine immuno-reactive neurons, which project from the mesothoracic ganglion to the AL. To characterize the effect of histamine on behavioral measures of odor detection and physiological measures of AL responses, we conducted two studies. First, we measured detection thresholds in the moth, *Manduca sexta* under control and pharmacologically impaired conditions. Moths were trained to respond to 2-hexanone; 24 h later, both ALs were injected with 0.8 nl of saline vehicle, either with or without drug, then tested (blindly) across a 5 log-step dilution series of 2-hexanone. In separate groups, we injected histamine, or 1 of 2 competitive antagonists, cimetidine or ranitidine. Three dilutions of each drug were used. Results indicate that histamine blockade raises odor detection thresholds by significantly increasing false positive rates, whereas histamine had the opposite effect. Next, we placed multichannel electrodes into the AL using standard methods and measured unitary pulse tracking ability before and during histamine application. Odor was pulsed at 20 Hz. Five 500 ms pulse trains were presented, each spaced by 10 s; this was repeated every 2 min. Power spectral density analysis indicated that histamine significantly increases the pulse tracking ability of AL. This effect took ~10 min to asymptote. Thus, as pulse tracking ability is enhanced, the ability to accurately detect the presence of odor increased. These findings suggest that histamine actively modulates sensitivity to the temporal structure of stimuli.
Acknowledgements: This work was supported by NIH-DC009417 to KCD

#P220 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Odor attraction behavior of *Drosophila melanogaster* is biased via inhibitory projection neuron activity in the lateral horn area

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The olfactory system of the vinegar fly *Drosophila melanogaster* provides an excellent system to study neuronal networks underlying coding and processing of sensory information. Initially, olfactory sensory neurons (OSNs) transfer peripheral information to the antennal lobe (AL), the primary olfactory neuropil. Within the AL dense synaptic connectivity between OSNs, local interneurons (LNs) and projection neurons (PNs) results in a discernible glomerular organization. The glomerular convergence of OSNs expressing a specific receptor and uniglomerular innervations of excitatory PNs (ePNs) create odor specific topographic activity maps in the AL. PNs equal mitral cells of vertebrates and relay the olfactory information to higher brain centers as the mushroom body calyx (MB) and the lateral horn (LH). Whereas a role in olfactory learning processes is assigned for the MB calyx, the function of the LH is still unclear. In this study we investigate inhibitory PNs (iPNs, ~45) which develop polyglomerular innervations within the AL and project exclusively to the LH. Morphological characterization of these neurons has been performed using photoactivated GFP, immunostainings with pre- and postsynaptic markers and reconstruction of 3-dimensional maps. Functional analysis via calcium imaging revealed several specific odor response domains in the LH differing in their characteristic spatial and temporal properties. The domains varied according to odor concentration as well as identity. Furthermore, high and low concentrated odors are clearly represented in separate regions of the LH. Silencing these neurons using RNAi leads to drastic changes in hedonic valences of odors. This indicates a crucial role for iPNs in evaluating pleasantness of ecologically important odors.

#P221 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Mapping the Microglial/Immune Response to Two Methods of Olfactory Bulb Deafferentation in Zebrafish

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Since the role of the immune system in neural degeneration is not understood, this study investigated the potential microglial response to two different olfactory bulb deafferentation methods in adult zebrafish. We compared complete, permanent olfactory organ removal by cautery and temporary, partial olfactory epithelium ablation with Triton X-100. We hypothesized that a microglial response to axonal degredation would be more aggressive and long lasting with complete olfactory organ removal than with detergent treatment. DiA was applied to both olfactory organs to label the olfactory axons. Three days later, olfactory bulbs were deafferented on the right side with either a cautery iron injury or a single application of 0.07% Triton X-100 to the nose. Fish were allowed to survive for 1, 3, 5, or 7 days. Cryostat sections of the brains were viewed using both fluorescence and confocal microscopy. As the olfactory bulb responded to the damage, phagocytic removal of degenerating axons by presumptive microglial cells caused them to pick up the fluorescent dye. As early as 1 day after cautery treatment, a noticeable increase in irregularly shaped, labeled profiles was visible and persisted through day 7. The profile labeling appeared to correlate directly with a decrease in axonal labeling. After treatment with detergent, an increase in profile labeling was observed as soon as 1 day but was reduced by 3 days. Thus, treatment with Triton-X-100 elicited a shortened time course of immune response and axon clearing. This is consistent with our previous finding of reinnervation occurring quickly after detergent treatment. This study is one step in better understanding the immune response of the brain to peripheral damage and the potential role of microglia in both deafferentation and reinnervation processes. Acknowledgements: Supported by NIH-NIDCD #011137 to CBJ.

#P222 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Deafferentation Affects the Expression of Glutamate Receptor Subunits in the Adult Zebrafish Olfactory Bulb

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Our goal was to understand the role of glutamate receptors in regulating deafferentation effects in the olfactory bulb (OB). This study examined both the presence of several glutamate receptor subunits in the adult zebrafish OB and the potential effect of deafferentation on their expression. We hypothesized that loss of afferent input from olfactory axons will alter expression of glutamate receptor subunits. Antibodies to ionotropic glutamate receptor 2/3 (iGluR2/3), metabotropic glutamate receptor 2/3 (mGluR2/3) and Kainate 2 receptor (KA2R) were chosen based on previous studies or protein sequence comparison between rat and zebrafish. The right olfactory organ was permanently ablated by cautery, leaving the left side untreated. Following two survival times, 1 day and 3 weeks, both the right and left sides of the olfactory bulb and telencephalon from 6 fish were dissected and homogenized separately. Protein levels were measured, and equal amounts of protein were separated by SDS-PAGE and transferred to PVDF membrane. Blots were incubated with the three antibodies. Densitometry was used to quantify the band densities and compare to tubulin levels. We found that all three glutamate receptors exist in both deafferented and untreated zebrafish OB, with distinct bands at the predicted molecular weights. The expression of iGluR2/3 appeared to decrease in deafferented tissues at 3 weeks. The mGluR2/3 seemed to increase 1 day following deafferentation, but was not different from control level at 3 weeks. No obvious change of KA2R was observed in deafferented tissues. Thus, olfactory input may differentially regulate the expression of various glutamate receptor subtypes in the OB. Future studies will examine the cellular distribution of these glutamate receptors in the adult zebrafish OB. Acknowledgements: Supported by FRACAA #09-019 and SFSA from WMU (CBJ).

#P223 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Olfactory Recovery is Altered in Matrix Metalloproteinase-9 Knockout Mice

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The olfactory system has the remarkable capacity for functional recovery following injury, however the molecular mechanisms contributing to the recovery process remain unknown. We previously reported that matrix metalloproteinase-9 (MMP-9) expression increases immediately following olfactory nerve transection. To determine if MMP-9 plays a critical role in recovery, we compared the return of olfactory function in wild-type (WT) and MMP-9 knockout (MMP-9KO) mice after injury. An odor discrimination task was employed to test olfactory function. Mice were first trained to detect and distinguish between two odors prior to bilateral nerve transection. Following surgery, olfactory function was tested at recovery day 4 and subsequently every third day. Shortly after surgery (day 4), both the WT and MMP-9KO mice were unable to detect or distinguish between the two odors, demonstrating that the surgery produced loss of smell. At day 13, the WT mice showed initial improvement in olfactory discrimination function, while the MMP-9KO mice were unable to distinguish between the odors. By day 25, WT mice performed the discrimination task at near pre-surgical levels. However, the MMP-9KO mice showed minimal or no improvement. These data suggest that MMP-9 plays a critical role in olfactory recovery. The early expression of MMP-9 following injury may represent a novel therapeutic target for restoring olfaction function.

#P224

POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Rehabilitation of Olfactory Function Despite Persistent Olfactory Nerve Pathophysiology in a Mouse Model of Cadmium-Induced Neurotoxicity

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Exposure to aerosols of the heavy metal cadmium has been linked to olfactory dysfunction including anosmia, hyposmia and parosmia in humans. However, behavioral studies of olfactory function following Cd exposure in rodent models have produced mixed results. Here we a) investigate the pathophysiological, histopathological, and sensory consequences of intranasal cadmium exposure for four weeks following acute exposure and b) evaluate a model of sensory training for rehabilitating the observed olfactory impairments. Using *in vivo* optical imaging in transgenic mice expressing the fluorescent exocytosis indicator synaptopHluorin in olfactory receptor neuron terminals (Bozza et al., 2004), we found that acute intranasal Cd exposure greatly suppresses odorant-evoked neurotransmitter release from the olfactory nerve compared to vehicle controls, and this effect persists for at least 4 weeks. Throughout this time, Cd levels remain elevated in the olfactory bulb (measured using mass spectrometry), and there is a gradual reduction in ORN axonal projection density to the olfactory bulb. In mice trained to perform a go/no go olfactory detection task, Cd-exposure drops performance to chance. Remarkably, two weeks of additional explicit training in the detection task was sufficient to recover behavioral performance to baseline levels in all mice. However, optical imaging in rehabilitated mice revealed that this training did not induce any restoration of olfactory nerve physiology, suggesting that the recovery of sensory function reflects a learned reinterpretation of degraded sensory input in downstream brain regions. These results demonstrate that sensory learning can mask severe underlying pathophysiology, but also suggests that rehabilitation training may rescue toxicant-induced olfactory deficits. Acknowledgements: This work was supported by the National Institute on Deafness and Other Communication Disorders, grant number R00 DC009442 to JPM as well as a grant from the Busch Biomedical Research Program to JPM.

#P225

POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Mouse Strain effects on the distribution of glomeruli throughout the glomerular layer

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The surface of the main olfactory bulb (MOB) represents a massive convergence of olfactory information. In mice, axons from ten million olfactory sensory neurons (OSN), distributed pseudorandomly in the olfactory epithelium, are sorted into ~1800 spherical neuropil called glomeruli. Due to the topographic patterns of activation seen in this layer during olfactory perception, the glomerular layer is thought to contain an odor map important for encoding olfactory information. Despite intense scrutiny, we still do not fully understand the complete addressing mechanism that allows for the precise wiring of the sensory neurons to their destined glomerulus in the MOB. Nor do we understand the full implication of the topographic organization of glomeruli as it relates to odor coding and, ultimately, olfactory-driven behavior. We have recently shown that environmental factors play a role in the proper formation and maintenance of semiochemically-responsive glomeruli. In this study, we have fully characterized glomerular metrics throughout the MOBs of two strains of mice, C57Bl6 and SVJ129, raised in identical housing conditions. In both strains of animals, we find roughly the same number of glomeruli asymmetrical distributed in both size and number throughout the glomerular layer, where the highest density and largest glomeruli are found primarily in the ventral regions of the bulb. Interestingly, however these asymmetrical distributions differ significantly between the two strains. This work suggests that strain of the animal has a subtle, but significant effect on the size and distribution of glomeruli throughout the surface of the MOB. Acknowledgements: NIDCD

#P226

POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Adult-born Interneurons are Necessary for Intrabulbar Map Refinement

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The olfactory system is unique in that organizational maps persist in spite of ongoing replacement of sensory and interneuron populations. Superficial tufted cells receive input from glomeruli on one side of the olfactory bulb and send their axons to discrete locations on the opposite side of the same bulb, producing an intrabulbar map. These projections connect isofunctional odor columns within the olfactory bulb and are activity dependent such that they broaden in response to sensory deprivation and gradually re-refine once afferent activity is restored. We tested the hypothesis that newly generated interneurons play a role in intrabulbar map plasticity. We conducted experiments using transgenic mice expressing the herpes simplex virus thymidine kinase under the control of either the glial fibrillary acidic protein (GFAP) promoter (GFAP-TK) or the nestin promoter (Nestin-TK). When GFAP-TK or Nestin-TK mice are given the antiviral agent ganciclovir (GCV), stem cells expressing these markers are selectively killed as they divide, thus eliminating most adult born interneurons. We first induced a period of sensory deprivation in GFAP-TK and Nestin-TK mice and used targeted tracer injections to observe the characteristic broadening of intrabulbar projections. We then treated with GCV for the following 8 week "recovery" period and compared the intrabulbar maps in TK and wild type mice. We found that all wild type mice that underwent deprivation exhibited normal recovery. In contrast, sensory deprived GFAP-TK and Nestin-TK mice treated with GCV during the recovery period were unable to re-refine their intrabulbar projections and exhibited reduced map specificity. Therefore, we conclude that adult-born neurons play an integral role in intrabulbar map plasticity. Acknowledgements: NIH Intramural Program 1ZIANS003002-09 (Belluscio), 1ZIAMH002784-10 (Cameron), and K01 Award (Cummings)

#P227 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Connexins and AMPA receptor subunits have diurnal rhythms of expression in the rat olfactory bulb

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Connexins and AMPA receptors together allow mitral and tufted cells in the mammalian olfactory bulb to fire synchronous action potentials and thus affect synaptic transmission and odor processing. We examined connexins 36, 43, and 45 within the rat olfactory bulb for rhythms in expression. We found, via quantitative PCR, that connexin36 and connexin45 mRNAs are expressed with a specific diurnal rhythm. Because the synchronicity of firing is an effect of both connexin36 and AMPA receptors, we examined the AMPA receptor subunits GluR1-4 via qPCR as well. mRNA for GluR1 and GluR2 appeared to peak in the dark phase and decrease in the light. We also examined the proteins for these genes in the plasma membrane, using Western analysis and subcellular fractionation to isolate the membranes. We found that connexins 43 and 45 expressed peaks in the dark phase, as did GluR1 and GluR3 proteins. Some protein expression in the membrane peaked during the light phase, which may indicate the presence of an oscillatory input to the olfactory bulb aside from the endogenous oscillations first identified by Granados-Fuentes et al. (2004).

#P228 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

A quantitative analysis of the Islands of Calleja in the Olfactory Tubercle

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The olfactory tubercle (OT) is an olfactory cortical structure with an exceptionally unique cytoarchitecture. One of the unique features of the OT is the presence of dense cell clusters termed 'islands of Calleja' (IC) within the multiform cell layer (layer iii). The apparent predominant localization of the ICs within the OT suggests a role for the ICs in olfactory processing or perhaps more specifically odor-guided behaviors, however, the function of the ICs remain unknown. Precluding this realization, not even a thorough quantification of the ICs anatomical properties is currently available. To address this, here we examined the ICs from 20µm cresyl violet stained sections of 25 male C57bl/6J mice. Following staining, basal forebrain sections were sequentially imaged to allow reconstruction and quantification of the ICs. We found evidence for hemispheric differences in the numbers of ICs of individual mice. We also observed that the volume of the ICs, but not cellular density, is heterogeneous within individual mice, yet in manners not necessarily predicted by anterior-posterior or medial-lateral positioning in the OT. More ICs are found within posterior versus anterior portions of the OT. Interestingly, the major IC as well as some other ICs were often found to be donut shaped in nature, with a void in their center, verses simply crescent or spherical shaped as previously thought (Fallon et all., J Comp Neurol, 1978). Studies to explore how these factors change throughout aging in mice are underway. These neuroanatomical studies provide a foundation for future works exploring the physiological contributions of the ICs in the context of olfactory perception and odor-guided behaviors. Acknowledgements: Supported by NSF grant ISO-1121471 to D.W.W.

#P229 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Differential projections of the anterior and posterior medial amygdala in female mice

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In rodents both appetitive and consumatory behaviors concerned with reproduction are mediated by chemosignals released from opposite sex conspecifics. These signals are detected by two anatomically distinct systems, the main olfactory system (MOS) and the accessory olfactory system (AOS), which detect primarily volatile and non-volatile body odor cues, respectively. Recently, it has been shown that the medial amydgala (Me) receives inputs from both the main and accessory olfactory systems, with inputs from the MOS to the Me being selectively activated by opposite sex urinary odors (Kang et al., 2009). It has been suggested anterior (MeA) and posterior (MeP) Me subdivisions play distinct roles in the processing of body chemosignals (DiBenedictis et al., 2012; Maras & Petrulis, 2006). It is likely that differential processing of olfactory information by Me subnuclei reflects differences in their downstream targets. To test this hypothesis, we injected female mice with the anterograde dextran amine, Fluoro-Ruby into either the MeA or MeP and quantified resultant labeled fiber densities in 8 forebrain projection target sites. We found significantly denser anterograde fiber labeling of the posterolateral cortical amygdala (PLCo), bed nucleus of the stria terminalis (BNST) and shell of the nucleus accumbens (AcbSh) in MeP-injected females compared to MeA-injected females, whereas we found equivalent innervation of the mOT, AcbC, MPA, VMHdm and VMHvl. Several sites preferentially targeted by the MeP are associated with the mesolimbic reward system, corroborating previous behavioral data from our laboratory suggesting that a functional MeP is necessary for the normal display of motivational aspects of sexual behavior, including the intrinsic preference of females to investigate male urinary odors. Acknowledgements: NIH grant R01DC008962

#P230 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Parallel odor processing by two anatomically distinct olfactory bulb target structures

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The olfactory cortex encompasses several anatomically distinct regions each hypothesized to provide differential representation and processing of specific odors. Studies exploring whether or not the diversity of olfactory bulb input to olfactory cortices has functional meaning, however, are lacking. Here we tested whether two anatomically major olfactory cortical structures, the olfactory tubercle (OT) and piriform cortex (PCX), differ in their neural representation and processing dynamics of odors by performing *in*

vivo extracellular recordings from the OT and PCX of anesthetized mice. We found a wealth of similarities between structures, including odor-evoked response magnitudes, breadth of odor tuning, and odor-evoked firing latencies. In contrast, only few differences between structures were found, including spontaneous activity rates and odor signal-to-noise ratios. These results suggest that despite major anatomical differences in innervation by olfactory bulb mitral/tufted cells, the basic features of odor representation and processing, at least within this limited odor screen, are similar within the OT and PCX. We predict that the olfactory code follows a distributed processing stream in transmitting behaviorally and perceptually-relevant information from low-level stations. Acknowledgements: Supported by grant IOS-1121471 to D.W.W. and D.A.W. from the National Science Foundation and DC003906 to D.A.W. from the National Institutes of Health.

#P231 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Dreaming of Odors: Odor Replay During Slow Wave Sleep Enhances Memory

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Post-training slow wave sleep (SWS) may contribute to memory consolidation by allowing replay during a time of reduced sensory input and possibility of interference. Here, by using precise spatiotemporal patterns of electrical olfactory bulb stimulation as the CS+ and CS- during differential odor-fear training, we tested the replay hypothesis of SWS, by applying replay CS+ stimuli during either SWS or waking during the immediate post-training period. We used an electrical odor (e-odor) paradigm utilizing electrical stimulation of various locations in the olfactory bulb (OB) as conditioning stimuli in a differential odor-fear conditioning task. We recorded local field potentials from the anterior piriform cortex (aPCX) in behaving animals during fear conditioning and ensuing sleep. Rats were chronically implanted with electrodes in the aPCX and two stimulating electrodes in the OB. After recovery, the rat was placed in a conditioning box for 30 min on three baseline days, differentially conditioned with 5 CS+ e-odor/footshock and 25 CS- e-odor stimuli on the 4th day, and tested with 5 CS+ and CS- stimuli on the 5th day in a new context. CS+ and CS- were delivered (100Hz, 4 pulse trains, 160ms inter-train interval, 2 sec total stimulation) via different electrodes located 1mm apart in the OB. During the 4 hours post-training at least 20 CS+ stimuli were delivered during either SWS or waking, as monitored with EEG and EMG. On the test day, freezing responses to the CS+ and CS- were examined. The results suggest that CS+/CS- e-odor stimulation supports differential fear conditioning. Furthermore, CS+ e-odor stimulation during post-conditioning SWS enhances fear memory, while the same stimulation during waking slightly reduces (extinguishes) memory — consistent with odor replay during SWS. Acknowledgements: NIDCD, DC03906

#P232 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Functional connections of the medial amygdala and response to chemosignal salience

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In rodents, the vomeronasal organ detects conspecific and heterospecific chemosensory signals and relays information to the accessory olfactory bulb and medial amygdala. The anterior and posterior medial amygdala (MeA, MeP) project to preoptic and hypothalamic areas involved in social behavior. In mice, immediate early gene FRAs expression in MeA increases for conspecific and heterospecific stimuli. In MeP, conspecific reproductive stimuli increase FRAs expression in the dorsal division, while a predatory heterospecific stimulus activates the ventral division. Similar results are seen in hamsters, although a response to predatory odors has not yet been identified. The main intercalated nucleus (m-ICN), a group of mostly GABAergic neurons lateral to MeP, may modulate MeP activation, preventing response to non-relevant stimuli. For heterospecific stimuli, the hamster m-ICN is active while MeP is suppressed and the inverse is true for responses to some conspecific stimuli. Responses in medial amygdala may represent an evaluation of chemosensory signals, categorizing stimuli based on salience. The immediate early gene expression data suggest m-ICN is involved in shaping MeP response. Preliminary slice electrophysiology results also suggest a functional connection between m-ICN and MeP, in that stimulation of m-ICN leads to inhibition of MeP neurons. Given that MeP activates for unlearned relevant odors, changing the relevance (with conditioning) may change activation within MeP and modulation by m-ICN. Basolateral amygdala (BLA) is known to be activated by conditioned odors and can be used as a positive control. Preliminary results confirm the established effect of training in BLA and suggest odor conditioning may decrease MeP activation. Acknowledgements: Supported by NIDCD grants R01-DC005813, T32-DC000044 and FSU Neuroscience Program Fellowship

#P233 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Short-term Synaptic Plasticity Contributes to Differential Cortical Population Responses to LOT Stimulation that Mimics Passive or Active Respiratory Frequencies

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This study focuses on how short-term plasticity at synapses between mitral/tufted (M/T) cells and cortical neurons influences population activity in the piriform cortex. We are particularly interested in population responses to LOT stimulation at timescales that mimic olfactory bulb input during passive breathing or active sniffing. We hypothesize that LOT stimulation using burst stimuli (40 Hz) delivered at 2 Hz (passive breathing) or 8 Hz (active sniffing) produces differential population responses. Furthermore, these differences are correlated with the type of short-term plasticity expressed at M/T-to-cortical neuron synapses. To assess population activity, piriform cortex slices (n=13) were loaded with the calcium indicator, Oregon Green Bapta-1. The slices were then

activated by suprathreshold LOT stimulation such that the imaged calcium transients were due to action potentials in individual neurons. In each slice, a significantly greater number of cortical neurons responded to 2 Hz (10 ± 5) versus 8 Hz (5 ± 3, $p<0.01$) stimulation. Typically, neurons that spiked during 8 Hz stimulation also responded to 2 Hz stimulation (n=60), while additional neurons responded solely to 2 Hz stimulation (n=70). Following population imaging, targeted patch clamp recordings were made from neurons that responded to both stimuli (2 Hz and 8 Hz) or solely to 2 Hz stimulation. Cells that spiked in response to both stimuli received facilitating synaptic input during subthreshold LOT stimulation (n=9). Cells that responded solely to 2 Hz stimuli received depressing synaptic input (n=10). These results suggest that short-term plasticity at LOT synapses contributes to differential cortical population responses to stimuli delivered at passive (2 Hz) versus active (8 Hz) respiratory frequencies. Acknowledgements: NIDCD: R03DC011375 to AMMO, R01DC0005798 and R01DC011184 to NNU

#P234 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

TRP channels underlie temperature-mediated changes in responses of Geniculate Ganglion neurons to chemical stimulation in rats

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In our prior studies we showed that stimulus temperature influenced the response patterns of geniculate ganglion (GG) neurons to the basic taste stimuli. To determine the contribution of the transient receptor potential (TRP) channel to coding, we recorded stimulus-evoked lingual potentials (electrogustogram; EGG) simultaneously with single-cell 2.5-s neural responses from 12 narrowly tuned (5 NaCl-best; 5 MSG-best; 2 sucrose-best) and 15 broadly tuned (10 citric acid-best, 5 NaCl generalist) GG neurons. We adapted the tongue at two different stimulus temperatures of 20° and 35° C and recorded EGG and GG neuron responses to 100 mM NaCl, 100 mM MSG, 500 mM sucrose, 10 mM citric acid, 20 mM quinine HCl, and 100 mM KCl at two different stimulus temperatures of 18°- 23° and 25°- 38° C with a two-channel temperature control system. Additionally, we used Ruthenium Red (20-50 μM) as a nonspecific antagonist of TRPV channels. Artificial saliva (15mM NaCl, 22mM KCl, 3mM $CaCl^2$, 0.6mM $MgCl^2$) served as the rinse solution and solvent for all taste stimuli. Our preliminary results show that the addition of Ruthenium Red (50 μM) to the rinse solution altered the responses of broadly tuned GG cells (13 from 15 cells) adapted to 35°C, but did not alter their responses when adapted to 20°C. The effect of Ruthenium Red was reversible as normal responses were restored after 5-8 min of control rinse. The Ruthenium Red did not change the responses of narrowly tuned cells (11 from 12). Only TRPV3 and TRPV4 from TRPV subfamily are active at 27°- 35° C. The present results suggest the participation of vanilloid channels in coding taste quality information by the peripheral gustatory system. Acknowledgements: NIH grant R01 DC004785

#P235 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Delayed effects of lipopolysaccharide ingestion on peripheral taste function

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Lipopolysaccharide (LPS) is an endotoxin derived from Gram-negative bacteria, which are frequent contaminants of food and water. We tested whether LPS modulates taste input to the CNS by recording chorda tympani nerve (CT) responses to taste stimuli in C57BL/6 mice. First, we recorded CT responses before and after 10 min lingual application of LPS (10ug/ml). LPS (5ug/ml) was also present in the diluent of tastants applied during the second series. Acute treatment with LPS did not alter the magnitude of CT responses. Next, we provided water-deprived mice with 12 hr access to LPS (10ug/ml) diluted in 5% sucrose, or sucrose alone. CT recordings were then performed at day 1, 7, or 14 days after LPS ingestion. At day 1 post-ingestion, responses to salt, bitter, umami, and sour stimuli were similar between groups. However, at day 7, neural responses to 0.50 M and 1.0 M sucrose were significantly reduced in mice that drank LPS compared to controls. Mice that drank LPS mixed in 0.15 M NaCl also exhibited reduced CT responses to sucrose, indicating that the effect is dependent on LPS rather than the vehicle. CT responses returned to normal by day 14 after LPS ingestion. A transient drop in sweet signals to the CNS, perhaps via downregulation of T1R2 and/or T1R3 in taste cells, may reduce the appeal of endotoxin-tainted nourishment. Acknowledgements: NIDCD DC005811

#P236 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Capsaicin given orally in moderate doses does not produce edema in rat tongue tissue

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Capsaicin, the chemical irritant that gives peppers their characteristic spicy heat, is commonly consumed around the world as a daily component to many animal and human diets. Capsaicin is known to cause damage to TRPV1 receptors and thus provides an ideal natural approach to assessing damage and recovery in the taste system (Nagy, Santha, Jancso & Urban, 2004). Earlier work from our laboratory examined the effects of 1 ppm capsaicin on taste bud volumes (Samson & Sollars, 2010). This work produced interesting though variable results, thus we sought to determine the potential source of the variance. Evans Blue dye was used to examine whether a slightly higher level of capsaicin (5 ppm) causes acute localized edema. Previous research identified capsaicin-related swelling in rats at much higher dosages (100 ppm) and was proposed as a potential cause for the taste differences seen with frequent users of capsaicin (Simons, Boucher & Carstens, 2003). Thus identification of whether swelling occurs in animals treated with a much lower dose provides clarification as to whether the variance in our previous study may have been produced by the dose of capsaicin used and allows us to consider using a higher dose of capsaicin to examine effects on taste buds. Edema was tested by injection of Evans Blue followed by capsaicin application to the tongue and perfusion. Capsaicin at 5 ppm (in ethanol) did not cause

edema of the tongue during acute exposure and looked similar to control tissue in which only ethanol was applied. As a positive control, capsaicin at 100 ppm in ethanol was applied and produced widespread staining with Evans Blue, indicating edema. Results of taste bud volumes from tongue tissue in animals given 5 ppm capsaicin solution (e.g. a higher dose than earlier work) will be also be presented.

#P237 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Vertebrate Bitter Taste Receptors

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Vertebrate bitter taste perception is facilitated by a variable number of bitter taste receptor (*Tas2r*) genes. Whereas many vertebrate species, including humans, possess average numbers of *Tas2r* genes, some species fall below or exceed this number by far. At the extremes, species can have as few as 3 functional *Tas2r* genes, such as chicken, and as many as ~50 *Tas2r* genes in frogs. In humans, the repertoire of Tas2rs consists of 3 broadly tuned receptors and several receptors with a limited range of agonists in addition to those receptors exhibiting an average breadth of tuning. To elucidate whether extreme low or high numbers of functional *Tas2r* genes rather relate to the average tuning properties of the corresponding receptors or whether they may reflect elevated or reduced importance of bitter taste *per se* in different vertebrate species, we performed functional calcium imaging experiments. We cloned all 3 chicken (*G. gallus*) Tas2rs and 6 Tas2rs of the African clawed frog covering major branches of the phylogenetic tree of *X. tropicalis Tas2r* genes, and screened them with ~50 bitter compounds. Whereas all chicken Tas2rs represent broadly tuned receptors suggesting that a low number of *Tas2r* genes indicate rather wide average agonist spectra, frog Tas2rs differed considerably in their breadth of tuning, ranging from broad to rather narrowly tuned ones. We conclude that a low number of functional *Tas2r* genes can be compensated by an increased average breadth of tuning and, hence, is not necessarily correlated with a reduced importance of bitter taste for the corresponding species. A high number of functional Tas2r genes, however, may allow the generation of more specialized receptors perhaps efficiently protecting a species against specific toxins in addition to broadly tuned "generalist" receptors. Acknowledgements: Supported by the German Research Foundation (DFG (Me 1024/3-2) to WM).

#P238 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Expression and Functional Characterization of Bitter Taste Receptors in Mammalian Testis

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Mammalian spermatogenesis and sperm maturation are susceptible to the effects of internal and external factors. However, how male germ cells interact and respond to these elements including those potentially toxic substances is poorly understood. Here we show that many bitter taste receptors (T2rs), which are believed to function as gatekeepers in the oral cavity to detect and innately prevent the ingestion of poisonous bitter-tasting compounds, are expressed in mouse seminiferous tubules. Our *in situ* hybridization results indicate that Tas2r transcripts are expressed postmeiotically. Transgenic studies with mouse lines generated using the promoter of the mouse bitter taste receptor gene *Tas2r105* confirmed their expression in the haploid germ cells. Furthermore, the expression of a toxin protein, diphtheria toxin A (DTA), driven by the Tas2r105 promoter, led to the ablation of nearly all spermatozoa, indicating that many but not all spermatogenic cells expressed Tas2r105. Functional analysis showed that wild-type spermatids and spermatozoa responded to both naturally occurring and synthetic bitter-tasting compounds by increasing intracellular free calcium concentrations. In congruency with the Tas2R105 expression pattern, the majority of spermatids and sperm cells were responsive to this receptor's agonist cycloheximide. Nevertheless, individual male germ cells exhibited different ligand-activation profiles, indicating that each cell may express a unique subset of T2r receptors. Taken together, our data strongly suggest that male germ cells, like taste bud cells in the oral cavity and solitary chemosensory cells in the airway, utilize T2r receptors to sense chemicals in the milieu and that the outcome may affect spermatogenesis and fertilization.

#P239 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Molecular Mechanism for the Sweet Taste Enhancer Selectivity

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Sweet taste enhancers have been developed at Senomyx to reduce dietary sugar intake for human health benefits. Sucralose enhancer **SE-2** and sucrose enhancer **SE-3** have been used as tool molecules to understand the mechanism of these positive allosteric modulators (PAMs) for the sweet taste receptor, which may also apply to other family C GPCRs. Our mutagenesis studies of the human sweet taste receptor have identified a group of shared residues in the T1R2 VFT domain that are required for the enhancement activity of both PAMs. However, the molecular mechanism for the selective effect of these small molecules on sucralose and sucrose remains unclear. Here for the first time, we have identified new key residues in the T1R2 VFT domain required for the selectivity of these PAMs. **SE-2 and SE-4** (a more potent sucrose enhancer) require different sets of pincer residues for their selective enhancement effects on sucralose and sucrose. The differential binding mode of these small

molecules on the receptor may establish the interactions with different sweeteners during a cooperative binding process for sweet taste enhancement. Our data provide some molecular evidence for the mechanism of PAM selectivity on the human sweet taste receptor.

#P240 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Logic of glycerol input to behavioral output in *Drosophila*

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In Drosophila, sweet taste recognition is mediated by Gr5a and Gr64a that belong to a highly conserved clade within a large family of Gustatory receptors (Gr)s. Other receptors in this clade are also expressed in sweet-sensing neurons, but their function is poorly understood. Moreover, little is known about how stimuli such as beer, typically not rich in sugars, trigger highly attractive gustatory responses in Drosophila. We recently found that Gr64e, a receptor in the sweet clade, plays an essential role in feeding preference for beer and yeast fermentation products. We identified that Gr64e is necessary for neuronal and behavioral responses to an abundant component of yeast and fermentation products, glycerol. Moreover, ectopic expression of the Gr64e receptor in the CO_2-sensing olfactory neuron is sufficient to confer glycerol sensitivity. Drosophila species that carry a polymorphism disrupting Gr64e function have reduced behavioral preference for beer, suggesting that Gr64e may contribute to specific evolutionary variations in appetitive selectivity. Expression analysis shows that Gr64e-GAL4 broadly labels multiple classes of taste neurons displaying distinct representation patterns in the brain. This observation presents an opportunity to dissect the behavioral contribution of subsets of glycerol-sensing neurons by selectively silencing or rescuing Gr64e subpopulations using a collection of sweet Gr promoter-GAL4 drivers. We have already tested a number of different neuronal subsets and are now constructing transgenic tools for finer manipulations. Our studies will enable us to map specific aspects of feeding behavior to glycerol taste circuits, and reveal the extent to which the temporal sequence of sensory neuron activation in different taste organs plays a role in feeding behavior.
Acknowledgements: Whitehall Foundation (2010-12-42) and NSF-IGERT in Video Bioinformatics (DGE0903667).

#P241 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Spatiotemporal Coding in Gustatory Receptor Neurons

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The gustatory system allows animals to perceive a vast array of chemical tastants, and to use this information to guide behavior. Despite its vital role, it remains unclear how gustatory information is processed by successive populations of neurons within the brain. We are studying this question in an insect, the moth *Manduca sexta,* which is capable of complex gustatory behaviors but possesses a relatively simple nervous system. To explore how gustatory information is represented within the population of gustatory receptor neurons (GRNs) and within their follower neurons we designed a novel apparatus that delivers pulses of tastant at different concentrations with temporal precision. This device allowed us to make the first intracellular recordings from GRNs. GRNs vary greatly in levels of spontaneous activity, and in responsiveness to the number, identity, and concentration of tastants. Tastant application excites some GRNs, inhibits others, and causes still others to respond with reliable sequences of excitation and inhibition. Interneurons immediately downstream from the GRNs remain uncharacterized. To understand how the tastant responses of GRNs are integrated and possibly reformatted downstream, we are also recording from and morphologically characterizing neurons in the Sub Esophogeal Ganglion, the primary gustatory center of the moth. Gustatory interneurons exhibit a wide range of tastant response profiles that include temporally complex firing patterns with multiple periods of excitation and inhibition. Our results suggest that the early gustatory system, like the olfactory system, employs an across fiber pattern code that utilizes time as well as neural identity as variables to encode the identity and concentration of tastants.
Acknowledgements: intramural grant from NIH–National Institute of Child Health and Human Development (NICHD)

#P242 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Topology and Functional Analysis of BmGr8, a Bombyx mori Gustatory Receptor

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"Sugar" and "bitter" receptors comprise two large clades in insect gustatory receptor (GR) phylogeny. Based on homologies with identified receptors, we identified five sugar receptors and a large number of putative bitter receptors from the genome of the lepidopteran *Bombyx mori*. Despite almost 60 putative sugar GRs being identified across all sequenced insect genomes, ligands have only been assigned to a few of the Drosophila and one of the *B. mori* receptor sequences. BmGr8, a silkmoth gustatory receptor from the sugar receptor subfamily, was expressed in insect cells. Functional analysis, using a modified calcium-imaging assay, showed that BmGr8 can function independently in Sf9 cells and

that it responds specifically and in a concentration-dependent manner to inositol, an essential nutrient for *B. mori.* The selectivity of BmGr8 responses is consistent with the known responses of one of the gustatory receptor neurons in the lateral styloconic sensilla of this species. Insect gustatory receptors are predicted to have seven-transmembrane domains. They are distantly related to insect olfactory receptors, which have an inverted topology compared with G-protein coupled receptors. We have now determined that the transmembrane topology of BmGr8 is the same as that of insect olfactory receptors and different from that of mammalian olfactory and gustatory receptors. We also found that an orphan receptor from the 'bitter' receptor subfamily, BmGr53, has the same topology as BmGr8. This is the first time that the topology of any insect gustatory receptor has been determined. Zhang, H. J.; Anderson, A. R.; Trowell, S. C.; Luo, A. R.; Xiang, Z. H.; Xia, Q. Y., Topological and functional characterization of an insect gustatory receptor. PLoS One 2011, 6(8): e24111. Acknowledgements: "This work was supported by a grant from the the National Natural Science Foundation of China (30972147), the Ministry of Education of the People's Republic of China Program for Changjiang Scholars and Innovative Research Team in University (No. IRT0750), CSIRO and the Doctoral Innovation Fund of Southwest University (kb2008002).

#P243 **WITHDRAWN**

#P244 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Taste representations in the lateral hypothalamus emphasize palatability

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The lateral hypothalamus (LH) is known to be critically involved in regulating feeding behavior (Boyle, 1975). Because our desire to eat is affected by how our food tastes, and because LH is extensively interconnected with canonical regions of the gustatory circuit (Lei, 2008; Cho, 2003), LH is likely to participate in taste processing, especially regarding palatability. We characterized the taste response properties of LH neurons via single-unit recordings in awake rats during the delivery of a pseudo-randomized sequence of five tastants: 300 mM sucrose, 150 mM sodium chloride, water, 10 mM citric acid, and 2 mM quinine hydrochloride, which range from highly palatable to unpalatable. Out of a total of 128 neurons, 47% (n=60) produced statistically distinguishable responses ($p<0.01$, ANOVA) to different tastants. A closer examination of the time course of the taste responses of these 60 neurons revealed a succession of epochs that reflect separate qualities of the tastant, a dynamic representation of the sensory experience reminiscent of what has been observed elsewhere in the gustatory circuit, including in the insular cortex (Katz, 2001) and the basolateral amygdala (Fontanini, 2009). Unlike the other two regions, however, LH neurons proceed through only two epochs—initial responses signaled the non-specific presence of a tastant on the tongue, and subsequent firing encoded the palatability of said tastant. Finally, palatable and unpalatable tastants preferentially activate non-overlapping LH subpopulations with distinct dynamics: palatable tastants reliably evoked much more transient responses than unpalatable tastants. We conclude that the lateral hypothalamus is a dedicated region for processing palatability, but that its role may differ for palatable versus unpalatable stimuli. Acknowledgements: R01 DC7703 and T32 NS007292

#P245 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Dietary exposure to sucrose solutions alters taste-mediated licking for sweeteners, but not taste-evoked neural responses of the NST in mice

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Following dietary exposure to sugar solutions, most strains of mice exhibit increased intake of and preference for sweeteners. In addition, some (e.g., 129) but not all (e.g., C57BL/6) strains of mice exhibit increased motivation to obtain sugar solutions. The neurobiological bases of these exposure-induced changes in sugar responsiveness are poorly understood. We asked whether they are mediated (at least in part) by enhanced orosensory responsiveness. In Experiment 1, we examined short-term licking responses of two mouse strains (129X1/SvJ [129] and C57BL/6 [B6]) to two solutions (0.5 M sucrose and 19 mM saccharin) following 3 days of exposure to a diet supplemented with 0.5 M sucrose solution (experimental) or water alone (control). There was no effect of diet treatment on the rate at which the mice licked for the sweetened solutions. However, there was a significant effect of exposure type on the number of 5 s trials initiated during the 30 min test sessions. The experimental 129 mice initiated significantly more trials than controls for both sweetener solutions, whereas the experimental B6 mice initiated significantly fewer trials than controls. In Experiment 2, we asked whether these behavioral changes were associated with altered perception of sweet taste intensity. To this end, we compared taste-evoked multi-unit responses of the nucleus of the solitary tract (NST) to the sweetener solutions across experimental and control mice. There was a significant effect of mouse strain, but not of dietary exposure regime, on taste-evoked NST responses to sucrose. This indicates that the exposure-induced changes in licking for sweeteners were not mediated by changes in early taste processing. Instead, they may reflect altered central reward pathways in the ventral forebrain.

#P246 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Accounting for trial-to-trial variability unmasks a sudden transition to palatability coding in gustatory cortex

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Single neurons in the rodent insular cortex respond to the delivery of natural rewards with time-varying firing rate patterns. Distinct epochs of these responses correlate with different stimulus properties, with one response epoch faithfully reflecting how these animals value each stimulus. With detailed modeling, it has become clear that these responses are not perfectly stimulus-locked, and some trial-to-trial variability may mask when and how strongly this value-based coding appears in cortex. To explore this, we modeled our cortical ensembles as sequences of ensemble rate-states through hidden Markov modeling (HMM), and have found that by aligning neural responses to the onset of one of these rate-states, the onset of palatability coding in single neurons and in the population at-large appears more suddenly and stronger than without this realignment. Acknowledgements: This work was supported by National Institutes of Health/National Institute on Deafness and Other Communication Disorders Grants R01DC00945, R01DC007703, F31DC009955, and the Swartz Foundation.

#P247 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Neuroanatomical maps of sweet and umami taste in the mouse PBN

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Umami and sweet taste share common transduction mechanisms, including the T1R family of taste receptors. We sought to characterize whether or not these peripheral commonalities lead to similar patterns of neuronal activation in the parabrachial nucleus (PBN) of male and female C57BL/6J (B6) mice. Sweet and umami taste stimuli, including sucrose, saccharin, monopotassium glutamate (MPG), + inosine monophosphate (IMP), an MPG+IMP mixture, and deionized water were administered via an intraoral cannula in a 20 minute taste reactivity test. These tests were videotaped, and the pattern of ingestive behavior was reviewed and scored at a later time following testing. Two hours after the start of behavior, mice were perfused and immunohistochemistry for the immediate early gene protein c-Fos was performed. C-Fos positive nuclei were mapped and quantified throughout the span of the mouse PBN shown to possess taste-activated neurons. Generally, each stimulus evoked c-Fos in the caudal PBN, including the medial, waist and ventral lateral subnucleus. The sweet stimuli and the MPG-IMP mixture also elicited robust c-Fos at an intermediate level in the lateral area, including a dense cluster of activated neurons in the dorsal lateral (dl) subnucleus. This close correspondence between sweet and "synergistic" umami mixtures supports the idea that these particular stimuli evoke a similar perception in mice. Acknowledgements: NIH DC000353 (J.D.B.)

#P248 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Mapping central representation of MSG taste in the nucleus of the solitary tract using mice that lack the T1R3 receptor subunit important for sweet and umami taste

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The sense of taste is intimately associated with the regulation of food intake. Yet, little is known regarding how loss of taste input may reorganize the way taste information is represented in the central nervous system. Particular taste qualities tend to activate distinct subdivisions of the nucleus of the solitary tract (nTS), as determined by patterns of c-Fos activation. For example, MSG preferentially activates cells within medial and mid subregions of the nucleus. Our previous study (Stratford and Finger, 2010) showed that complete loss of taste input into the brainstem (via genetic deletion of the P2X2/P2X3 receptor subunits) resulted in loss of quality- specific representation within the nTS. Thus, in the absence of taste information, orosensory representation in the nTS is reorganized. However, whether similar brainstem reorganization occurs following loss of specific taste modalities (e.g. sweet, salty, bitter, sour, umami) is unknown. Therefore, our current study measured changes in nTS coding space following a combined loss of sweet and umami sensory input induced by deletion of the T1R3 subunit. We found that MSG-induced (a combination of Na+ and umami) c-Fos expression was reduced in T1R3 knockout mice (T1R3 KO) as compared to WT mice- particularly in areas we previously identified as being glutamate-responsive. In contrast, c-Fos patterns evoked by citric acid were similar between WT and T1R3 KO mice. Together, these results suggest that loss of specific taste modalities may result in a corresponding loss of central representation within in the brainstem. Further investigation is required in order to test whether there is a systematic remapping of taste quality in the nTS of mice in which specific taste modalities are genetically deleted. Acknowledgements: Supported by NIH grants to TEF and JMS.

#P249 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Effect of Leptin on Neurons of the Rostral Nucleus of the Solitary Tract and Potential Roles for Primary Cilia

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Leptin, secreted by adipocytes, acts on CNS neurons to modulate energy balance. For example, in the hypothalamus ciliated neurons respond to circulating leptin to produce melanocyte-stimulating hormone which inhibits feeding. Because the rostral nucleus of the solitary tract (rNST) is a critical brainstem nucleus that processes gustatory signals important in feeding, we investigated: location and number of ciliated neurons in rNST; presence of receptors associated with feeding effects of leptin in rNST; colocalization of leptin receptors and cilia in rNST neurons; and, responses to leptin in rNST neurons. Cilia are present on the majority of adult mouse and rat rNST neurons and rNST cilia stain positively for somatostatin receptor 3 and melanin concentrating receptor 1, both known to be important in feeding control. In addition, the leptin receptor OB-Rb colocalized with rNST cilia. The effect of leptin on biophysical properties of rNST neurons was examined using patch-clamp recording in horizontal brain slices. Bath application of leptin (100 nM) resulted in membrane hyperpolarization in 40% of rNST neurons tested, depolarization in a further 5%, and no effect in the remaining neurons. Leptin inhibited the frequency of depolarization-induced action potentials in 55% of rNST neurons but did not alter the amplitude of excitatory postsynaptic currents initiated by stimulation of the solitary tract. Superfusion of TTX, and the synaptic blockers CNQX, APV and bicuculline had no effect on leptin initiated changes in membrane potential demonstrating that leptin did not influence synaptic transmission. The results suggest that leptin might act on receptors on rNST neuronal cilia to modulate transmission of taste initiated signals to higher brain centers important in the control of feeding behavior. Acknowledgements: NIH NIDCD Grant DC000288

#P250 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Retronasal Olfaction/Taste (Volatiles/Sweetness) Interactions in Tomatoes

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Interactions between retronasal olfaction and taste have been of interest for many years for practical as well as theoretical reasons. The mechanisms underlying these interactions are not well understood and indeed, multiple factors are likely involved. We have been particularly interested in altering retronasal olfaction by removing taste (e.g., anesthesia, gymnema sylvestre). Most recently, we have begun to study the contributions of retronasal olfaction to taste in natural products. Tomatoes with known chemical variation were grown at the University of Florida. Sugars as well as 61 volatiles were chemically assessed and sensory characteristics (including sweetness and flavor intensity) were psychophysically assessed. Multiple regression showed that flavor made a contribution to sweetness that was independent of the contribution associated with sugars ($p<.0001$). Evaluation of each volatile showed that 7 of the 61 made contributions to sweetness that were independent of those made by sugars (at least $p<.05$). Those volatiles were neral (lemon), 4-carene (woody, sage, thyme), 1-nitro-2-phenylethane (cinnamon), isopentyl acetate (juicy fruit, banana), 3-methyl-1-butanol (whiskey), 6-methyl-5-hepten-2-ol (green, coriander), isovaleric acid (cheesy, sweaty). One of the attributes of retronasal olfaction/taste interactions that has been considered is the "congruence" of the odorant and tastant. "Congruence" is roughly defined to mean the degree to which the two are commonly experienced together (e.g., orange and sweet). Some of the tomato volatiles noted above are congruent with sweet but others are not (4-carene, 6-methyl-5-hepten-2-ol, isovaleric acid). Further studies like this using natural products may lead to new insights about the rules governing retronasal olfaction/taste interactions. Acknowledgements: University of Florida Research Foundation, Florida Agricultural Experiment Station

#P251 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

The effects of stimulus intensity on retronasal odor enhancement by taste

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It was recently reported that enhancement of retronasal odors by tastes is a more pronounced and reliable effect than enhancement of tastes by odors. However, the degree of odor enhancement also varied and appeared to be greater when the perceived intensity of the odor was weak rather than strong. The present study was therefore designed to investigate how the intensity of odors and tastes affects the degree of retronasal odor enhancement. In the first experiment Ss sampled aqueous solutions of two test odors (citral, furaneol) at three concentrations with different levels of sucrose (0, 0.18, 0.32, 0.56M) and rated the perceived intensities of sweetness, sourness, saltiness, bitterness and "other" on the gLMS. The addition of sucrose significantly enhanced ($p<.05$) the perceived intensity of both odors (i.e., "other" ratings) to an extent that was inversely related to their perceived intensities alone. Interestingly, increasing sucrose concentration beyond 0.18M did not necessarily produce further increases in odor enhancement. To assess the reliability of the odor intensity relationship, a follow-up study was conducted in which Ss inhaled three concentrations of citral in vapor phase via the mouth while tasting a fixed concentration of sucrose (0.32M). Consistent with the prior results, the presence of sucrose in the mouth significantly enhanced citrus odor ratings compared to when the citral odor was inhaled alone ($p<.001$). Again, the degree of odor enhancement, however, became smaller and insignificant as the perceived intensity of citral by itself became stronger. These findings confirm that sucrose can enhance weak, congruent retronasal odors in a manner that may serve to strengthen the salience and thus the flavor identity of nutritive foods. Acknowledgements: Supported by OSU start-up funds and R01 DC005002

#P252 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Olfactory sensing of glutamate and its modulation by hunger and satiety signals in humans

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Monosodium glutamate (MSG), a derivative of glutamate acid and a naturally occurring nutrient, contributes to umami, one of the five basic tastes, and signals amino acids. While glutamate plays an important role in taste, little is known about its role in olfaction. A special class of glutamate receptors has been identified as olfactory receptors in the fruit fly and the Protostomia but whether it exists in other animals is not known. Using triangular triple-forced-choice discrimination tasks, we show that MSG (≥99%, Sigma-Aldrich) dissolved in purified water has an olfactory property that is detectable by the nose. Moreover, olfactory sensing of MSG is independent of either retronasal olfaction or trigeminal stimulation. We subsequently assess subjects' olfactory threshold of MSG, several other tastants, and a non-tastant control, both after fasting and after satiation. We show a significant enhancement of olfactory sensitivity following fasting that is unique to MSG. Taken together, our findings show that basic tastes carry orthonasal olfactory properties and offer the tantalizing evidence that olfactory glutamate receptors also operate in humans.

#P253 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

The roles of congruency and nutritive vs. non-nutritive tastes in taste-odor interactions

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Previous studies in our laboratory have shown two types of taste-odor interactions: odor enhancement by taste and odor referral to the mouth. The study findings have suggested that the presence of a nutritive taste that is also congruent with an odor is a necessary condition for both phenomena. However, the previous studies used odors that were primarily congruent with a nutritive (sweet or salty) taste. The present study therefore investigated the role of the nutritive status of tastes in both taste-odor interactions using odors that are congruent with a non-nutritive taste (bitter or sour). Coffee and citrus odors were presented alone or with sucrose, CA, or caffeine. In three separate sessions, 24 Ss 1) rated the perceived intensities of sweetness, sourness, bitterness, and specific odor in a sip-and-spit procedure; 2) reported the perceived locations of odors after inhaling odors through the mouth alone or in the presence of either water or tastes in the mouth; and 3) rated the congruency of tastes and odors. The results showed that only sucrose significantly enhanced the perceived intensities of citrus and coffee odors (Tukey test, $p<0.05$), while other tastes (caffeine, CA) failed to enhance or even suppressed the odors. However, congruent tastes significantly increased localization of odors to the tongue (χ^2, $p<0.05$), independent of nutritive status. These findings suggest that taste-odor congruency is a necessary but not sufficient condition for retronasal odor enhancement. In contrast, taste-odor congruency is the only requirement for retronasal odor referral, and the degree of congruency modulates the degree of odor referral to the mouth. The implications of the study findings will be discussed in terms of the cognitive and perceptual factors of flavor perception.

#P254 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Influence of Color and Viscosity on Milk Pleasantness and Intensity Ratings in Disordered Eaters

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While previous research on viscosity and taste perception tends to be in agreement, the research on color and taste perception exhibits a tremendous amount of inconsistency. Possible reasons for this inconstancy are the multi-modal nature of gustation and possible confounds, such as level of disordered eating, which are rarely accounted for. The purpose of the present study was to evaluate the effect of both color and viscosity on the pleasantness and intensity ratings of milk, while taking level of disordered eating into account. Thirty-eight participants (22 male, 16 female) completed the study. The stimuli were distinct milk samples which varied in color (red, blue, brown, white) and viscosity (skim, 2%, whole), which led to 12 possible combinations. Food-neophobics (those individuals who are unwilling to try new foods) rated milk as less pleasant and more intense, as well as consumed less of it, when compared to food-neophilics (those individuals who are particularly willing to try new foods). However, the significant pleasantness and intensity ratings were found to disappear when Food Neophobia Score was used as a covariate, suggesting that significance within the data relied upon whether an individual was classified as food-neophilic or food-neophobic. While this does not provide an all-inclusive explanation for the past ambiguity, it does open up a new direction for future research on the multi-modal influences of taste perception where level of disordered eating should remain a covariate.

#P255 **POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION**

Trigeminal stimuli influence perception of olfactory stimuli

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Although most common odors target both, the olfactory and the trigeminal system, little is known about the influence of the trigeminal system on the perception of olfactory stimuli. With this in mind we examined the influence of a pure trigeminal (CO2) stimulus on the intensity perception of a pure olfactory stimulus (PEA). The stimuli were presented in pairs (containing a CO2 and a PEA stimulus) using the Burghart olfactometer OM6.b. Duration of one stimulus was set to 400ms. Forty normosmic subjects, 29 female, 11 male, age range: 20-32 years (mean: 24.95 SD 3.13) participated in the study. To ensure that subjects were normosmic, every subject was tested with the "Sniffin' Sticks" 16 odor identification test: range: 13-16 (mean: 14.60 SD 1.08). The study consisted of three parts: Part one: Both stimuli were presented at the same time. While the PEA stimulus was held constant the

concentration of CO_2 was changed. Second part: To examine the temporal interaction, the two stimuli were presented with an interval of 500 to 2000ms in between. Part three: The duration of the CO_2 stimulus preceding the PEA stimulus was changed to 1000 to 3000ms. After perceiving both stimuli the subjects were asked to rate the intensity of the odor (PEA stimulus) on a scale from 0 to 100. The results show, that the perceived odor intensity decreases with increasing trigeminal perception. This effect was only seen, when the two stimuli were presented without an interval between them.

#P256 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Influence of background noise on the performance in the odor sensitivity task

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Although we often perceive odors while being exposed to various background sounds, surprisingly little is known about an effect of background sound on odor perception. Recent research has demonstrated that participants' performance in the odor discrimination task was significantly distorted in the presence of background noise compared with a silent condition. This investigation aimed to determine whether background noise can alter participants' performance in a relatively simple odor sensitivity task. The study consisted of three sessions. In each session, participants were instructed to perform the odor sensitivity task (i.e. odor threshold task of the "Sniffin' Sticks" test) in the presence of one of three auditory stimuli: non-verbal noise (e.g. party sound); verbal noise (e.g. audio book); or silence (i.e. no additional auditory stimulus). The order of the sessions was randomly counterbalanced across the participants. Repeated measures analysis of variance revealed that the mean scores of task performance were not significantly different across three auditory conditions at $P < 0.05$. In conclusion, our findings suggest that background noise has no impact on the performance in a simple odor sensitivity task.

#P257 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Multisensory processing of taste and oral temperature in the mouse brain

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Taste neurons in the brain stem can show cross-modal capabilities, responding to tastants and somatosensory stimuli including changes in oral temperature. Little is known about the role these cells could play in cross-sensory integration related to taste. Integration in multisensory systems is known to involve additivity of unimodal inputs in logical agreement. Here, we studied processing of compound taste and thermal inputs by nucleus tractus solitarii neurons in anesthetized mice and hypothesized that hedonically aligned tastes and temperatures would induce additive responses. Electrophysiological activity was recorded during oral presentation of temperature-varied tastants, including (in mM) 100 sucrose, 30 NaCl, 3 HCl, 3 quinine, an umami stimulus, and purified water tested at 16, 18, 22, 30, and 37 °C. Stimulus and temperature interacted to shape the response properties of 18 of 22 neurons ($P < 0.05$) and effects were stimulus specific. Warmth (30 ºC) paired with sucrose induced a superadditive response, where bimodal activity was greater than the sum of the component responses ($P < 0.001$). Multiple studies show that rodents prefer warm water to cool (Kapatos and Gold, 1972; Gold, 1976). No additivity was found between warmth and aversive tastants, such as quinine ($P = 0.2$). Analyses of response time course over multiple trials showed parings of cooling and warmth with taste stimuli respectively delayed or accelerated response onset. Studies of multisensory systems show cross-modal stimuli frequently shift response latency. Thus, classically defined taste neurons show cross-modal receptive fields, where responses to taste stimuli depend on somatosensory context. Our finding of these effects in brain stem show multisensory interactions involving taste begin early along the neuraxis. Acknowledgements: NIH DC011579 (C.H.L.)

#P258 POSTER SESSION VI: OLFACTION CNS; TASTE PERIPHERY & CNS; MULTIMODAL RECEPTION

Food Hedonics and Sniff Magnitude

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Objective: Sniff magnitude varies depending on olfactory ability and the trigeminal component of the odor being tested. Moreover, sniff magnitude may be influenced by the hedonics towards the odors being tested. It is hypothesized that if hedonically positive, sniff magnitude would be greater than baseline no odor control and if hedonically negative, sniff magnitude would be substantially reduced compared to baseline. **Methods:** Ten subjects, 2 males and 8 females with an average age of 30 years underwent the Sniff Magnitude Test (Frank et al., 2003) while inhaling blank (control) or Sniffin Sticks banana and fish smell. Each participant underwent 3 different measurements per odorant, and the average magnitude was determined. Order of presentation was 1-blank, 2- fish, and 3-banana. Sniff Magnitude Test was performed as per manufacturer's instructions (CompuSniff). **Results:** Subjects rated on Visual Analog Scale (VAS) of 1-10 the bananas as hedonically positive (VAS 8), whereas fish was rated hedonically negative (VAS 1.8). Average sniff magnitude on deep breathing for blank was 33.6, fish 61.9, banana 41.1 ($p=0.003$ fish vs. blank). **Discussion:** Sniff magnitude with deep breathing did not decrease, but rather increased the negative hedonics aromas of fish ($p<0.01$). Pleasant aroma did not change sniff magnitude. Possibly the sniff apnea reflex in response to odor was overwhelmed by cognitive factors (curiosity, etc). Having had experience of negative odor, subjects may have unconsciously assumed negative hedonics to any further tests which may have acted to inhibit sniff magnitude. Moreover, this test was performed with food odors. These findings suggest that sniff magnitude may be refined enough to ultimately be used to assess hedonics of odor independent of subject self-rating. **Source of Funding**: None.

Tolerance for Bitterness in Chocolate Milk is Not Dependent on Detection Threshold

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Bitterness is generally considered a negative attribute in food, yet many individuals enjoy some amount of bitterness in products such as coffee or dark chocolate. In chocolate, bitterness arises from naturally occurring alkaloids and phenolic compounds. Cacao is processed to develop the typical chocolate flavor and aroma. Fermentation and roasting help reduce the extreme bitterness of raw cacao by destroying the majority of these alkaloids and phenolics. As it becomes increasingly common to fortify chocolate products with 'raw' cacao to increase the content of potentially healthy compounds, it will be important to identify the point at which the concentration of bitter compounds becomes objectionable, even to those who enjoy some bitterness. Classical thresholds focus on the presence or absence of a sensation rather than acceptability or hedonics. Here, we sought to quantify and compare differences in Rejection Thresholds (RT) and Detection Thresholds (DT) in chocolate milk spiked with various amounts of sucrose octaacetate (SOA), a highly bitter GRAS additive with no known genetic variation in bitterness. A series of a paired preference tests were used to measure the RT (Experiment 1) and a forced choice ascending method of limits was used to measure the DT (Experiment 2). Participants were segmented on the basis of self-declared solid chocolate preference. For those preferring dark chocolate, the RT was approximately 3 times higher than the RT for those preferring milk chocolate. In contrast, the DT for both groups was functionally identical. This suggests that the tolerance for bitterness in chocolate products may not be based on the ability to detect bitterness in those products. Acknowledgements: Supported by funds from the Pennsylvania State University and the Pennsylvania Manufacturing Confectioners' Association (PMCA).

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Visual Program at a Glance

REGISTRATION
3:30 pm – 8:00 pm

Wednesday, April 25, 2012

REGISTRATION
7:00 am – 1:00 pm
6:30 pm – 7:30 pm

Thursday, April 26, 2012

AChemS Executive Committee Meeting
12:00 p.m. - 3:30 p.m.
Vista Ballroom

Welcome Banquet
(Ticketed event)
6:00 p.m. - 8:00 p.m.
Lighthouse Courtyard

Welcome/Awards Ceremony
8:00 p.m. - 9:00 p.m.
Grand Ballroom Salon D

GIVAUDAN LECTURE:
Neural Control of Aggression in Drosophila
9:00 p.m. - 10:00 p.m.
Grand Ballroom Salon D

POSTER SESSION I:
Multimodal Reception; Chemosensation and Disease; Taste Periphery; Olfaction Periphery
8:00 a.m. - 12:00 p.m.
Huntington Ballroom

SYMPOSIUM:
The Flavor of Things to Come: Expectation and the Processing of Chemosensory Information
9:00 a.m. - 10:45 a.m.
Grand Ballroom Salon D

BREAK
10:45 a.m. - 11:15 a.m.
Grand Foyer

INDUSTRY SYMPOSIUM:
Taste and Smell in Translation: Applications from Basic Research
1:00 p.m. - 4:05 p.m.
Grand Ballroom Salon D

BREAK
2:10 p.m. - 2:25 p.m.
Grand Foyer

NIH WORKSHOP:
Funding Opportunities for the New Invesigator
3:00 p.m. - 5:00 p.m.
Grand Ballroom Salon C

Industry Reception
(Ticketed event)
4:15 p.m. - 6:00 p.m.
California Courtyard

Refreshments Available
7:00 p.m. - 7:30 p.m.

PRESIDENTIAL SYMPOSIUM:
Neural Epigenetics and Olfaction
7:30 p.m. - 10:10 p.m.
Grand Ballroom Salon D

POSTER SESSION II:
Trigeminal System; Taste CNS; Neuroimaging; Olfaction CNS
7:00 p.m. - 11:00 p.m.
Huntington Ballroom

Friday, April 27, 2012

REGISTRATION
7:30 am – 12:00 pm
7:30 pm – 8:00 pm

POSTER SESSION III: Olfaction Development & CNS; Human Psychophysics; Taste Periphery
8:00 a.m. - 12:00 p.m.
Huntington Ballroom

PLATFORM PRESENTATIONS: Olfaction
8:00 a.m. - 9:45 a.m.
Grand Ballroom Salon D

BREAK
9:45 a.m. - 10:00 a.m.
Grand Foyer

SYMPOSIUM: Chemical Senses in Health and Disease
10:00 a.m. - 12:25 p.m.
Grand Ballroom Salon D

AChemS Business Meeting
1:00 p.m. - 2:30 p.m.
Grand Ballroom Salon D

PLATFORM PRESENTATIONS: Polak Young Investigator Award Winners
2:30 p.m. - 4:00 p.m.
Grand Ballroom Salon D

Refreshments Available
3:30 p.m. - 4:00 p.m.
Grand Foyer

JOINT SOCIAL: Chemosensory Enterprise and Mentorship Alliance (ChEMA) with Industry Careers Workshop
5:00 p.m. - 7:00 p.m.
Lighthouse Courtyard

Refreshments Available
7:00 p.m. - 8:00 p.m.
Grand Foyer

SYMPOSIUM: Wiring Neural Circuits in Olfactory Systems
8:00 p.m. - 9:45 p.m.
Grand Ballroom Salon D

WORKSHOP: Considering a Career in Industry? Things Your Mentor Never Told You
4:00 p.m. - 5:00 p.m.
Grand Ballroom Salon D

POSTER SESSION IV: Chemical Signaling and Behavior; Psychophysics; Chemosensation and Disease; Olfaction Periphery; Taste Periphery
7:00 p.m. - 11:00 p.m.
Huntington Ballroom

Saturday, April 28, 2012

REGISTRATION
7:30 am – 12:00 pm
7:30 pm – 8:00 pm

POSTER SESSION V: Trigeminal System; Behavior and Psychophysics; Odorant Receptors & Olfaction Periphery
8:00 a.m. - 12:00 p.m.
Huntington Ballroom

PLATFORM PRESENTATIONS: Taste
8:00 a.m. - 9:45 a.m.
Grand Ballroom Salon D

Refreshments Available
9:45 a.m. - 10:15 a.m.
Grand Foyer

SYMPOSIUM: The Role of Respiration in Olfactory and Flavor Processing
10:00 a.m. - 12:15 p.m.
Grand Ballroom Salon D

CLINICAL LUNCHEON: Bitter Taste, A Major Determinant for Food Preferences
(Ticketed event)
12:30 p.m. - 2:30 p.m.
Vista Ballroom

SYMPOSIUM: Modulation of Early Olfactory Processing by Internal Physiological States
3:00 p.m. - 5:10 p.m.
Grand Ballroom Salon D

POSTER SESSION VI: Olfaction CNS; Taste Periphery & CNS; Multimodal Reception
7:00 p.m. - 11:00 p.m.
Huntington Ballroom

Refreshments Available
7:00 p.m. - 8:00 p.m.
Grand Foyer

IFF LECTURE: Neural and Molecular Mechanisms of Taste Reception, Transmission and Modulation: A Sweet (Taste) Story that Began with Simple Mendel's Law
8:00 p.m. - 9:00 p.m.
Grand Ballroom Salon D

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AChemS

Association for Chemoreception Sciences

35th Annual Meeting

April 17-21, 2013

Hyatt Huntington Beach, CA

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THE
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