AChemS XL

April 16-20, 2018
Hyatt Regency
Coconut Point
Bonita Springs, FL

40th Annual Meeting of the Assocation for Chemoreception Sciences

Printable Program & Abstracts

April 17-20, 2018
Bonita Springs, FL

Monday, April 16, 2018

1:50 - 4:20 PM	Calusa ABC

SATELLITE SYMPOSIUM: CENTRAL MECHANISMS FOR CHEMOSENSORY PROCESSING AND PERCEPTION

Chair(s): Claire Cheetham

1:50 **Welcome & Introduction**
Max Fletcher[1], Daniel Wesson[2]
[1]The University of Tennessee Health Science Center, [2]University of Florida

2:00 **Inhibition And Modulatory Circuitry In The Nucleus Of The Solitary Tract**
Susan Travers, Zhixiong Chen, Kalyan Balasubramanian, Joseph Breza, Joseph Travers
The Ohio State University, Division of Biosciences, College of Dentistry, Columbus, OH, United States

2:20 **Synaptic Organization Of Local Circuits That Determine Input/Output Relationships In The Olfactory Bulb**
Ben W. Strowbridge
Dept. of Neurosciences, Case Western Reserve University, Cleveland, OH, United States

2:40 **Links Between Somatosensory And Taste Processing In Mouse Brain**
Christian Lemon
Department of Biology, University of Oklahoma, Norman, OK, United States

3:00 **Organization And Plasticity Of Olfactory Memory Circuits In Zebrafish**
Thomas Frank, Peter Rupprecht, Nila Moenig, Anastasios Moressis, Rainer W. Friedrich
Friedrich Miescher Institute for Biomedical Research, Maulbeerstrasse 66, 4058 Basel, Switzerland

3:20 **Heterogeneity Of Neuron Types In The Nucleus Of The Solitary Tract Suggests Fluidity In The Neural Code For Taste**
Patricia M. Di Lorenzo[1], Alexander Denman[1], Joshua D. Sammons[1], Jonathan D. Victor[2]
[1]Department of Psychology, Binghamton University, Binghamton, NY, United States, [2]Feil Family Brain and Mind Research Institute and Department of Neurology, Weill Cornell Medical College, New York, NY, United States

3:40 **State-Dependent Balance In Piriform Cortical Inputs And Outputs**
Donald A. Wilson
Department of Child & Adolescent Psychiatry, NYU School of Medicine Emotional Brain Institute, Nathan Kline Institute for Psychiatric Research, New York, NY, United States

4:00 **Sweet Taste And The Human Gut-Brain Axis**
Dana M Small[1,2]
[1]Professor, Department of Psychiatry, Yale University School of Medicine, New Haven, CT, United States, [2]Director, Modern Diet and Physiology Research Center, New Haven, CT, United States

4:20 - 4:40 PM	Calusa Foyer
Coffee Break	

4:40 - 7:00 PM	Calusa ABC
SATELLITE SYMPOSIUM: CENTRAL MECHANISMS FOR CHEMOSENSORY PROCESSING AND PERCEPTION	

Chair(s): Lindsey Schier

4:40 **Modelling Prodromal Parkinson&Rsquo;S Disease By Triggering Alpha-Synuclein Pathology In The Olfactory Bulb**
Patrik Brundin
Van Andel Research Institute

5:00 **Oxytocin In Cortical Control Of Olfactory Perception**
Wolfgang Kelsch
Central Institute of Mental Health, Heidelberg University,, , Germany

5:20 **Cortical And Subcortical Processing Of Gustatory And Cognitive Signals**
Alfredo Fontanini
Departiment of Neurobiology and Behavior - Stony Brook University School of Medicine, Stony Brook, NY, United States

5:40 **Mapping Excitation And Inhibition In The Olfactory Bulb**
Matt Wachowiak
Department of Neurobiology and Anatomy, University of Utah School of Medicine, , UT, United States

6:00 **Modulation Of Piriform Cortex Encoding And Connectivity By Sleep Deprivation**
Thorsten Kahnt
Department of Neurology, Northwestern University Feinberg School of Medicine, Chicago, IL, United States

6:20 **The Role Of Dopamine In Taste Recognition Memory. Implications For Alzheimer'S Disease.**
Federico Bermudez-Rattoni
Department of Cognitive Neuroscience, Institute of Cellular Physiology, National University of Mexico UNAM, , Mexico

6:40 **Mechanosensory-Based Phase Coding Of Odor Identity In The Olfactory Bulb**
Takeshi Imai
Graduate School of Medical Sciences, Kyushu University

Tuesday, April 17, 2018

8:00 - 9:40 AM	Calusa ABC

SATELLITE SYMPOSIUM: CENTRAL MECHANISMS FOR CHEMOSENSORY PROCESSING AND PERCEPTION

Chair(s): Chad Samuelsen

8:00 **Diet And Gut Hormone Signaling Modulate Internal State And Olfactory Processing In The Mouse**
Debra Fadool
Florida State University, Tallahassee, FL, United States

8:20 **Oromotor Circuits For Gustatory Acceptance And Rejection**
Wenfei Han
Yale University, New Haven, CT, United States

8:40 **Synaptic Modulation Of Gustatory Sensory Neurons Underlies Integration Of Tastes And Internal State In *Drosophila***
Michael Gordon
Department of Zoology, University of British Columbia, Vancouver, BC, Canada

9:00 **Navigating Space With Only The Luxury Of Smell And A 6-Fold Compass**
Xiaojun Bao[1], Eva Gjorgieva[1], Laura K. Shanahan[1], James D. Howard[1], Thorsten Kahnt[1], Jay A. Gottfried[1,2]
[1]Department of Neurology, Northwestern University, Feinberg School of Medicine, Chicago, IL, United States, [2]Departments of Neurology and Psychology, University of Pennsylvania, Philadelphia, PA, United States

9:20 **The Integration Of Perception And Action In Single-Trial Taste Cortical Activity.**
Donald B. Katz
Brandeis University Department of Psychology and Program in Neuroscience

9:00 - 1:00 PM	Offsite- Imaginarium Science Center
Outreach Event	

AChemS is pleased this year to be partnering with two schools, both Crestwell School and Discovery Day Academy! Volunteer AChemS Members will be inspiring 3rd and 4th graders from these schools in fun and interactive demonstrations which will illustrate various taste and smell topics. The event will be held at the Immaginarium Science Center, an interactive science museum. We are pleased that AChemS has the good fortune to forge a community connection again, and enlighten and inspire a new generation of chemosensory scientists.

9:40 - 10:00 AM	Calusa Foyer
Coffee Break	

10:00 - 11:40 AM	Calusa ABC
SATELLITE SYMPOSIUM: CENTRAL MECHANISMS FOR CHEMOSENSORY PROCESSING AND PERCEPTION	

Chair(s): Joost Maier

10:00 **Olfactory Bulb And Pyriform Cortex Gamma And Beta Oscillations Define A Cognitive Sequence During Odor Sampling**
Leslie M. Kay
Department of Psychology, Institute for Mind and Biology, University of Chicago, Chicago, IL, United States

10:20 **Investigating Experience-Dependent Plasticity In The Accessory Olfactory Bulb**
Hillary Cansler[1], Julian Meeks[2]
[1]Department of Pharmacology and Therapeutics, University of Florida, [2]Department of Neuroscience, University of Texas Southwestern Medical Center

10:40 **Precision Of Classification Of Odorant Value By The Power Of Olfactory Bulb Oscillations Is Altered By Optogenetic Silencing Of Local Adrenergic Innervation**
Daniel Ramirez-Gordillo[1,2,3], Ming Ma[1,2,3] , Diego Restrepo[1,2,3]
[1]Department of Cell and Developmental Biology, University of Colorado Anschutz Medical Campus, Aurora, CO, United States, [2]Rocky Mountain Taste and Smell Center, University of Colorado Anschutz Medical Campus, Aurora, CO, United States, [3]Neuroscience Program, University of Colorado Anschutz Medical Campus, Aurora, CO, United States

11:00 **Behavioral Approaches To Discerning The Function Of Gustatory Cortex In A Rat Model**
Alan C. Spector
Department of Psychology and Program in Neuroscience, Florida State University, Tallahassee, FL, United States

11:20 **The Mushroom Body And Learning - Flexibly Assigning Valence To Odors**
Glenn Turner
Janelia Research Campus, Ashburn, VA, United States

12:00 - 4:00 PM	Blue Heron
AChemS Executive Committee Meeting (Invite Only)	

5:00 - 6:00 PM	Calusa ABCD
Welcome/Awards Ceremony	

6:00 - 7:00 PM	Calusa ABCD
Givaudan Lecture	

6:00

Brain Systems Of Chemosensory "Liking" & "Wanting": Roles In Addiction
Kent Berridge
University of Michigan

Pleasure “liking” for sensations such as sweetness is an essential psychological function for well-being. Motivational “wanting” for such pleasures is crucial for survival and can normally give zest to life. Yet in addiction, these processes go awry. Recent findings indicate that “liking” for intense pleasure is generated by a frail and tiny network in the brain, whereas “wanting” for pleasures has a much more robust and larger brain generating network. In addiction, hyper-reactive brain systems can create intense “wants” even in absence of any “liking.”

7:00 - 9:00 PM	Pool Deck & Cypress Courtyard
Welcome Banquet (Ticket Required)	

Join us for the traditional AChemS Welcome Banquet, the first opportunity to reconnect with colleagues and kick the meeting off right! Cash bar is available. An RSVP was required at time of registration and your ticket is available on your name badge; additional tickets can be purchased at the Registration Desk.

9:00 - 11:00 PM	Mangroves Patio
Graduate Student Happy Hour	

A relaxed, casual gathering and opportunity to mingle with other graduate students over a cocktail! The patio of Mangroves will be the exclusive gathering spot for this event. Cash bar.

Wednesday, April 18, 2018

7:30 - 9:00 AM	Estero Foyer
Breakfast Corners With Industry	

The Ajinomoto Group's corporate message is "Eat well, live well." This is harmonized with our founding aspiration, "To create good, affordable seasonings and turn simple but nutritious fare into delicacies", from the time we launched our business with umami seasoning AJINO-MOTO® in 1909. Keeping this aspiration in our mind, we are working for R&D to discover taste of the future. In this Breakfast Corner, we will introduce our research grant, "Ajinomoto Innovation Alliance Program" (https://www.ajinomoto.com/en/rd/AIAP/ , coming soon). We stimulate chemosensory research field through "AIAP" and bridge your science to more better life, "Eat well, live well." Please join to the Ajinomoto table for more information about "AIAP"!

8:00 - 10:30 AM	Estero Ballroom
Poster Session I	

D1 **Large Bilateral And Right Unilateral Gustatory Cortex Lesions, Not Left Unilateral Lesions, Significantly Impair Taste Sensitivity To Nacl But Not To Maltrin Or Citric Acid In Rats.**

Michelle B. Bales, Alan C. Spector
Department of Psychology and Program in Neuroscience, Florida State University, Tallahassee, FL, United States

Our prior studies show that bilateral gustatory cortex (GC) lesions significantly impair taste sensitivity to salts and quinine but not to sucrose in rats. Here we extended the range of tastants tested to include the polysaccharide, Maltrin, and citric acid (CA) in rats with ibotenic acid-induced lesions in GC and in sham-operated controls (SHAM). The rats were postsurgically trained and tested in a gustometer to discriminate a tastant from water in a two-response operant taste detection task (n=9-16/surgical group). Psychometric functions were derived separately for each tastant (NaCl, Maltrin, then CA) by lowering the stimulus concentration across test sessions. A mapping system was used to determine acceptable placement and size of left (LGCX) or right (RGCX) unilateral lesions and placement, size, and symmetry of bilateral (BGCX) lesions (89, 91, and 83% damage to GC on average, respectively). For NaCl, there was a significant difference in taste sensitivity between BGCX and SHAM rats indicated by a rightward shift (ΔEC_{50}=0.62 $\log_{10}$ units, p=0.001) in the psychometric function, replicating our prior work, and between RGCX and SHAM rats (ΔEC_{50}=0.48 $\log_{10}$ units, p=0.008). Interestingly, taste sensitivity to Maltrin and CA was not significantly different between lesion and SHAM groups. However, some declines in BGCX performance relative to SHAM rats were evident for higher concentrations of CA (ANOVA; p<0.001). Together with prior results, sensitivity to carbohydrates is unchanged while quinine is modestly and CA is marginally disrupted by complete lesions in GC, and although salts are most affected, even by RGCX, rats perform well at higher concentrations. The extent of impairment appears to depend on taste quality and, clearly, there are other central taste regions that contribute to detection.

D2 **Evaluation Of Brain Function For Congenital Anosmia With Chemosensory Event-Related Potentials And Functional Magnetic Resonance Imaging**

Jia Liu, Xing Gao, Yongxiang Wei, Qianwen Lv, Wei Xiao
Beijing Anzhen Hospital, Beijing, China

Background Congenital deficits in other sensory systems appear to have distinct effects on brain function and structure, but little is known about congenital anosmia.We measured brain activation in response to olfactory stimuli and cerebral processing in patients with congenital anosmia using functional magnetic resonance imaging (fMRI) and chemosensory event-related potentials (ERPs). Our goal was to understand the central manifestations of congenital anosmia. Methods We acquired brain fMRI in response to two olfactory stimuli (phenethyl alcohol [PEA] and common valeric acid [CVA]) and ERPs (olfactory and trigeminal: oERP and tERP) stimulated by PEA and CO_2 respectively from 7 patients with congenital anosmia and from 7 age- and sex-matched controls. Subjective olfactory function was measured by Sniffin' Sticks [SS]. Results Healthy subjects showed brain activity in regions that are associated with olfactory processing (insula, thalamus, limbic lobe, parahippocampal gyrus, amygdala and orbitofrontal cortex). Subjects with congenital anosmia exhibited no activation in these areas, but did show activity in regions outside of the olfactory cortex (temporal lobe, angular). oERPs were absent in all anosmia patients,but present in all controls. tERPs were evoked in 3 anosmia patients; signals in these patients showed lower amplitude and longer latency in the N_1 and P_2 waves compared to controls (p<0.05 for both). Conclusions Congenital anosmia patients show neurophysiologic dificits and functional inactivation in olfactory cortex, along with increased activity in regions outside it. These results support the concept of distinct central nervous system alterations in congenital anosmia.

D3 **Interactions Of Odorants At Odorant Receptors *In Vivo* Correlate With Perceptions Of Odor Mixtures**

Timothy McClintock[1], Claire De March[2,3], Tomoko Sengoku[4], William Titlow[1], Patrick Breheny[5], Hiroaki Matsunami[2,3]

[1]Department of Physiology, University of Kentucky, Lexington, KY, United States, [2]Department of Molecular Genetics, Duke University Medical Center, Durham, NC, United States, [3]Duke Institute for Brain Sciences, Department of Neurobiology, Duke University Medical Center, Durham, NC, United States, [4]OdoRcept, LLC, Versailles, KY, United States, [5]Department of Biostatistics, University of Iowa, Iowa City, IA, United States

Mixtures of odorants often produce responses that differ from the sum of the responses produced by the individual odorants in the mixture. These effects could arise during signal processing in the brain, but work ranging from arthropods to mammals often implicates the olfactory periphery instead. Discovery of the ability of odorants to act as antagonists at odorant receptors (ORs) suggests that odor mixture effects might result from pharmacological interactions between odorants at ORs. To directly test whether such interactions can be responsible for the unpredictable effects of mixing odorants on odor perception we used the Kentucky assay to identify patterns of OR responses in freely behaving mice. We first used a mixture of isoamyl acetate (IAA) and whiskey lactone (WL) that evokes in humans the woody percept of WL but not the fruity sensation of IAA. IAA produces strong responses from 5 mouse ORs *in vivo* while WL produces strong responses from 2 other ORs. The 2 ORs most responsive to WL respond to the mixture *in vivo* but the ORs responsive to IAA are suppressed. Functional expression assays in heterologous cells confirm the ability of WL to antagonize ORs responsive to IAA. Similarly, we find that undecanal and bourgeonal, known to interact at a human OR, also interact at mouse ORs *in vivo* and *in vitro*. Both negative and positive interactions are observed, but the unique OR response pattern that emerges includes the ORs most responsive to both odorants, consistent with the ability of humans to perceive both undecanal and bourgeonal in the mixture. Though species differences prevent firm conclusions, these findings support the idea that odorant mixture effects on perception may often be explained by interactions of odorants at ORs.

D4 **Awake, *In-Vivo* Imaging Of Taste Processing In Mouse Gustatory Cortex Using Miniature Head-Mounted Microscopes**

Stephanie M. Staszko, Lianyi Lu, John D. Boughter, Max L. Fletcher
University of Tennessee Health Science Center, Memphis, TN, United States

Current research in our laboratory focuses on investigating the spatial organization of taste representation in the gustatory cortex (GC) in mice using *in vivo* imaging. Previous studies suggest that particular regions of gustatory cortex underlie specific behaviors, with anterior GC being implicated in sweet-seeking behaviors and posterior GC being involved in the acquisition of a conditioned taste aversion. However, relatively little is known about the spatial organization of taste responses in individual cells across GC. Previous work in our laboratory has utilized *in vivo* two-photon calcium imaging to characterize taste responses in cortical neurons in the “central” portion of GC. This approach is limited, however, in that imaging can only be conducted in anesthetized animals across a single day-long imaging session. By employing implantable endoscopes combined with miniature head-mounted fluorescence imaging sensors, we are able to image the activity of cortical neurons in awake, behaving mice. A few weeks following GCaMP6 injection into GC, a 6 mm x 0.5 mm GRIN lens is stereotaxically placed in the mouse’s brain. For imaging, a light-weight, removable, head-mounted microscope is attached over the GRIN lens, and freely-moving animals are stimulated with taste solutions delivered through an intraoral cannula. Preliminary results show stable imaging fields within GC with more than 20-50 GCaMP6-expressing cells. We collected taste-specific responses to basic taste stimuli in cortical neurons that are repeatable across trials within a session and across sessions on multiple days. Cells varied in breadth-of tuning and best-response. Current experiments are focused on characterizing spatial coding along the anterior – posterior axis of gustatory cortex.

D5 **As Soon As You Taste It&Hellip; Taste Detection And Discrimination Responses Vary With Hedonic Value**

Raphael Wallroth[1], Kathrin Ohla[2]

[1]NutriAct - Competence Cluster Nutrition Research Berlin-Potsdam, Potsdam, Germany, [2]Cognitive Neuroscience, Institute of Neuroscience and Medicine (INM-3), Research Center Jülich, Jülich, Germany

The sense of taste is crucial for the evaluation of food, promoting the ingestion of nutrients, while helping us avoid possibly toxic substances. Humans are innately able to discriminate between taste categories (e.g. Cowart, 1981), yet it is unclear whether discrimination occurs instantaneously, or whether a general taste detection precedes taste category discrimination. Behavioral evidence suggests faster detection than discrimination in the gustatory system (e.g. Halpern, 1986), yet it is unclear whether such differences occur during early neural, or later decisional processes. We investigated this question using both behavioral responses and multivariate classification analysis of 64-channel scalp electrophysiological recordings obtained from 20 participants during two tasks: detection of salty, sour, sweet, or bitter and binary discrimination between sour and salty and between sweet and bitter. We found that both behavioral and neural responses were significantly faster in detection of salty and sour tastes than their discrimination, yet no such difference was observed for sweet and bitter tastes. One factor contributing to this contrast-dependent result is likely task difficulty, as accuracy rates were markedly higher for the detection of salty and sour tastes as compared to their discrimination, whereas sweet and bitter detection and discrimination accuracy was similar. The major difference between the two contrasts is the hedonic value of the tastes, such that salty and sour are similarly pleasant, whereas sweet and bitter differ significantly in pleasantness. Together, our findings suggest that the human gustatory system does not necessarily discriminate taste categories as quickly as it detects a taste event, but rather that it quickly discerns its hedonic value (cf. Sewards, 2004).

100 ***Comprehensive Peripheral And Cerebral Evaluation Of Taste Processing In Patients With Idiopathic Dysgeusia***

Lisa Sophie Grzeschuchna[1], Cagdas Guducu[1,2], Preet Bano Singh[3,4], Charlotte Enger[1,4], Antje Hähner[1], Thomas Hummel[1]

[1]Smell and Taste Clinic, Department of Otorhinolaryngology, TU Dresden, Dresden, Germany, [2]Dokuz Eylul University, Faculty of Medicine, Department of Biophysics, Izmir, Turkey, [3]Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, University of Oslo, Oslo, Norway, [4]Faculty of Health Sciences, Oslo and Akershus University College of Applied Sciences, Oslo, Norway

A comprehensive evaluation of peripheral and cerebral findings in patients with dysgeusia (distortions of taste perception) may provide valuable information for diagnosis and management. Medical history, depression score and self-reported smell and taste scores were obtained from all the participants. Unstimulated saliva secretion rates were measured. Smell and taste function was tested using Sniffin' Sticks, taste sprays and taste strips. Taste detection threshold was determined using an electrogustometer (EGM). Participants were phenotyped for bitter-taste receptors and the density of fungiform papillae was determined using the Denver Papillae Protocol. Central processing of taste was evaluated with gustatory event-related potentials (gERP). Preliminary results in 28 patients and 38 controls indicate that the patient group (i) had lower smell and taste scores, (ii) scored higher on depression questionnaire, (iii) required stronger electrical stimuli to detect taste, and (iv) showed prolonged latencies for gERPs. Interestingly, dysgeusic patients were not significantly different from controls in terms of chemical taste tests (taste strips, taste sprays). Across both groups, there was correlation between taste function, saliva flow and degree of depression. These findings imply that both peripheral and cerebral taste function is significantly disturbed in patients complaining of idiopathic dysgeusia.

101 **Taste Assessments In Two Population Health Exam Surveys: Nih Toolbox Norming Study, 2011, And National Health And Nutrition Examination Survey (Nhanes), 2013-2014**

Howard J. Hoffman[1], Chuan-Ming Li[1], Susan E. Coldwell[2], Shristi Rawal[3], Linda M. Baroshuk[4], Katalin G. Losonczy[1], Nadia K. Byrnes[5,6], John E. Hayes[5], Valerie B. Duffy[7]

[1]Epidemiology and Statistics Program, National Institute on Deafness and Other Communication Disorders (NIDCD), National Institutes of Health (NIH), Bethesda, MD, United States, [2]School of Dentistry, University of Washington, Seattle, WA, United States, [3]Department of Nutritional Sciences, Rutgers University, Newark, NJ, United States, [4]Food Science and Human Nutrition, University of Florida, Gainesville, FL, United States, [5]Department of Food Science, Pennsylvania State University, University Park, PA, United States, [6]Global Sensory Science, Ocean Spray, Inc., Lakeville, MA, United States, [7]Department of Allied Health Sciences, Storrs, CT, United States

Our objective was to compare two large U.S. health exam surveys. The NIH Toolbox Regional Taste Test was administered to a community-dwelling sample of 2,560 12- to 85-year-olds at ten locations to establish population norms. This protocol was modified slightly and incorporated into the 2013-2014 NHANES Taste Exam for 4,296 adults aged 40 to 85+ years. Tongue-tip and whole-mouth intensities of bitter (1 mM quinine hydrochloride) and salt (1 M NaCL) were rated using the generalized labeled magnitude scale (gLMS). We calculated percentiles and linear regression models to examine associations by age, sex, lifestyle and health characteristics. The 10, 25, 50, 75 and 90 gLMS percentiles for whole-mouth and tongue-tip NaCl and quinine indicated similar distributional shapes in both studies. The effects of age, race/ethnicity, education, and household income were small. In contrast, females (aged 40+ years) had significantly larger median and 90%-ile gLMS scores compared to males for whole-mouth quinine taste in both the Toolbox and NHANES samples. The median and 90%-ile gLMS scores were also increased for females in the tongue-tip quinine assessment, but not for NaCl assessments. There were substantial differences in correlation between the quinine and NaCl assessments for the two studies. For example, the R^2 measure of variance accounted for in predicting whole-mouth NaCl gLMS from quinine gLMS, after controlling for age and sex, in the NIH Toolbox sample was 6.1%, while in the NHANES sample it was 33.8%, or one-third of the variance. The higher correlation of intensity measures in NHANES may be due to improved training of examiners and protocol monitoring. Using nearly identical, established taste protocols, the two datasets have comparable distributions and revealed sex differences in taste intensity.

102 **Alterations Of Olfaction-Related Brain Grey Matter Density And Olfactory Bulb Volume In Post-Traumatic Brain Injury Patients**

Thomas Hummel[1], Nicole Winkler[1], Cornelia Hummel[1], Johannes Gerber[2], Antje Haehner[1], Pengfei Han[1]

[1]Smell & Taste Clinic Department of Otorhinolaryngology, TU Dresden, Dresden, Germany, [2]Dept. of Neuroradiology, TU Dresden, Dresden, Germany

Objectives: Olfactory loss may cause anatomical brain alterations in humans. There was relatively little research on olfactory loss patients due to traumatic brain injury (TBI). Methods: Brain grey matter (GM) density were examined for forty-six TBI olfactory loss patients (22 hyposmia and 24 functional anosmia) and 22 age-matched healthy controls using voxel-based morphometry. Olfactory bulb (OB) volumes were calculated by manual segmentation of acquired T2-weighted coronal slices using a standardized protocol. Results: Compared to controls, patients with hyposmia or functioinal anosmia had smaller OB volumes ($p < 0.01$). Further OB atrophy was seen in patients with anosmia as compared to patients with hyposmia ($p < 0.05$). GM reductions in the primary and secondary olfactory areas were found for TBI patients with functional anosmia, while less severe

GM reduction was found for hyposmia. In addition, increased GM density was found in the right angular gyrus in TBI patients with hyposmia compared to healthy controls (107 voxels, T = 4.08, uncorrected-p <0.001). Furthermore, longer duration of olfactory loss was associated with larger GM reductions in primary olfactory area, insula cortex, putamen, gyrus rectus, and temporal gyrus (p <0.001). Conclusions: This association indicated either damages expand with post-injury duration, or longer duration of olfactory loss induced further GM reduction in olfactory-related areas. The pronounced and simultaneous atrophy of OB volume and GM density may explain the relatively low recovery rate for TBI-related olfactory loss patients.

103 **Relationship Between Serum Zinc Concentration And Taste Sensitivity In United States Adults: The National Health And Nutrition Examination Survey, 2013-2014**

Paule V. Joseph[1], Kathleen E. Bainbridge[2], Rachel Fisher[3], Katalin G. Losonczy[2], Xuemin Zhang[1]

[1]National Institute of Nursing Research, Sensory Science, and Metabolism Unit, [2]National Institute on Deafness and Other Communication Disorders, [3]National Institute of Diabetes and Digestive and Kidney Disorders

Taste disorders can affect the quality of life of an individual. One factor associated with taste disorder is zinc (Zn). Low levels of zinc have been associated with changes in the number, size and structure of taste bud cells as well as a decrease in nerve sensitivity affecting taste perception. The mechanisms by which zinc deficiency affects taste are not understood. The aim of this cross-sectional study was to determine whether taste sensitivity varied by serum Zn concentration in a nationally representative sample of US adults aged ≥40 years. Nine hundred ninety-eight participants who completed the taste protocol administered as part of the 2013–2014 National Health and Nutrition Examination Survey (NHANES) and for whom serum zinc data were available were included in the analysis. Salt and bitter taste sensitivities were assessed using tongue tip and whole mouth taste stimuli and were rated by participants using the generalized linear magnitude scale (gLMS). We examined measures of central tendency (mean, median, mode) of taste sensitivity (gLMS) by percentile of serum zinc concentration using the 10^{th} and 90^{th} percentile cutoffs. We found that those with serum Zn in the $>90^{th}$ percentiles reported lesser taste sensitivity via tongue tip salt Mean=24.30, 95%CI [20.79-27.81] compared to those in the $<10^{th}$ percentiles Mean=26.01, 95% CI [23.19-28.82]. Similar patterns were seen for tongue tip bitter, whole mouth salt (1M), whole mouth salt (.32M), and whole mouth bitter. Differences were not statistically significant. Taste sensitivity did not vary by serum zinc concentration, possibly due to tight regulation of zinc metabolism.

104 **(Don Tucker Award Finalist) Abnormal Anticipatory Activity In The Anterior Lateral Motor Cortex Is Associated With Licking Deficits In Hemi-Parkinsonian Mice**

Fanny Lecuyer Giguere[1,2,4], Andreas Frasnelli[5], Elaine de Guise[1,4,6], Johannes Frasnelli[1,2,3]

[1]Department of psychology, University of Montreal, Montreal, QC, Canada, [2]Hopital du Sacré-Coeur, Montreal , QC, Canada, [3]Department of anatomy, Université du Quebec à Trois-Rivieres, Trois-Rivières, QC, Canada, [4]Centre de recherche interdisciplinaire en readaptation du Montréal metropolitain (CRIR) , Montreal, QC, Canada, [5]Hopital de Viège, Viège, Switzerland, [6]McGill University Health Center , Montreal, QC, Canada

Olfactory dysfunction is frequently reported by patients with traumatic brain injury (TBI). More precisely, patients tend to report total (anosmia) or partial (hyposmia) loss of their sense of smell. However, the majority of these studies have evaluated all three degrees of TBI together (mild, moderate and severe). Even if they represent more than 80% of the brain injured population, no study to date has focused on mild traumatic brain injured (mTBI) patients. In addition, we know little about the evolution of olfactory disorders appearing after a mTBI. Facing this lack in the literature, we aimed to evaluate the olfactory system in the mTBI population within the first 24 hours after their accident and one-year post-mTBI. To do so, we evaluated a group of 20 mTBI patients and a control group of 22 patients with orthopedic injuries with regards to olfaction, cognition and emotional states. More specifically we evaluated olfactory function objectively (Sniffin' Sticks) and subjectively (questionnaire of olfactory disorders) and applied a battery of neuropsychological tests (memory, inhibition, organization). We found significantly lower scores on the all the objective olfactory subtests for the mTBI group. As a result, 55% of mTBI patients exhibited hyposmia, compared to 5% in the orthopedic group. Further, a positive correlation was found between olfactory discrimination short-term memory, as the mTBI showed a deficit on this particular memory task. However no other correlation was found between neuropsychological and emotional aspects and the olfactory tasks, suggesting that the olfactory deficit is tributary of a real loss of olfactory function post-mTBI rather than an epiphenomenon due to depression, anxiety or cognitive dysfunction.

106 **Food Attitudes Of Anosmics Across Different Cultures**

Curtis Luckett[1], Robert Pellegrino[1], Thomas Hummel[2], Rosa Emrich[2], Rakesh Chandra[3], Justin Turner[3], Timothy Trone[3]

[1]Department of Food Science, University of Tennessee, Knoxville, TN, United States, [2]Smell & Taste Clinic, Department of Otorhinolaryngology, TU Dresden, Dresden, Germany, [3]Division of Rhinology, Department of Otolaryngolog, Nashville, TN, United States

Little is known about how food attitudes change when someone loses their sense of smell. Furthermore, it is likely that the culture in which an anosmic identifies with will influence how their smell loss impacts their relationship with food. This study aims to examine the current attitudes of anosmics in the United States and Germany toward food attributes, focusing on the comparison between anosmics and those with a healthy since of

smell. Secondary factors of culture, gender, age, and the time since diagnosis were also examined. Free responses were classified into categories and subcategories, the frequency of those responses were then compared across groups. Responses relating to spiciness/heat and appearance were more common in anosmics. Interestingly, when compared to normosmics, the frequency of aroma-related responses was not different in anosmics. In general, differences in response frequency between anosmics and normosmics were consistent across cultures. This study shows the changes in consumer attitudes toward foods which accompany smell dysfunction and could be used to design interventions to help anosmics enjoy food consumption more.

107 **Morphological Evaluation Of The Olfactory Filament In Brain Traumatic Rat Model With Mri**

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Aims: To investigate whether magnetic resonance imaging (MRI) can be used to directly assess the olfactory bulb (OB) lesions and quantify the associated morphological changes of olfactory filament (OF) in an OB-lesion model in rat brain in vivo. Methods: a surgical group (N=5) of male Sprague-Dawley rats were subjected to the unilateral damage the in OB by the steel needle. The control group (N=5) did not receive surgery. To assess the olfactory system injury in vivo, T2-weighted MRI images were acquired in an oblique plan at a 30^{o} angle from transverse plan one day after surgery in the surgical group and in the control group, respectively. The olfactory function of rats evaluated with buried food test (BFT) before and 5 days after surgery. Result: The OFs could be clearly observed on the MRI images from all animals. The left and right OF mean length (mm) were similar in the control rats (0.81±0.18 vs. 0.89±0.17, $P > 0.05$). In the surgical group, the OB was partially injured in all rats. The surgical group rats did not show differences in OF length (0.83±0.18 vs 0.93±0.24, $P>0.05$) at the time of measurement. The time of BFT before and after the surgery shows statistical difference (83.8±34.37 vs. 231.4±53.23, $P<0.05$). Conclusions: (1) Needle damage OB methods can be used to establish a partial OB injury model. (2) MicroMRI can be used for quantifying the associated OF morphological changes for development of olfactory brain traumatic injury animal models.

108 **Gingival Solitary Chemosensory Cells (Sccs) Protect Against Periodontitis And Oral Bone Loss.**

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Mucosae are colonized by a complex microbiome interacting with the epithelium for mutual benefit or that can lead to pathology. Chemosensory sentinel cells in the airways (SCCs) and gut (tuft cells) monitor the microbiome, triggering protective responses to keep pathogens under control. We have discovered SCCs expressing several taste signaling elements in the junctional gingival epithelium attached to teeth. Knockout (KO) mice lacking SCCs (e.g. Skn1a KO) or key components of the SCC signaling cascade (e.g. TrpM5- or Gnat3-KOs) show enhanced natural occurring oral bone loss that is markedly increased in the tooth ligation inflammatory model. In these three KO mice, inflammatory cytokines are upregulated, expression of microbial defensins is nearly abolished, while periodontal inflammation is increased and innate immunity impaired. The absence of Gnat3 alters the oral microbiome, with higher levels of *Streptococcus* and *Pasteurellae* and a marked increase of the mouse gram-negative NI1060 proteobacteria, related to the human pathogen *A. actinomycetemcomitans* (causes aggressive periodontitis). Heterologously expressed Tas2R105 responds to several compounds, including denatonium benzoate (a known SCC ligand), acyl homoserine lactones (*P. aeruginosa*) and cycloheximide (*S. griseus*). Topical application of denatonium to the gingiva for one week stimulated the production of defensins and reduced alveolar bone loss in wildtype but not in $Gnat3^{-/-}$ mice. In sum, mouse gingival SCCs likely respond to bacterial signals via taste signaling components triggering host secretion of antimicrobial peptides and innate immunity to prevent overgrowth of pathogenic oral bacteria and regulate gingival microbiome. This research could lead to novel diagnostic tools and new therapeutic agents for periodontal disease.

109 **Spatiotemporal Dynamics Of Human Olfactory Attention During An Odor Search Task**

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The process of sensory perception begins prior to any physical contact with the stimulus. Expectation of a stimulus triggers a predictive pattern in the brain which confers advantages to an organism's survival in sensory environments. Previous fMRI studies have found that attention to olfactory contents evokes baseline deviations prior to odor sampling in humans. However, the fMRI signal is slow and does not allow direct recording of local field potential (LFP) oscillations with precise temporal resolution. In this study, we used intracranial EEG (iEEG) recordings obtained directly from human piriform cortex to investigate the spectral properties of human olfactory attentional neural signatures. Five patients participated in a simple olfactory search task. Each trial began with the instruction to sniff, followed by the presentation of either odorized or clean air. Trials were separated by 15 seconds of natural breathing of clean air, resulting in 3 conditions: 1. Attended sniffs of odorized air, 2. Attended sniffs of clean air, and 3. Unattended sniffs of clean air (natural breaths in between trials). By examining the

period prior to inhale onset, we looked for attentional effects occurring in the absence of any sniffing and any odor, two parameters unrelated to attention which could potentially impact LFP oscillations. Preliminary analyses indicate that attention to odor induces desynchronization of low frequency (Delta/Theta) oscillations, phase-amplitude decoupling of Alpha and Gamma frequencies, and inter-trial delta phase clustering in piriform cortex just prior to inhale onset in attended trials. Statistical comparisons between conditions were conducted using a permutation method combined with correction for multiple comparisons (cluster-based method), P <0.05).

110 **Cross-Species Configural Perception Of Binary Odor Mixtures**

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Animals face a same challenge to adapt and survive across the life span: to rapidly extract pertinent information from the highly complex and dynamic environment. To cope with this complexity, sensory systems can break down a complex stimulus into its elements (elemental perception) or combine the elements in a synthetic information (configural perception). But is it possible that similar stimuli induce similar perception in different animal species? Within olfaction, taking advantage of the fast odor learning induced by the mammary pheromone in newborn rabbits, pups were shown perceiving an AB mixture of ethyl isobutyrate (A) and ethyl maltol (B) in a weak configural way, i.e. as the addition of the component odors and a new odor for AB. When the 30/70 ratio of A/B is changed in 68/32 then the perception of this A'B' mixture becomes elemental. We have reported similar results in humans. Here, we evaluated whether adult mice also discriminate between these two mixtures, and between the mixtures and their components. Odors were presented to B6sJLF/J mice in their home cage through a habituation (4 repeats of a given stimulus) / cross-habituation procedure (4 repeats of a new stimulus). All possible combination of stimuli were tested among AB, A'B', A and B. The results showed that: 1) the mixtures were investigated longer than the individual components; 2) habituation to AB appeared to be more rapid than to A'B', and 3) cross-habituation between AB->A'B' was asymmetrical compared to A'B'->AB. Taken together, the results are consistent with a partial configural perception of AB and pure elemental perception of A'B' in mice, as it is in rabbits. Thus, convergent perception of similar mixtures may exist between rodents, lagomorphs and humans, suggesting stable rules for odor perception across species.

111 **The Influence Of Odor Context On Post-Task Resting-State Networks**

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Even at rest the human brain presents spontaneous dynamic activity that is highly synchronized between different brain regions. These so-called resting-state networks are affected by the performance of different types of task, like encoding memory, language processing, or simple visuomotor tasks. This interaction between rest and task allows the hypothesis that the engagement of task-related brain dynamics during a subsequent resting-state period might enhance the expertise on that given task. Here we aim to investigate if different perceptual information in the on-task state could differently affect functional connectivity in a subsequent resting-state fMRI. In this functional MRI (fMRI) study thirty-four normosmic participants (18 females) performed a simple memory encoding task either with an odor context or without. Functional imaging data was analyzed using seed-based functional connectivity (FC) analyses comparing pre- and post-task resting-state fMRI in both groups. Results of the FC analyses showed that an odor context presented during the encoding task induced stronger post-task functional connectivity in regions associated with object representation and episodic memory encoding. This increase in FC may indicate the integration of olfactory with visual information. On the other side, odor context and its integration constitute a higher cognitive demand as seen by lower FC within Default-Mode related networks. This evidence furthers previous literature and emphasizes the importance of the perceptual context in which a task is performed since it is relevant also for the understanding of functional connectivity changes during rest.

112 **Brief Cognitive-Behavioral Therapy For Pain Tolerance, But Not Transcranial Direct Current Stimulation, Affects Odor Sensitivity**

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Abnormally heightened odor sensitivity (OS) is an increasingly recognized psychosomatic condition associated with significant distress and impairment. Yet, there are no existing treatments that effectively address this condition. A sample of participants enrolled in a clinical trial on pain tolerance was used to examine whether a brief cognitive-behavioral intervention (CBT) and/or transcranial direct current stimulation (tDCS) would be effective at modulating odor thresholds in healthy adults. Seventy-two healthy adults underwent odor threshold testing for phenyl-ethyl alcohol, as well as thermal pain testing, before and after the intervention. Participants were randomized to receive one of 6 conditions consisting of either brief CBT or psychoeducation, sham or real tDCS, and anodal or cathodal tDCS. Significant main effects of time (Pre-Treatment = -4.69; Post-Treatment = -4.55, p = .001), and CBT (Psychoeducation = -4.74; CBT = -4.50, p = .011), as well as an interaction between time and CBT (F[1, 64] = 6.82, p = .011) were found. Persons who received CBT showed higher odor thresholds post intervention. Moreover, higher baseline anxiety sensitivity significantly predicted reductions in sensitivity

after CBT ($r(35) = .45$, $p = .007$).There were no significant effects of tDCS (all p-values ≥ .89). CBT demonstrates promise for treating OS, particularly in persons with heightened anxiety sensitivity who may be more emotionally reactive to sensory stimuli. It does not appear that modulation of prefrontal activity via tDCS had any significant effect on odor thresholds. Yet, more research on mechanisms of change may offer insights into other neural regions of interest as well as refinement of cognitive and behavioral interventions for OS and other psychosomatic phenomena.

113 **Olfactometer Improvement For Reaction Time Measurement For Supplement Odor Under Background Odor Presentation**

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The olfactometer, Kobal and his colleague developed, was utilized for measuring EEG or reaction time for a few decades. This device can present with short (within 50ms) stimulus rising time, without air pressure change. Many experiments were performed to measure chemosensory event related potential or reaction time for target odor, in contrast to odorless air. From the point of view of daily life situation, especially food experience, we often meet with the situation that base odor is continuously flowing and some another odor add to this odor. In order to reproduce this situation in laboratory, we tried to improve our olfactometer so that it can present background (base) odor, during controlled duration, and insert supplement (target) odor into the background. After this improvement, we tried to measure reaction time target A on odorless air, target B on air, target A on tea vapor, and target B on tea vapor. Flow of odorless air and background odor shared one flow line, and target odor A and B shared another flow line, and these odors and air were switched by solenoid valves. These valves were driven by small controller (Arduino) through amplification circuit. It is possible, in principle, the number of background odors or target odors can be easily increased because of simple structure. This olfactometer improvement will contribute new sensory evaluation methods.

114 **Odor Labels Affect The Stability Of Olfactory-Visual Cross-Modal Associations**

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Research has demonstrated robust cross-modal associations between olfactory and visual stimuli. Odor-color associations depend in large part upon knowledge of odor identity (strawberry=red), while odor associations with abstract shapes may reflect shared sensory properties (“sharp” trigeminal odors are associated with pointed shapes). We examined this hypothesis by comparing the test-retest reliability of odor-color and odor-shape associations while manipulating odor label information provided to participants. In two sessions 9 days apart, participants (N=43) completed odor-color and odor-shape association tasks with 8 odors. Participants in one group were provided the names of each odor; a second group was asked to identify the odors; and a third group was given no odor label. Test-retest reliability of odor-color associations was determined by calculating a correlation coefficient of color ratings and analyzed using Analysis of Variance. There was an effect of label condition on reliability $F(2,40)=7.56, p<.01$. Participants who were provided the names of each odor (mean r=.66) had higher reliability than those who had to generate a name (r =.46) and those given no name (r=.39). Odor-*shape* associations, however, were less variable overall and were slightly more stable from time 1 to time 2 (*Provided label* mean r=.66, *Generate label* r=.49*, No label* r=.56). Unlike color associations, the test-retest reliability of shape associations was not affected by labeling condition, F (2,40)=.96, p=.39. The results lend further support to the hypothesis that multiple processes determine olfactory cross-modal associations, in that odor-color associations are mediated by semantic identification while odor-shape associations are driven by less variable sensory mappings between stimulus features.

115 **(Achems Undergrad Award Finalist) The Influence Of Cognitive And Psychological Parameters On Olfactory Assessment In Childhood**

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Aim: Performance in olfactory testing increases from childhood to adolescence. Assuming an early development of olfactory function the question arises whether this increase in test performance in due to an increase in olfactory function or related to other factors. Accordingly, the study aimed to identify influencing factors on olfactory test performance in children and adolescents. *Methods:* The study included 200 participants aged 6 to 17 years (mean age: 11.5±3.5 years). They were divided into four age groups: 1) 6-8 years, 2) 9-11 years, 3) 12-14 years, 4) 15-17 years. The "Sniffiin' 'Sticks" olfactory threshold test and the "U-Sniff" odor identification test were used to investigate the sense of smell. The executive function was assessed using the "Wisconsin Card Sorting Test" in 12- to 17-year-olds and Raven's Progressive Matrices in the whole group in the age appropriate form. In addition, the "Wortschatz- und Wortfindungstest" (WWT) was used to identify the vocabulary of 6 to 11 year-olds. Lastly, the entire group underwent the "Depressionsinventar für Kinder und Jugendliche”, a German questionnaire on the current depression state. *Results:* There were no significant differences in olfactory threshold concerning age groups, school level and tests carried out. In contrast, age groups ($F(3,196)=9.989$, $p<0.001$) and school level ($F(3,196)=10.509$, $p<0.001$) showed significant influence on odor identification scores. Furthermore, it correlated significantly with CPM ($r=0.204$, $p=0.044$) and WWT ($r=0.235$, $p=0.02$). *Conclusion:* Especially the educational level, the developing verbal abilities and executive function have an influence on odor identification performance during the first decade of life. In contrast, measurement of olfactory threshold seems to be a more independent test.

117 **(Don Tucker Award Finalist) Abnormal Anticipatory Activity In The Anterior Lateral Motor Cortex Is Associated With Licking Deficits In Hemi-Parkinsonian Mice**

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Orolingual motor deficits such as tongue tremor are prevalent in Parkinson's disease. However, little is known about the dysfunction of neural circuits controlling tongue movement. In rodents, the anterior lateral motor (ALM) cortex has been shown to play a role in planning and execution of licking. Here, we combine behavioral training, electrophysiological recordings, and pharmacological manipulations to study how abnormal neural activities in ALM cause abnormal licking in a mouse model of PD. 6-OHDA was unilaterally injected into the medial forebrain bundle (MFB) to generate a mouse model of PD. To investigate potential licking deficits, mice were trained to lick a movable spout 1 s after an anticipatory cue and collect a drop of sucrose. Linear arrays of electrodes were bilaterally implanted into ALM to record spiking activity. We found that hemi-parkinsonian mice displayed slower licking initiation and shorter licking bout duration. In addition, tongue protrusions were deviated towards the lesion side in hemi-parkinsonian mice. Local infusion of dopamine D1 receptor antagonist (SCH23390) in ALM but not D2 receptor antagonist (raclopride) could reproduce the slower licking initiation. Neural recordings in ALM revealed that majority of neurons in ALM changed their firing rate in preparation of licking. However, preparatory activity emerged more slowly in hemi-parkinsonian mice. In addition, the ALM ipsilateral to the lesion side exhibited a shift of excitation-inhibition ratio in preparatory activity. In conclusion, our data describe licking deficits and a correspondent dysfunction of ALM in hemi-parkinsonian mice. Our work establishes a novel model for exploring the function of dopamine in modulating licking and the dysfunction of licking-related neural circuits in hemi-parkinsonian mice.

118 **Overshadowing Of Taste-Predictive Cues And Cue Representation In The Gustatory Cortex Of Alert Mice**

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Cues predicting tastes have been shown to significantly affect spiking activity in gustatory cortex (GC) neurons (Vincis & Fontanini, 2016). However, not all cues are created equal. Just as some sensory modalities are more easily associable with certain outcomes than others (a phenomenon called selective associations), some non-taste cues evoke more activity in GC than others. Here, we adapt a classic overshadowing paradigm to test the behavioral relevance of this differential representation of sensory modalities in GC. Our experiments test the following hypotheses: 1) stimuli belonging to different sensory modalities interact with each other in predicting taste; and 2) stimuli with strong representations in GC overshadow those with weaker representations. Training and testing were performed in head-fixed mice implanted with bundles of tetrodes in GC. Mice were trained that at the end of a two second simultaneous presentation of an odor (isoamyl acetate) and a tone (2 kHz, 75 dB), licking a dry spout would deliver sucrose (200mM). During training, both odor and tone always perfectly predicted sucrose availability. After successful training (licking on 75% of trials for 3 consecutive days), mice were assessed for learning by presenting independently and unrewarded each of the two cues. Mice licked robustly to the odor (~73% of trials), but rarely to the tone (~15% of trials). Analysis of single unit activity revealed that the simultaneous presentation of odor and tone in compound created a configural representation in GC. Data on the overlap of this configural representation with that of each single cue will be presented. Taken together, these experiments provide evidence for cross-modal interactions in predicting taste and establish a model for investigating the role of GC in selective associations.

119 **A Precise And Portable Gustatory Stimulator**

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Gustatory stimulation during neuroscience experiments proves to be exceptionally challenging, as the required stimulus control is non-trivial. We designed a new stimulator that meets the demands of behavioral, EEG/MEG, and neuroimaging (fMRI) studies. The device is based on the *neMESYS* syringe pump system (Cetoni, Korbußen/Germany) and controlled through a Python-based software package. The system is portable and modular and can be equipped with multiple pumps, valves, and digital I/O boards for sending triggers to any laboratory equipment. The pumps deliver stimuli through plastic tubing to commercially available or custom-made mouthpieces or spray heads. Another distinguishing feature is the system's ability to stimulate either side of the tongue independently. We present latency measurements that highlight the precision and reliability over time using two spray heads placed side-by-side. The delay between triggering the pumps and onset of liquid delivery showed minuscule variation within and across pumps (SDs <2ms and <1ms, resp.). We validated a lateralized setup in a behavioral study using spray heads on either side of a plastic barrier spatially separating the tongue at the midline. 18 participants (p.; median age: 28.6y; 13f) performed two tasks. During the *taste* task, salty (2% NaCl) stimuli were presented on both or only one side of the tongue, while water was sprayed on the other, and p.s reported the locus of taste stimulation (left, right, both). In the *touch* task, water was sprayed on both or only one side of the tongue and p.s reported the locus of touch. P.s identified 69% of the taste and 91% of the touch stimulations correctly, corroborating that the liquids did not cross the barrier, and demonstrating the suitability of the stimulator for use in complex experimental setups.

121 **Nasal Breathing Modulates Functional Connectivity Of Bed Nucleus Of The Stria Terminalis**

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Nasal breathing, which is synonymous with olfactory sampling, impacts local field potential (LFP) oscillations in

both olfactory and non-olfactory limbic brain regions, including the amygdala, which is heavily connected to olfactory structures. In the human amygdala, nasal (not oral) inhalation enhances delta and theta range (1–8 Hz) amygdala LFPs. Furthermore, electrical stimulation of the amygdala causes respiratory arrest, but only during nasal, not oral, breathing. These findings suggest a key role for the amygdala in respiratory control that is unique to the nasal breathing route, raising the possibility that the amygdala plays a role in complex sniffing behaviors. In order for sniffing to occur, autonomic respiratory centers must be overridden, allowing conscious control over nasal respiration. The amygdala may impact autonomic breathing via the bed nucleus of the stria terminalis (BNST), an extended region of the amygdala with extensive anatomical connections to the brainstem. Here, we set out to test the hypothesis that breathing route (nasal/oral) alters the intrinsic functional circuitry of the BNST. Resting functional magnetic imaging data were collected from 17 subjects who performed 15 min of both nasal and oral breathing. Seed-based whole-brain functional connectivity maps were calculated for each condition using the BNST as a region of interest. Preliminary analyses suggest that the BOLD time series in BNST and the pons are more strongly correlated during nasal compared to oral breathing (whole-brain corrected $p < 0.05$). These findings suggest that interactions between autonomic respiratory centers and limbic regions may contribute to the neural mechanisms underlying nasal breathing, sniffing and emotional processing.

122 **A Time-Course Of Regeneration Of The Taste Branches Of The Chorda Tympani And Glossopharyngeal Nerves In Mice**

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In rodents, it is known that taste buds degenerate following denervation, and regenerate upon reinnervation. However, little work has been done to systematically study the time-course of such events in mice. In one phase with B6 and 129 mice, bilateral transections of the chorda tympani (CTX) or glossopharyngeal (GLX) nerves were performed to either allow regeneration (-REGEN) or prevent (-P) it by either physical blockade (CTX) or removal of ~1 mm of nerve (GLX) – techniques similar to those used in rats. These mice were left to recover for 2-12 weeks (n=4-5, 2-3 males & females in each group) and then tongue epithelia were processed with immunofluorescence (anti-keratin-8) and taste buds were counted in fungiform (CTX) and circumvallate (GLX) papillae. In a second phase, mice with a mixed B6/129 background recovered 2-12 weeks after similar prevention surgeries, but only a 12-wk -REGEN group (n=4-5, 2-3 males & females in each group) was included. Whole tongue tissue was processed using methylene blue for CTX or hematoxylin/eosin for GLX; taste pores were counted in fungiform and circumvallate papillae. While there were significantly fewer taste buds in the primary taste field for each nerve following CTX or GLX (>60% decline; all $p<0.01$), some taste buds remained at all time points, implicating the presence of additional maintenance mechanisms. Further, little regeneration seemed to occur across the recovery period tested here. Unlike in the rat, there was little difference between –P and –REGEN groups for all time points ($p>0.05$), suggesting no benefit to the prevention methods used here. Additionally, some differences in counts across the two histological methods suggest benefits and drawbacks for each protocol. Further investigations of these results are in progress.

123 **Distinct Progenitor Cell Niches Are Required For Taste Bud Formation, Maturation And Maintenance**

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To investigate the contribution of surrounding tissues to taste buds (TBs), *K14-Cre* and *Dermo1-Cre* were used to trace basal epithelial cell and mesenchymal cell lineage, respectively. TBs were incompletely labeled by *K14-Cre* despite the complete labeling of the surrounding epithelium at postnatal 1 week (1w); at the same time point, *Dermo1-Cre* labeled both mature TB cells and underlying connective tissue cells, raising a question: are there distinct progenitor niches for TBs. To better understand the progenitor niche in surrounding tissues for TB formation, maturation, and maintenance, different stages of *K14-Cre* and *Dermo1-Cre* mice crossed with a nuclear tdTomato to eGFP switch Cre-reporter (nTnG) were used to map labeled cells in lingual TBs. In *K14-Cre/nTnG* mice, labeled cells were not observed at E18.5 when early TBs emerge, but were frequently seen in the TBs at birth. By 1w, the number of labeled cells had increased significantly, and at 2w labeling was extensive. After 4w when TBs are mature and undergo continuous turnover, TBs were almost fully labeled. In contrast, *Dermo1-Cre*-labeled TB cells if any, were rarely observed at 1d and 1w. At 2-4w, labeled cells were seen within many TBs. By 8w, *Dermo1-Cre*-labeled cells were abundant in the majority of TBs. Interestingly, *Dermo1-Cre*-labeled TB cells were not apparent for the immunosignals of K8, a widely used marker for differentiated TB cells. Our data indicate that 1) $K14^+$ epithelial cells contribute to the maturation and maintenance, but not initial formation, of TBs; 2) *Dermo1-Cre* labels a unique population of mature TB cells implicating the presence of $Dermo1^+$ precursors for TB cell renewal. These results suggest that distinct progenitor niches contribute to different aspects of TB formation, maturation and maintenance.

124 **Bmi1 Deficiency Causes Increased Olfactory Neuron Turnover**

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In the initial step in olfaction, inspired odor molecules interact with olfactory sensory neurons (OSNs) in the nasal cavity. OSNs are vulnerable to damage and cell death due to their contact with the nasal airspace. Human olfactory disorders due to aging and disease are common and lack effective therapies. Identification of mechanisms regulating OSN maintenance and turnover are necessary to develop treatments for olfactory loss. Our investigations into homeostasis in the olfactory epithelium (OE) led to the identification of the Polycomb protein BMI1 (PCGF4) in adult OE. Polycomb complexes function as chromatin modifiers to regulate critical cellular functions. Here, we sought to elucidate the function(s) of BMI1 in OSNs. By co-IP, we confirmed that

olfactory BMI1 binding partners include specific components of Polycomb Repressive Complex 1. We utilized the Cre/loxP system to generate a mouse model that is BMI1-deficient selectively in mature OSNs. Our findings indicate that BMI1-deficient OSNs undergo faster rates of turnover in vivo compared to controls, as measured by increased apoptosis (23±4 vs. 10.3±0.8 caspase3$^+$ cells/mm of OE, mean±SD, n=3). Increased proliferation in the basal layer was also observed, indicating the presence of activated neural progenitors to replace degenerating OSNs (64±6 vs. 48±8 BrdU$^+$ cells/mm of OE, mean±SD, n=3). Our data suggest that BMI1 plays an important role in OSN survival and OE maintenance. Ongoing work will investigate functional consequences of BMI1-deficiency in OSNs, as well as relevant downstream targets regulated by BMI1-dependent chromatin modifications.

125 **Alk3-Mediated Bmp Signaling In The Tongue Mesenchyme Is Essential For The Proper Development Of Tongue And Taste Papillae.**

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The development of tongue and taste papillae requires mesenchymal-epithelial interactions via multiple molecular pathways, including bone morphogenetic protein (BMP) signaling in which type I receptors (ALK2, ALK3, ALK6) are the main determinant of downstream signaling specificity. Our studies have demonstrated that BMP signaling mediated by ALK2 in the tongue mesenchyme plays an important role in regulating the tongue shape and size. Here we report that BMP signaling mediated by ALK3 (ALK3-BMP signaling hereafter) in the tongue mesenchyme exerts distinct roles in the development of tongue and taste papillae. The RNA-Seq analysis demonstrated that *Alk3* is highly expressed in both tongue epithelium and mesenchyme in embryonic and newborn mice. We used transgenic mouse models to constitutively activate (*ca*) and conditionally knock out (*cKO*) *Alk3* in a mesenchyme-specific manner using *Wnt1-Cre*. At E12.5, *Wnt1-Cre/Alk3 cKO* mutants had a smaller tongue with a truncated tip compared to the littermate controls. In the posterior region, tongue swellings were not fused. At E12.5 when *Shh*+ taste papilla placodes normally emerge, taste papilla placodes were absent in the *Wnt1-Cre/Alk3 cKO* tongue. In contrast to *Wnt1-Cre/Alk3 cKO*, *Wnt1-Cre/caAlk3* mutants did not depict obvious changes of tongue shape, size and papilla pattern. Our data indicate that a proper level of ALK3-BMP signaling is needed for the formation of tongue and taste papillae. Absence of taste papillae in the *Wnt1-Cre/Alk3 cKO* mutants suggests that ALK3-BMP signaling in the tongue mesenchyme is critical for the mesenchymal-epithelial interactions in taste papilla formation. Further studies are ongoing to explore the role and mechanism of ALK3-BMP signaling in tongue and taste papillae formation.

126 **Investigation Of The Number Of Fungiform Papillae In Children With Tooth Number Anomalies**

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Objective: Teeth and taste papillae developed from a common tissue. Hypodontia (lack of tooth germ) and hyperdontia (extra tooth) are two of the anomalies commonly seen in Pediatric population. The purpose of this study was to investigate differences in fungiform papilla (FP) counts in children with hypodontia or hyperdontia in terms of gender &age, and whether the FP numbers of these children differed from normal. Material-Methods: One hundred and fifty-six children who applied to the Marmara University Pediatric Dentistry Department, Istanbul, Turkey aged between 7 to 12 and had hypodontia [n= 52 (19 males, 33 females), hyperdontia [n= 52 (36 males, 16 females)], or did not have tooth number anomalies [n=52 (26 males, 26 females)] were included in the study. All missing germs and supernumerary teeth were diagnosed during clinical and radiographic examinations. The FP counts on the dorsal surface of the 1/3 anterior tongue was scored using the Denver Papilla Protocol. Statistical analyses were done using the NCSS program. Results: The mean number of FP of the hypodontia group was significantly lower than the mean FP number of the control and hyperdontia groups (p=0.001, p=0.043 respectively). FP number was found not be affected by age and gender in the children (p=0,341 and p=0,461). It was also observed that there was no difference in the mean number of supernumerary tooth type, missing germ, location and number of FP (p=0,464, p=0,473, p=0,214). Conclusion: Our findings showed that there was a decrease in the number of FP in hypodontia cases whereas no changes in hyperdontia cases as compare to control group. The low FP counts in hypodontia cases may suggest different pattern of taste perception compared to normal children.

127 **Gender Differences And Influences To Olfactory Nerve Regeneration By Ovariectomy In Mice**

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Introduction Post-infectious olfactory dysfunction (PIOD) is the second most frequent cause of olfactory dysfunction. Furthermore, PIOD is more frequent in middle-aged or older women than men. However, the reason why PIOD occurs in middle-aged and elderly women has not been shown. In this study, we aimed to investigate the gender differences and influence of ovariectomy (OVX) on regeneration in the mouse olfactory system. Materials and methods Bulb-c male and female mice (8 weeks of age; young adult mice) were used. Female mice recieved bilateral OVX or a sham operation (Sham-op) at 8 weeks of age and were injected intraperitoneally with methimazole (75mg/kg) at 9 weeks to induce degeneration of olfactory neurons. The olfactory bulbs were excised respectively at 2, 4, and 6 weeks after administration of methimazole. Samples were paraffin embedded, and histological sections of the olfactory epithelium were used to determine the immuno-reactivity of OMP, Ki-67 and TrkA. In addition olfactory bulb tissue samples were used to measure NGF concentration by ELISA method two weeks after methimazole injection. Results The number of OMP and Ki-67 positive cells were significantly decreased in OVX mice compared to both Sham-op and male mice at 2 weeks after administration of methimazole. However, there was no significant difference in NGF concentrations between the OVX and

sham groups. Conclusion These data suggest that NGF is depleted when olfactory cells are proliferating in both the OVX and Sham-op groups.

128 **Histological Changes During Temporary Anosmia**

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Chemosensory epithelia degenerate and regenerate throughout life. Damage to the olfactory epithelium (OE) induces anosmia (smell loss) and is associated with clinical depression. Intranasal irrigation with detergent solution damages OE cilia in aquatic vertebrates. However, this has not been shown in laboratory rodents. Therefore,we hypothesized that intranasal detergent solutions would temporarily damage mouse olfactory cilia, and thus produce a clinical model for anosmia. Mouse OE structure and function was investigated 24- and 48-hours following intranasal irrigation with a detergent solution (0.1% triton X-100 in PBS). The OE was imaged using both light microscopty and scanning electron microscopy (SEM) techniques. Intranasal irrigation with triton did not appear to damage cilia at either 24- or 48-hours post irrigation. However, in the SEM images, matted cilia and an overall reduced thickness (N= 3) of the mucus layer was evident, indicating a reduction in mucus. OE mucus was then detected using periodic-acid Schiff (PAS) stain and imaged with light microscopy. PAS staining appeared reduced 24-hours, but not 48-hours post irrigation (N= 3). In a seperate group of mice, OE function was investigated with an olfactory-dependent food-finding assay (buried food test). Compared to PBS-treated mice, detergent-treated mice had decreased food-finding ability 24-hours post irrigation that recovered at 48 hours (N= 8/9 per group; ANOVA: $F= 9.7$, $P<0.001$). Thus, intranasal triton induces temporary anosmia with minor histological changes to the epithelium. Future studies will investigate the expression of cilia proteins and Bowman gland function within the OE 24-hours post irrigation.

129 **Differential Time Course Of The Microglia Response To Neonatal And Adult Rat Ctx Is Not Influenced By Dietary Sodium Deprivation**

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Transection of the chorda tympani nerve (CTX) in adulthood (>40 days of age; P40) results in transient loss of taste buds and a preserved CT terminal field. In contrast, CTX performed in neonates (≤ P10) leads to permanent loss of taste buds and papillae, and near total degeneration of the CT terminal field. We observed a greater microglia response in the rostral nucleus of the solitary tract (rNTS) after CTX at P50 compared to P10 CTX. In other models, the timing and protein expression of microglia after injury are known to influence recovery. We assessed Iba1+ and CD68+ (marker for phagocytosis) microglia in the rNTS 1, 2, 4, 7, 14, 21, and 30 days post P10 or P50 CTX in rats. After P50 CTX, microglia increased at all time points (ps <.05). In contrast, the microglia response to P10 CTX started at 1-day post, but returned to baseline levels by 21 days post ($p > .10$), suggesting the microglia response to P10 CTX is not only smaller, but more acute than after P50 CTX. No CD68+ cells were detected in the rNTS for either surgical age at any timepoint examined, indicating microglia were not phagocytosing. Dietary Na restriction has been linked to gustatory system restructuring, as well as mitigating the macrophage response to adult CTX. We injected P50 CTX rats with furosemide, placed them on a Na-deprived diet and assessed Iba1+ microglia 4 days later. While Na deprivation did not influence the number or morphology of microglia following CTX (ps > .10), Na-deprived females had a higher percent of reactive microglia in the rNTS than all other conditions (ps <.05). Our results highlight novel differences in the microglia response to P10 and P50 CTX, and suggest Na-deprivation is insufficient to attenuate that response in adults.

131 **(Achems Undergrad Award Finalist) Time Frequency Analysis Of Olfactory Evoked Potentials In Infants**

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Aim: The sense of smell is of essential importance for infants. Several studies have shown that infants have a well-functioning sense of smell. Infants are able to recognize and discriminate between odors. They are able to discriminate their mothers‘ ‘smell from others. Measurement of olfactory function relied mostly on behavioral, autonomic, and facial responses of infants. Therefore, the interpretation of the odor response is to some degree subjective. Olfactory evoked potentials objectively measure olfactory function, but they have not been measured systematically in new-borns and young infants. Aim of the present study was to investigate central odor processing in young infants by analyzing olfactory induced EEG-power change via time frequency analysis with the focus on the question whether food associated odor and non-food associated odor differentiate in central odor processing. Methods: Term-born healthy infants, who were formula or breast-fed, were included. Medical history and written informed consent was obtained. Odor stimuli were presented via custom-built olfactometer. Breast milk or formula milk was used as food associated odor and Farnesol was presented as a non-food associated odor. EEG was recorded from eleven electrodes according to the international 10-20 system (Fp1, Fp2, F3, Fz, F4, C3, Cz, C4, P3, Pz, P4). EEG data were pre-processed and analyzed using the Letswave 5 toolbox for Matlab, followed by a statistical evaluation. Results: A total of 23 term-born infants (11 male, 12 female) participated with an age range from two to nine months. The study could be completed in all infants and no child had to be excluded. The analysis of the EEG data by means of time frequency analysis is currently in progress. The results of the study will be presented at the conference in detail.

133 **Defining The Just Noticeable Difference (Jnd) In Olfaction Allows Digitizing Smell**

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A major goal in olfaction research is prediction of odor perception from odor structure. To this end we devised algorithms that predict perceptual similarity of multi-component odorants from their physicochemical structure alone (Snitz et al., 2013). Whereas our previous model was validated for "lab mixtures" where components were individually diluted to equal perceived intensity, here we expanded the algorithmic framework to apply to natural odorant mixtures of un-equated intensity. Twenty-six subjects compared 95 mixture pairs whose components were not equated for intensity. Our modified model yielded a correlation of $r=0.68$ $p<0.001$ between predicted and actual similarity ratings. Thus, we now have a metric that approximates perceptual similarity of natural mixtures.
We next conducted an extensive series of three-alternative forced-choice discrimination tests between mixtures differing by various metric distances (50 experiment, ~20 subjects in each). From this data we identified the typical metric distance where humans fail to discriminate mixtures, or in other words, the just noticeable difference (JND) in olfaction. We next selected ~2500 odorant molecules, simulated nearly all possible mixtures containing between 4 and 40 molecules, and applied our JND to this huge cloud of mixtures in order to identify all mixtures that are discriminable from all others. This remaining set is a faithful approximation of all the odors humans can perceive. We then identified ~300 molecules that provided for combinations that are within JND to each of these odors. Put in other words, we can mix subsets of these ~300 molecules to create any odor humans can smell. In this, we have set the ground for digitizing smell.

134 **Reliability Of Olfactory Threshold Testing Depends On The Diversity Of Odor Compounds And Its Quality**

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Results of the recent reports suggest that mixtures of odorants produce significantly more reliable and favorable results of olfactory threshold. Within the current study we aimed to determine the optimal number of odor compounds and examine potential differences caused by qualitative difference between stimuli. One-hundred-nine individuals volunteered to participate in the study procedure wherein their olfactory threshold was measured with stimuli varying in the number of compounds during two sessions. We found that molecularly varied stimuli makes olfactory threshold assessments relatively independent from an individual variability in sensitivity to specific odorants. Nevertheless, this is only true in certain conditions – depending on the number of components and quality of the odorants. On this basis we outline future directions for studies aimed to advance assessments of olfactory threshold by examining the relationships between chemical and physical properties of odorants and threshold assessment results they produce.

136 **Interactions Between Citral-Related Odorants In The Activity Of Periglomerular Interneurons In The Mouse Olfactory Bulb**

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Simultaneous presentation of multiple odorants can produce perceptions that differ radically from either odor individually. These effects are typically considered at the periphery, where odorants compete for receptor binding sites or exhibit receptor antagonism. However, they can potentially occur in the circuitry of the olfactory bulb, where interglomerular connectivity and centrifugal inputs from olfactory cortices appear positioned to shape odorant-evoked activity based on specific odorant conjunctions. To explore this possibility, we used optical neurophysiology to test for mixture interactions in the activity of periglomerular (PG) cells in the mouse olfactory bulb, which both receive strong peripheral input from the olfactory nerve and are modulated by complex input from lateral and top-down circuits. We used citrals, a family of odorants with widespread commercial applications that are particularly limited by our poor understanding of their mixture interactions. As expected, citral-related odorants like citral, citronellal, and dihydromyrcenol evoked activity in a sparse but distinctly overlapping set of olfactory bulb glomeruli. Systematic presentations of citral and citronellal individually and as a mixture at various concentrations revealed a diversity of interactions across glomeruli, notably sub-linear summation of PG cell activity evoked by the mixture compared to its components. The presence of these interactions within populations of interneurons may reflect upstream interactions (i.e. in the olfactory sensory neurons) or local processing within the bulb, but in either case potentially influences the neural representation of the odor to downstream structures.

137 **(Don Tucker Award Finalist) Olfactory Sensory Signals Modulate Respiration-Related Rhythmic Activity In The Prefrontal Cortex And Conditioned Fear Behavior**

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Voluntary control of respiration, especially via rhythmic nasal breathing, alleviates negative feelings such as fear and has been used clinically to manage certain types of panic attacks. The role of breathing-related signals in modulating neural activity throughout the brain is increasingly being recognized as significant, however, the neural mechanisms that link respiration-entrained olfactory inputs to fear circuits remain unknown. Here we show that during conditioned fear-induced freezing behavior, mice breathe at a steady rate (4.05 ± 0.29 Hz, $n=8$), which is strongly correlated with a predominant 4-Hz oscillation in the prelimbic prefrontal cortex (plPFC), a

structure critical for conditioned fear behavior. During freezing, the correlation and coherence between local field potential signals recorded from the olfactory bulb (OB) and plPFC significantly increase from non-freezing periods. Acute ablation of the sensory epithelium via methimazole treatment (n=9) or unilateral naris closure (n=7) significantly reduces the freezing-related OB-plPFC correlation and coherence indicating that olfactory inputs contribute to the 4-Hz oscillation in the plPFC. We then demonstrate anatomical and functional connections between the olfactory pathway and plPFC via circuit tracing and optogenetics. Behaviorally, methimazole treated animals spend significantly more time freezing (341.33 ± 32.43 seconds, n=9) during retrieval sessions as compared to controls (179.75 ± 16.23 seconds, n=8). Increased freezing is also observed in mice with inactivated OBs (via TTX infusion, n=7). Collectively, our results indicate that olfactory inputs can modulate rhythmic activity in fear circuits and suggest a neural substrate that may underlie the behavioral benefits of respiration-entrained olfactory signals.

138 **Infraslow Oscillations In The Mouse Accessory Olfactory Bulb**

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The accessory olfactory bulb (AOB) represents the first stage of information processing in the rodent accessory olfactory system. In the AOB, mitral cells (MCs) receive sensory input from peripheral vomeronasal neurons. This sensory information is (pre-)processed in the AOB and relayed to third-order nuclei in the amygdala and hypothalamus. We recently demonstrated that a subpopulation of MCs is intrinsically rhythmogenic and exhibits slow stereotypical oscillatory discharge triggered by cyclic activation of three interdependent ionic conductances: subthreshold persistent Na^+ current, R-type Ca^{2+} current, and Ca^{2+}-activated big conductance K^+ current. Using voltage- and current-clamp whole-cell recordings in acute AOB tissue slices from C57BL/6 mice, we now identify an excitatory circuit within the AOB that entrains oscillatory activity in a second MC subpopulation. These MCs display periodically increased synaptic input that correlates with their respective rhythmic discharge patterns. Blocking fast glutamatergic synaptic transmission reveals that, at least in a subgroup of MCs, entrainment largely depends on an intact glutamatergic network, whereas a second MC subpopulation appears insensitive to such pharmacological inhibition. Ongoing patch-clamp and Ca^{2+} imaging experiments now aim to identify the exact physiological mechanisms of oscillatory entrainment and synchronization. Together, our long-term goal is to gain a detailed mechanistic understanding of slow synchronous oscillatory discharge in the mouse AOB and thus to dissect the functional role of such rhythmic activity in information processing along the accessory olfactory pathway.

139 **Visualizing Cholinergic Signaling In The Olfactory Bulb**

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Cholinergic neurons from the horizontal limb of the diagonal band of Broca (HDB) innervate most layers of the olfactory bulb (OB), with dense input terminating in the glomerular layer. While multiple studies have demonstrated the importance of acetylcholine release within the OB in terms of odor coding and perception, nothing is known regarding the basic characteristics of cholinergic fiber activity within the OB. To explore how cholinergic fiber activity within the OB is influenced by odor input, different states, and novel stimuli, we expressed the calcium indicator GCaMP6f in basal forebrain cholinergic neurons using viral expression in ChAT-cre mice. We first characterized the extent and specificity of the labeling within the OB using both in vivo 2-photon imaging and immunohistochemistry in fixed tissue. Using wide-field imaging in the OB, we characterized the activity of cholinergic terminals to odor input in awake and anesthetized mice. Overall, we find rapid and diffuse odor-evoked activity in the OB that diminishes with anesthesia. Using a panel of similar and dissimilar odorants, preliminary findings suggest that odor stimulation evokes wide-spread, non-specific activation across much of the dorsal surface. Electrical stimulation of the HDB while OB imaging cholinergic fiber activity will be used to determine how previously used stimulation parameters affect OB cholinergic responses. Finally, as acetylcholine release in other regions is often associated with stimulus novelty and previous reports suggest decreased HDB activity as odors become familiar, we are exploring the extent to which HDB cholinergic input to the OB changes as odors become familiar.

140 **Sniff Invariant Odor Concentration Coding**

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Sampling regulates stimulus intensity and temporal dynamics at the sense organ. Despite variations in sampling behavior, animals must make veridical perceptual judgments about external stimuli. In olfaction, odor sampling varies with respiration, which influences neural responses at the olfactory periphery. Nevertheless, rats were able to perform fine odor intensity judgments despite variations in sniff kinetics. To identify the features of neural activity supporting stable intensity perception, in awake mice we measured responses of Mitral/Tufted (MT) cells to different odors and concentrations across a range of sniff frequencies. Amplitude and latency of the MT

cells' responses vary with sniff duration. A fluid dynamics (FD) model based on odor concentration kinetics in the intranasal cavity can account for this variability. Eliminating sniff waveform dependence of MT cell responses using the FD model significantly improves concentration decoding. This suggests potential schemes for sniff waveform invariant odor concentration coding.

141 **Functional Characterization Of A Class I Odorant Receptor Regulatory Element**

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Olfactory sensory neurons in the main olfactory epithelium choose from three classes of chemosensory G-protein coupled receptors: class I and class II odorant receptors, and TAARs. In mice, roughly 10% of the OR gene repertoire are class I genes. The functional contribution of class I OR genes to olfaction is not known. The Class I OR genes are found in an extensive cluster, interspersed among other genes, making it difficult to functionally delete the entire cluster. Given that long-range, cis-acting enhancer elements play a critical role in the expression of class II ORs, an alternate approach would be to inactivate similar regulatory elements in the class I cluster. To this end, we identifiifed three putative enhancer elements (E1-E3) in the class I OR cluster, based on sequence conservation and presence of known motifs that are important for OR gene regulation. One of the elements (E1) was capable of driving OSN-specific reporter gene expression in transgenic mice. Using CRISPR-based gene editing in mice, we found that deleting E1 significantly reduced expression neighboring class I OR genes. In vivo imaging in awake mice revealed a severe reduction in odor-evoked glomerular response patterns in mice that lack E1. The loss of responses is particularly severe for short chain organic acids and related compounds. Together, our results define a class I-specific cis-acting enhancer element within the class I cluster, and provide an approach to study how the loss of class I ORs affects olfactory function.

142 **Inhibitory Signaling In Mammalian Olfactory Transduction Mediated By GA_O**

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Many G protein-coupled receptors (GPCRs) do not activate a single signaling pathway, but instead a network mediated by multiple effectors in a ligand-dependent manner. Olfactory GPCRs in mammalian olfactory receptor neurons (ORNs) mediate excitation through the $G\alpha_s$ family member $G\alpha_{olf}$. Here, we provide evidence that a PI3K-mediated inhibitory signaling pathway is associated with $G\alpha_o$, the second most abundant G protein in ORNs. We demonstrate that odor-evoked PI3K-dependent inhibitory signaling is no longer detectable in mice carrying an OMP-Cre conditional deletion of Gnao ($cGnao^{-/-}$). We also show that $G\alpha_o$ expression is reduced in the ORNs of the $cGnao^{-/-}$mice, and that fluorescently-tagged $G\alpha_o$ is trafficked to the cilia of native ORNs using viral-mediated ectopic expression. $G\alpha_o$ was also implicated in mediating odor-dependent activation of PI3K by a single olfactory receptor (OR) *in vitro* using an ELISA. Single cell RT-PCR was used to identify an OR expressed by mammalian ORNs that were activated by octanol and inhibited by citral in a PI3K-dependent manner. The functionality of the identified OR (Olr1845) persisted in a HEK293T cells. Collectively, these results are consistent with the idea that a single OR can interact with two different G protein complexes to activate distinct signaling pathways in a functionally identified, ligand-dependent manner.

143 **Taar5 Mediates State-Dependent Valence Of Trimethylamine And Inter-Male Social Interactions In Mice**

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Trimethylamine (TMA) is a putrid odorant that is enriched in the urine of adult male mice. TMA selectively activates TAAR5, one of 14 trace amine-associated receptors expressed in the mouse main olfactory epithelium. The TAARs have been shown to be important in mediating attraction and aversion to amines. We reasoned that if TMA functions as a male-specific social cue, then the TAAR5-mediated behavioral response to this odorant may depend on the social and neuroendocrine status of mice. To test this, male mice were pair housed and their social status was determined via differential scent marking. Using a place preference assay, we observed that subordinate males were averse to TMA, while dominant males were attracted. Similarly, we observed state-dependent valence of TMA in females—diestrus females were averse to trimethylamine while estrus females failed to display a preference. Importantly, all valence responses to TMA were abolished in TAAR5 deletion mice, demonstrating that both aversion and attraction to TMA require TAAR5. To examine the ethological relevance of altered TMA perception, we tested whether deleting TAAR5 affects male social interactions. Dominant male mice lacking TAAR5 exhibited a marked decrease in several aggressive behaviors compared to dominant wild-type littermates. Importantly, this loss of aggression is due to an olfactory (chemosensory) deficit as we were able to rescue normal aggression by selective expression of TAAR5 in the olfactory epithelium. Our data provide strong evidence that trimethylamine is a social cue in mice and define a novel role for TAARs in mediating intraspecific chemical communication. Moreover, these results define a single olfactory receptor that influences social interactions via the main olfactory pathway.

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Spontaneous Ca^{2+} Oscillation Induces Vesicle Release/Recycling In Trpm5-Expressing Microvillous Cells Of Mouse Main Olfactory Epithelium

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The main olfactory epithelium (MOE) is primarily made up of four distinct cell types. Mechanisms that coordinate the activities of these cells, which are important for maintaining MOE functions, are understudied. We previously reported that transient receptor potential channel M5-expressing microvillous cells (TRPM5-MCs) in the MOE are responsive to diverse chemical stimuli and capable of releasing acetylcholine (ACh) to influence activities of olfactory sensory neurons and supporting cells (Ogura et al., 2011); and that Skn-1a knockout mice lacking TRPM5-MCs display compromised odor responses and olfactory-guided behavior after being challenged with a chemical mixture for two-weeks (Lemons et al., 2017). To further understand their function, we imaged TRPM5-MC intracellular Ca^{2+} responses to ATP and an odor mixture as well as the uptake of an endocytotic dye pHrodo Red dextran. Responsive TRPM5-MCs significantly increased cytosolic pHrodo-labeled puncta compared to control and non-responsive TRPM5-MCs, indicating that chemical activation led to vesicle release of signaling molecules. Interestingly, we also found that about 30% of TRPM5-MCs showed spontaneous oscillation of intracellular Ca^{2+} levels, resulting a higher average Ca^{2+} level than that of non-oscillating cells. The Ca^{2+} oscillation relied on extracellular Ca^{2+}, but was independent of ATP and expression of TRPM5. Interestingly, cytoplasmic pHrodo labels were also higher in the oscillating cells than non-oscillating cells, suggesting spontaneous vesicle release/recycling occurs without stimulation. Our data indicate both spontaneous oscillation and stimulation-evoked Ca^{2+} increases can trigger vesicle release in TRPM5-MCs, supporting their role in paracrine regulation of the MOE multicellular network.

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Vapor Detection And Discrimination With A Panel Of Odorant Receptors Expressed In Heterologous Cells

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Mammalian olfactory systems have evolved extraordinary capability that discriminates volatile odorants in the environment using hundreds of olfactory receptors encoded in the genome. Fundamentally, olfactory relies on the interaction of odorant molecules and their cognate olfactory receptors (ORs). In this study, we identified ORs robustly responding to a set of odorants and developed an OR-based odorant sensor system, capable of detection and discrimination of odorants presented as vapor. First, we conducted a large-scale cell-based screening using the majority of mouse ORs against seven odorants using the luciferase reporter gene assay in which cells were directly stimulated by various odorants dissolved in the media. To test whether ORs expressed in heterologous cells are activated by odors presented in vapor phase, we selected a diverse set of 31 ORs robustly responding to at least one of the tested odorants. We expressed individual ORs and measured responses against vapor phase odor stimulation using the GloSensor assay system, capable of measuring cAMP levels in real time. All the tested structural analogs differentially activated at least one OR . Last, we asked whether co-expressing an olfactory metabolic enzyme affects OR activation by volatile odorants. We chose a carboxylesterase (Ces) member Ces1d to investigate the effect of OR responses. Co-expression of Ces1d resulted in marked enhancement or suppression of OR activation in specific combination of odorant-OR. These results form a basis for OR-based volatile sensor assays.

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Trpm5-Expressing Microvillous Cells In The Mouse Main Olfactory Epithelium Influence Regional Homeostasis During Chemical Exposure

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Inhalation places the main olfactory epithelium (MOE) in the mammalian nasal cavity in constant contact with the external environment, exposing it to potentially noxious stimuli such as pollutants and odorous irritants which can adversely impact MOE structure and function. Intercellular mechanisms for maintaining MOE integrity and regulating olfactory activity in response to environmental conditions are poorly understood. We previously reported that transient receptor potential channel M5-expressing microvillous cells (TRPM5-MCs) in the MOE are cholinergic and responsive to strong odor stimuli. Skn-1a knockout mice (Skn-$1a^{-/-}$) lacking TRPM5-MCs show reduced odor-evoked electrophysiological responses and impaired olfactory behavior after continuous two week exposure to inhaled chemicals. Here, we exposed Skn-$1a^{-/-}$ and control mice to chemicals or water for two weeks and examined morphology and cell marker expression in the MOE using immunohistochemistry. We observed increased density of apoptotic cells positively labeled with cleaved caspase-3, decreased thickness of the epithelium and OMP-expressing mature olfactory sensory neuron (OSN) layer, and decreased density of GAP-43 immunopositive immature OSNs in the anterior dorsal recess of the MOE in chemical-exposed control mice. While the posterior dorsal recess also showed an increase in the density of apoptotic cells, there was a lack of epithelial thinning and increased density of immature OSNs. We did not observe these changes consistently in chemical-exposed Skn-$1a^{-/-}$ mice. In sum, there was a marked region-specific response to chemical exposure in control mice, but not in Skn-$1a^{-/-}$ mice, indicating a role of TRPM5-MCs in maintaining MOE homeostasis and region-specific protective regulation.

147 **Consensus Odorant Receptors Support Robust Cell Surface Expression In Non-Olfactory Cells**

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Mammalian odorant receptors (ORs) are diverse members of G-protein coupled receptors abundantly expressed in the olfactory cilia membrane. The vast majority of ORs show poor cell surface expression in non-olfactory cells due to endoplasmic reticulum (ER) retention. Here we investigated amino acid residues that involved in cell surface expression of ORs in heterologous cells. We conducted a large screening by transfecting each mouse OR with an N-terminal Rho tag in HEK293T cells and performed FACS to quantify surface OR levels in these cells. We selected 26 and 126 ORs that show positive and negative cell surface expression, respectively, for a statistical approach. We identified 66 critical sites scattered throughout the receptors associated with cell surface expression. Inconsistent with the OR-specific retention signals, divergence from conserved amino acid residues among ORs are associated with poor cell surface expression. To directly test importance of conserved residues, we synthesized nine "consensus ORs" based on the most frequently used residues for a given human OR subfamily and expressed in heterologous cells. Most of the consensus ORs showed high cell surface expression levels that surpass any natural ORs in HEK293T cells and NIH3T3 cells. Furthermore, they showed OR specific responses to tested odorants, suggesting proper folding. Our results suggest divergence from conserved residues underlies ER retention of ORs in non-olfactory cells.

148 **A Subset Of Olfactory Sensory Neurons Express Foxj1-Driven Gfp**

Shivani Pathak[1,2,3], Eric Larson[1,2,3], Thomas E. Finger[1,2,4], Vijay R. Ramakrishnan[1,2,3]

[1]University of Colorado School of Medicine, Aurora, CO, United States, [2]Rocky Mountain Taste and Smell Center, Aurora, CO, United States, [3]Department of Otolaryngology, Aurora, CO, United States, [4]Department of Cell and Developmental Biology, Aurora, CO, United States

Each olfactory sensory neuron (OSN) possesses 10-30 sensory cilia that extend into the mucosal layer of the olfactory epithelium (OE) as well as a basal axon directed toward the olfactory bulb. The cilia, although in the 9+2 microtubule configuration, are immotile as they lack the dynein arm necessary for motility. Cells of the respiratory epithelium that have motile cilia arise from progenitors that express the forkhead box protein J1 (FOXJ1), a member of the FOX family transcription factors leading to the hypothesis that FOXJ1 is a transcriptional regulator of motile ciliogenesis. FOXJ1 knockout mice show a complete loss of the axonemes of motile cilia from the multiciliated cells of the airways (Choksi, 2014). Using a FOXJ1-eGFP reporter mouse (Ostrowski et al, 2003), we find robust eGFP expression not only in the ciliated respiratory cells of the nasal cavity, but also in a distinctive subset of apparent OSNs in the OE. These GFP-positive cells lie at the extreme apical part of the layer of OSNs, just below the level of the supporting cells. Each GFP-positive OSN has a thin basal process that can be followed into the bundles of OSN axons in the submucosa. Consistent with this, GFP-positive axons are evident in the olfactory layer of the olfactory bulb but their locus of termination is unclear since many cells within the olfactory bulb also express the FOXJ1-driven GFP. The nature of these bulbar GFP-positive cells is unclear at this juncture as they do not resemble known bulbar neuronal types. These findings suggest that FOXJ1 is involved in the development of a subset of mature OSNs that may have motile cilia and beg further analysis as to whether these OSNs are responsive to specific classes of inhaled odorants and project to specific glomeruli within the olfactory bulb.

9:00 - 10:30 AM	Estero Foyer
Coffee Break	

10:30 - 12:30 PM	Calusa FGH
INHIBITORY NEURONAL CONTRIBUTIONS TO CHEMOSENSORY PROCESSING	

Chair(s): Julian Meeks

10:30 **Introduction**

Olfactory Bulb Granule Cells Gate Oscillatory Transitions During Odor Sampling

10:40 Leslie Kay
University of Chicago, Dept of Psychology, Institute for Mind and Biology, Chicago, IL, United States

The mammalian olfactory system presents well-defined local field potential oscillations in the gamma (40-100 Hz) and beta (15-30 Hz) frequency ranges. Rats trained to discriminate odors in either 2-alternative choice or go/no-go behavioral tasks produce a reliable sequence of oscillatory events in the olfactory bulb (OB) and pyriform cortex (PC): 2-4 sniffs accompanied by gamma oscillations locally in the OB (feedforward sensory state), followed by an abrupt transition to beta oscillations that engage the entire circuit (global state). Beta oscillations are also initiated after repeated sampling of high volatility odorants in a sensitization-like fashion. Our modeling results suggest that the transition from gamma to beta oscillations is mediated by multiple factors that increase the excitability of OB granule cells, activating NMDA and voltage-dependent calcium channels. Beta oscillations are thus supported by slower and more coordinated GABA release by granule cells under elevated excitation. Excitability changes are likely mediated by peri-somatic top-down synapses in learning-based circumstances and strong sensory drive to granule cells during odor sensitization. Data supporting the model are presented from pharmacological manipulations and OB granule cell unit recordings.Funding: NIDCD R01 DC014367

A Population Of Projection Neurons That Inhibits The Lateral Horn But Excites The Antennal Lobe In *Drosophila*

11:10 Kazumichi Shimizu
The University of Tokyo, Institute of Molecular and Cellular Biosciences

In the insect olfactory system, odor information is transferred from the antennal lobe (AL) to higher brain areas by projection neurons (PNs) in multiple AL tracts (ALTs). In several species, one of the ALTs, the mediolateral ALT (mlALT), contains some GABAergic PNs; in the *Drosophila* brain, the great majority of ventral PNs (vPNs) are GABAergic and project through this tract to the lateral horn (LH). Most excitatory PNs (ePNs), project through the medial ALT (mALT) to the mushroom body (MB) and the LH. Recent studies have shown that GABAergic vPNs play inhibitory roles at the axon terminals of the ePNs in the LH. However, little is known about the properties and functions of vPNs at their dendritic branches in the AL. Here, we used optogenetic and patch clamp techniques to investigate the functional roles of vPNs in the AL. Surprisingly, our results show that specific activation of vPNs reliably elicits strong excitatory postsynaptic potentials (EPSPs) in ePNs. Moreover, the connections between vPNs and ePNs are mediated by direct chemical synapses. Neither pulses of GABA, nor pharmagological, or genetic blockade of GABAergic transmission gave results consistent with the involvement of GABA in vPN-ePN excitatory transmission. I will discuss a potential role of the vPN-ePN excitatory connections in olfactory information processing.

Chemosensory Processing Roles Of Accessory Olfactory Bulb Interneurons

11:30 Julian Meeks
Assistant Professor, University of Texas Southwestern Medical Center

The mammalian accessory olfactory bulb (AOB) is the only dedicated information processing circuit in the pheromone- and kairomone-associated accessory olfactory system (AOS). Proper AOS function has been directly implicated in the establishment and maintenance of social, reproductive, and predatory avoidance behaviors. Inhibitory interneurons massively outnumber excitatory neurons in the AOB, but their roles in information processing remain minimally understood. Here, we present work from the lab investigating the impact of defined populations of AOB interneurons on information processing and AOB plasticity. First, we will present work investigating the cellular and network mechanisms of AOB inhibitory plasticity following the male-male "resident-intruder" test, a salient, AOS-mediated behavioral paradigm. We will then briefly discuss ongoing work into external granule cells, a mysterious population of AOB interneurons with unknown function. We conclude by presenting a working model of inhibitory function in the mouse AOB.

Formation Of Interneuron Sensory Maps In The Mouse Olfactory Bulb

12:00 Benjamin Arenkiel
Associate Professor, Depts. of Molecular and Human Genetics and Neuroscience, Baylor College of Medicine

Sensory maps are created by networks of neuronal responses that vary with their anatomical position, such that representations of the external world are systematically and topographically organized within the brain. Current

understanding by studying excitatory maps, is that maps are sculpted and refined throughout development and/or through sensory experience. Investigating the mouse olfactory bulb, where ongoing neurogenesis continually supplies new inhibitory granule cells into existing circuitry, we isolated the development of sensory maps formed by inhibitory networks. Using *in vivo* calcium imaging of odor responses, we compared functional responses of both maturing and established granule cells. We found that inhibitory sensory maps become broader with maturation, and are sensitive to experience. These data describe the development of an inhibitory sensory map as a network, highlighting the differences from previously described excitatory maps.

10:30 - 12:30 PM	Calusa ABC

BARIATRIC SURGERY AND ITS EFFECTS ON TASTE AND FOOD SELECTION

Chair(s): Alan Spector and Carel le Roux

The Prevailing Views On Bariatric Surgery Regarding The Effects On Taste And Food Selection

10:30 Carel le Roux
Diabetes Complications Research Centre, University College Dublin, Dublin, Ireland

Bariatric surgery such as Roux-en-Y gastric bypass (RYGB) is currently the most effective treatment available for weight loss and Type-2 diabetes. It is of great interest to clinicians and basic scientists studying the controls of feeding and energy regulation. Understanding gastrointestinal regulation of appetite offers a view on a therapeutic window for obesity which promises better clinical benefits and fewer side-effects. Bariatric surgery is a good model to investigate appetite reduction in humans and rodents, because of the major changes in appetite with subsequent weight loss maintenance. Despite the commonly held view by clinicians that RYGB patients change their food preferences away from fats and sugars in favor of less energy dense alternatives such as vegetables, the empirical support for this claim is equivocal. It is currently thought that the taste and palatability of fats and sugars is affected by the surgery. Virtually all of the studies in humans to date are overwhelmingly reliant on verbal report and dietary recall measures. Although the data from such methods can provide initial insight regarding the consequences of the surgery and generate hypotheses, without direct and objective validation, the results are vulnerable to inaccurate interpretation and could lead to spurious conclusions. Moreover, such measures make it more difficult to logically bridge with data collected from animal models. This symposium will review some of these issues and present recent findings from experiments designed to use direct measures of feeding and food selection in humans and in a rat model. The symposium will explore the connection between taste and nutritional choices and intake control in the context of a surgical approach to the treatment of obesity and diabetes that has remarkable clinical outcomes.

The Effects Of Roux-En-Y Gastric Bypass On Food Selection And Taste-Related Motivation

10:40 Alan Spector
Department of Psychology and Program in Neruoscience

Roux-en-Y gastric bypass (RYGB) has become a common bariatric surgical procedure because of its long-term effectiveness at promoting weight loss and curtailing type-2 diabetes mellitus. In addition to decreasing appetite and food intake, RYGB is currently thought to instigate changes in food preference and selection in a direction away from high fat and high sugar options based on changes in the relative palatability of these items. The support for this in humans is equivocal and largely derived from verbal report measures. In rodent models, there is evidence that RYGB leads to a progressive decline in the relative caloric intake of fat and an increase in the relative caloric intake of complex carbohydrates. Moreover, RYGB decreases the preference for sucrose and fat solutions in long-term two bottle tests (vs. water) in rats. However, the motivational potency of sugar and fat solutions, as assessed in a variety of short-term taste tests, appears to be relatively unaffected by the surgery. The observation that RYGB-induced changes in sugar and fat intake are often progressive suggests that experience is critical in this process. The working hypothesis of our group is that rats, and perhaps humans, are learning how to adjust their intake to minimize negative postingestive events. If such learned changes are unaccompanied by modulation in the palatability of the taste of the food then this process would be akin to conditioned avoidance. In contrast, if the palatability of the taste of the food reverses then a conditioned aversion process would be implicated. Understanding the behavioral properties of RYGB-induced changes in food selection should help facilitate efforts to identify the underlying physiological/neural mechanisms. This talk will review current findings in this context.

Free-Living *Vs* Laboratory Assessment Of Food Selection And Intake In Bariatric Patients

11:10 Barbara Livingstone
Professor of Nutrition, Ulster University

Free-living *vs* laboratory assessment of food selection and intake in bariatric patient A robust methodology to assess various components of eating behaviour is critical for understanding the causal mechanisms underlying changes in food intake after bariatric surgery. The ideal experimental protocol should aim to optimise internal and external validity but in practice often involves compromises between them.While the external validity of free-living studies of food intake in bariatric patients is theoretically high, they are fraught with inherent and extrinsic methodologic problems which negate their internal validity. Traditional measurements of food intake have relied on a variety of self-report methods all of which are prone to bias, particularly under-reporting of energy intake and differential misreporting of macronutrients. Novel applications of information technologies in dietary assessment are unlikely to resolve the inherent bias related to self-reported data.On the other hand, the internal validity of measurements conducted under tightly controlled laboratory studies is high because they offer the highest degree of sensitivity and control over intervention and outcome measures. This presentation will provide interim results on covertly observed *ad lib* food intake and macronutrient selection in 32 Roux-en-Y gastric bypass patients and 32 controls living under fully residential conditions for 36 hours at each of 4 time points (1 month pre-surgery, 3, 12 and 24 months post-surgery: controls time matched). Robust laboratory observations of food intake are essential for providing crucial experimental data to complement free-living studies but it is essential that laboratory and field research in this area advance together to fully understand the clinical significance of changes in food selection and intake following bariatric surgery.

Direct Measurement Of Macronutrient Intake 12 Months After Roux-En-Y Gastric Bypass (Rygb).

11:40

Natasha Kapoor
Conway Institute, University College Dublin

Patients after gastric bypass (RYGB) verbally report a reduction in calorie dense foods. This shift in preferences is controversial and requires confirmation by direct measurement. The exaggerated satiety gut hormone responses after RYGB may contribute to changes in food preferences. Our interim analysis assessed the selection and intake of foods varying in macronutrient content in a buffet paradigm and tested whether blocking gut hormone responses would impact relative macronutrient consumption in RYGB (n=4) and normal weight subjects (n=6) 1 mo before and 12 mo after intervention. Subjects received saline and Octreotide (50μg, sc) in a cross over design at 12 mo to block gut hormone responses. At 12 mo, total caloric and relative macronutrient intake remained unchanged in normal weight subjects. In contrast, RYGB subjects reduced calorie intake by 47% (1949±257 to 1039±101kcal, p=0.02) with a 30% decrease in relative carbohydrate intake (49.1±5.2 to 34.5±2.9%, p=0.05); although there was a 33% increase in relative fat intake and a 19% increase in relative protein intake after RYGB, these changes failed to reach statistical significance. Calorie intake was unaffected by Octreotide in both normal weight and RYGB subjects. After RYGB, Octreotide increased relative carbohydrate intake by 9.9±1.7%, p=0.001 compared to saline. Relative protein and fat intake were unchanged. Thus, in this preliminary interim analysis, suppression of gut hormone responses did not affect caloric intake 12 mo after RYGB, but did partially reverse the effect of the surgery on relative carbohydrate intake. We demonstrated the feasibility of taking direct measurements of intake and food selection in RYGB patients as a means of interrogating the behavioural and physiological mechanisms underlying the effects of the surgery.

12:00

Effects Of Bariatric Surgery On Ingestive Behavior And Sweet Taste Perception In Subjects With Obesity

M. Yanina Pepino[1,2]

[1]Department of Food Science and Human Nutrition, College of ACES, University of Illinois at Urbana-Champaign, Urbana, IL, United States, [2]Division of Nutritional Sciences, College of ACES, University of Illinois at Urbana- Champaign, Urbana, IL, United States

Bariatric surgery procedures provide the most effective treatment for obesity. Currently, the most popular bariatric surgeries performed worldwide are Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and laparoscopy adjustable gastric banding (LAGB). All three procedures decrease gastric volume, but unlike LAGB, in which the stomach/intestine remain intact, both SG and RYGB alter gut anatomy. Patients who undergo RYGB or SG surgery lose more weight than those who undergo LAGB. However, the specific mechanisms responsible for these differences in weight loss between procedures are not fully understood. It is possible that RYGB- and SG-induced changes in taste perception affects food choices and contributes to a decrease in calorie intake. Findings from studies that measured sweet taste thresholds suggest that taste sensitivity is increased after RYGB surgery and thus, patients reset their palates to like less sugary foods. To study weight-loss independent effects of RYGB and SG surgeries on taste perception, we evaluated patients before and after losing ~20% weight loss by RYGB, SG, or LAGB. We found that patients who underwent RYGB or SG, but not LAGB, shifted palatability from pleasant to unpleasant after repetitively tasting sucrose. Furthermore, we found that the dislike patients experience when repetitively tasting sweetness post- surgery was not due to an enhanced perception of sweetness intensity. By using a battery of well-validated sensory techniques, we found that the sensory-discriminative component of taste perception remained remarkably unchanged after weight loss induced by RYGB, SG, or LAGB. These data suggest that changes in eating behavior after RYGB/SG are not due to changes in peripheral coding of taste, but more likely to changes in central gustatory reward.

12:30 - 1:30 PM	Cove at Tarpon Bay
Travel Fellowships for Diversity Award Luncheon	

12:30 - 1:30 PM	Lunch On Own
Lunch On Own	

Lunch items will be available for sale in Calusa Foyer

12:30 - 1:30 PM	Blue Heron
Chemical Senses Editorial Board Meeting	

1:30 - 3:30 PM	Calusa ABC
INDUSTRY SYMPOSIUM: TEXTURE AND ORAL PROCESSING: FROM BASIC MECHANISMS TO PRACTICAL APPLICATIONS	

Chair(s): Beverly Tepper

Introduction

1:30 Beverly Tepper
Rutgers University

In order for the taste and flavor of a food to be to be appreciated, it must be orally l processed. Oral processing of texture involves physical forces that prepare the food bolus for swallowing. This can include biting, chewing, manipulation of the food in the mouth, and mixing it with saliva. Texture is also a tactile sensation related to touch and what is commonly referred to as 'mouthfeel' characteristics. Although texture is a powerful driver food acceptance and rejection, our understanding of texture perception lags well behind other oral sensations. This symposium brings together 5 experts working in different areas of oral processing and texture perception. The first three speakers will discuss the biomechanics of chewing, basic cellular and molecular mechanisms of texture perception, and the functional significance of touch receptors and free nerve ending in lingual tissue. The last two speakers will address Individual differences in oral texture perception and food processing and their effects on taste and flavor perceptions, eating rate and food consumption.

Modulation Of Feeding Behavior And Neural Activity With Variation In Food Material Properties In Nonhuman Primates.

1:35 Callum Ross
Department of Organismal Biology and Anatomy

Nonhuman primates consume a wide variety of foods in the wild so they need to be able to modulate their feeding behavior in response to variation in food material properties. But which aspects of primate feeding behavior vary with food properties and which aspects are less variable? How do biomechanical constraints on primate feeding system design affect this variation? The basic pattern of primate jaw and tongue kinematics and muscle activity are reviewed before summarizing the available data on food related variation in these patterns. The majority of variance in jaw kinematics is found between gape cycles within feeding sequences, not on foods with different material properties: i.e., effects of feeding on foods with different material properties are smaller than the effects of changes in bolus properties between cycles within sequences. Species effects on jaw kinematics during the power stroke are only evident for hard, brittle foods (such as nuts). Primates have the ability to modulate their jaw movements in response to changing bolus properties, but the basic patterns of jaw kinematics are shared by different species. Similar analyses of variance in EMG amplitudes and relative timing again reveals that most of the variance in relative timing of jaw muscle activity is nested between chewing cycles, within feeding sequences.This suggests that variation in food bolus properties within sequences elicits greater variation in jaw kinematics via modulation of jaw muscle relative timing than does variation in food material properties associated with different foods. In contrast, variation in relative EMG amplitudes is more equally distributed both between and within feeding sequences. This reflects the fact that different foods require different amounts of force to process, and that the amount of force needed to process the bolus changes through the chewing sequence (mostly decreasing). The basic motor and kinematic patterns underlying primate feedign behavior are ancient, readily modulated, and adaptable. Increased extra-oral food processing in humans (e.g., cooking) may explain the reduced size of the human feeding system, as well as some pathologies.

Oral Tactile Sensitivity And Its Role In Texture Perception

2:00 Christopher T. Simons
The Ohio State University, Columbus, OH, United States

Food texture contributes to product acceptance, but oral texture perception is incompletely understood. Whereas

mechanosensation underpins texture perception, few studies have assessed oral tactile sensitivity or linked it to perception of food textures. Recently, we have assessed lingual tactile sensitivity by measuring threshold and suprathreshold sensitivity to punctate and roughness stimuli and by evaluating subjects' ability to detect and differentiate edges and points. We have also compared sensitivity to these stimuli in the tongue to that obtained in the glabrous skin of the forefinger. Results from these studies will be discussed and related to the perception and liking of various food textures.

Exploring The Molecular And Neural Mechanisms Underlying Food Texture Sensation

2:25 Yali Zhang
Monell Chemical Senses Center

Exploring the Molecular and Neural Mechanisms Underlying Food Texture Sensation

John Mack 1, Tingwei Mi 1, Craig Montell 2, Yali Zhang 1 1 Monell Chemical Senses Center, Philadelphia PA 19104 2 Neuroscience Research Institute, University of California, Santa Barbara CA 93106Food texture, the physical properties of food including food hardness and viscosity, is a critical element of food flavor. Food texture is mainly detected through the activation of mechanosensory receptors and cells in taste organs by forces produced during food chewing, enabling animals to make assessments of the stiffness and/or softness of the food. Although food texture plays a critical role in food preference, the molecular nature of the mechanosensory receptors and neurons dedicated to perceiving food texture remained poorly understood. To tackle this key question we, for the first time, established the fruit fly, *Drosophila melanogaster*, as an ideal animal model. We combined sophisticated fly genetic tools with cutting-edge techniques, including functional Ca2+ imaging and optogenetics, to dissect the molecular and cellular basis of food texture sensation. We will present our discoveries regarding the receptors and cells that orchestrate food texture sensation. Given that the conceptual framework of oral sensory responses is fairly conserved between flies and mammals, our work focusing on food texture sensation in the fruit fly may lead to a breakthrough in understanding how food texture affects food preference in other organisms, including humans.

The Role Of Oral Processing In Food Texture, Flavour Perception And Consumer Preference

2:40 Marco Morgenstern
Research Leader, New Zealand Institute for Plant & Food Research

The way food is broken down in the mouth during chewing affects the perception of texture and flavour. A better understanding of texture perception is needed that includes mechanical and physiological processes in the mouth during mastication and swallowing. Current research is exploring the link between food properties and texture/flavour perception during oral processing where the structure of food is broken down over time and the perception is continually changing. Novel methods for assessing dynamic sensory perception, such as temporal dominance of sensations, linked with physico-chemical assessments of food and food bolus are leading to new insights in processes involved in texture perception. New methods and ideas are emerging to influence flavour intensity by altering the food structure and subsequent texture breakdown in the mouth. Also, the way people eat and demographic factors such as age or culture affect perception and patterns are observed that group people by their oral processing behaviour and capability. While many questions remain, these patterns provide a powerful link between consumer preferences and food properties which in turn is an opportunity for tailoring food products more specifically to consumers by taking dynamics of eating into account. This presentation highlights the multidisciplinary nature of this research and the opportunities and challenges facing the food industry to design foods more specifically tuned to consumers' physiology and eating behaviours.

Texture, Oral Processing And Satiation

3:05 Paul Smeets
Division of Human Nutrition, Wageningen University and University Medical Center Utrecht

Food texture is a key food property that affects eating rate and thereby intake. In combination with energy density, 'fast' foods with a soft texture promote overconsumption and weight gain. Food texture affects all stages of eating behavior: anticipation (e.g. expected satiety), food oral processing and gastric digestion, as well as associated appetite feelings. I will review the effects of texture on chewing behavior, also addressing individual differences in eating rate, oro-sensory stimulation, satiation and gastric emptying. In conclusion, food texture manipulations can be used to alter the consumption experience as well as energy intake.

3:15 - 3:45 PM	Calusa Foyer
Coffee Break	

3:30 - 5:30 PM	Calusa ABC
The Barry Davis Workshop: Funding Opportunities for the New Investigator	

This workshop will include an overview of research, training, and funding opportunities for graduate students, postdoctoral fellows, and early stage investigators. The discussion will provide practical information on how grant applications are processed within NIH/NIDCD, including Institute and study section assignments, the peer review process, Advisory Council activities, pay lines, and the roles of program and review staff.

Chair(s): Kausik Ray, PhD and Susan Sullivan, PhD

7:00 - 9:00 PM	Calusa ABC
Polak Award Presentations	

Chair(s): Nirupa Chaudhari

7:00

Functional Organization Of The Islands Of Calleja In The Olfactory Tubercle

Yun-Feng Zhang[1], Janardhan P. Bhattarai[1], Julia Mohrhardt[2], David Fleck[2], Wenqin Luo[1], Marc Spehr[2], Minghong Ma[1]

[1]Department of Neuroscience, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, United States, [2]Department of Chemosensation, Institute for Biology, RWTH Aachen University, Worringerweg 3 Aachen, Germany

The Islands of Calleja (IC) are dense cell clusters located in the ventral striatum, predominantly in the olfactory tubercle (OT), an olfactory cortical region interconnected with brain reward centers. However, the functional properties and synaptic organization of the IC neurons are largely unknown. Unlike the ventral striatum which mainly contains medium spiny neurons (MSNs) expressing dopamine D1 or D2 receptor, the IC contain tightly packed, GABAergic granule cells expressing D3 receptor. By crossing transgenic D3-Cre mice with Cre-dependent reporter lines, we obtained D3-tdTomato and D3-ChR2 (channelrhodopsin-2) mice for whole-cell patch clamp recording and optogenetic manipulation of the IC neurons. Based on the electrophysiological properties, the IC neurons can be classified into two subtypes. Upon current injections, ~70% (39 out of 55) of the cells fired multiple spikes while the remaining 30% fired only a single spike. Further voltage-clamp analysis revealed that only the multiple spiking neurons exhibited predominant transient potassium current (I_A) — fast inactivation of I_A may allow these neurons to fire repeatedly. We next examined local synaptic connections of the IC neurons. Upon blue light activation of the IC D3-ChR2 neurons, inhibitory postsynaptic currents were evoked in 66.7% (24 out of 36) of the OT MSNs and the majority (22 cells) received monosynaptic connection. Conversely, nearly half of the IC neurons (13 out of 29) received monosynaptic inhibition from the OT D1 MSNs. In addition, we have obtained the whole-brain projections from the IC D3-tdTomato neurons using CLARITY. We are currently investigating the functional significance of the IC neurons via genetic manipulation and mouse behaviors.

7:20

Neural Activity Of Goal-Directed Decision Making In The Gustatory Cortex.

Roberto Vincis, Ke Chen, Lindsey Czarnecki, Alfredo Fontanini
SUNY at Stony Brook, Stony Brook, NY, United States

It is generally believed that primary sensory cortices exclusively represent basic sensory information. However, recent evidence points to these areas as regions capable of high levels of integration. The integrative nature of GC, suggests that it may be involved in computing complex cognitive variables associated with consummatory decision. Here, using electrophysiological, behavioral and chemogenetic techniques, we test the hypothesis that GC neurons can process decisions, goals and outcomes in a perceptual decision-making task. We designed a two-alternative choice taste discrimination task where mice are trained to discriminate between four tastants of two categories (sweets: sucrose S, maltose M; bitter: sucrose octacetate O, quinine Q) delivered at a central spout. Animals report taste identity on lateral spouts by licking either left or right for water reward. One taste of each category is rewarded on each lateral spout (S & Q à reward left; M & O à reward right), leaving animals unable to simply rely on quality (sweet vs bitter) or hedonics (palatable vs aversive) for their decisions. Bilateral chemogenetic inactivation of GC negatively affected task performance (25% reduction). We implanted moveable tetrodes in GC and recorded neural activity in well trained mice. Analysis of single unit activity revealed that GC neurons specifically represent: 1) planning of task response (43% of neurons reflect intention to lick right or left) 2) spatial goal of the response (48% of neurons represent licking right or left) and 3) reward outcome (40% of neurons represent correct or erroneous choice). Overall our results show GC involvement in all steps of a taste-based perceptual decision. These data suggest that GC may directly drive and shape decisions important for eating behaviors.

7:40 **Olfactory Bulb Granule Cells Date Of Birth Biases Their Synaptic Connectivity With Mitral And Tufted Cells**

Marta Pallotto[1], Simone Stanley[1], Kevin L. Briggman[1,2]

[1]National Institute of Neurological Disorders and Stroke, National Institute of Health, Bethesda, MD, United States, [2]Department of Computational Neuroethology, Center for Advanced European Studies and Research, Bonn, Germany

We aim to investigate whether the date of birth of granule cells (GCs) affects their connectivity pattern with mitral and tufted cells (M/TCs) in the mouse olfactory bulb (OB). GCs are produced from birth to adulthood and inhibit the activity of M and TCs. M/TCs are functionally distinct cell types and process different aspects of olfactory information. Using a combination of transgenic mice and AAV virus injection, we are able to label M/TCs with the light-activated channel ChETA, and perinatal (PN) and juvenile adult-born (jAB) GCs with the calcium indicators GCamP6s and Ruby-GCamP6s, respectively. Using a micro-mirror device we trigger action potentials in specific ChETA-expressing M or TCs and simultaneously record calcium transients in jABGC and PNGCs. Functional connectivity experiments predict that more jABGCs connect with MCs than PNGCs, whereas PNGCs exhibit higher functional connectivity strength when stimulated by TCs. Those findings suggest a cell-specific role for jABGCs in the OB. Ongoing experiments are investigating the role of mature (m) ABGCs in the OB circuitry, to understand if the differential connectivity observed is a developmental, transitory effect or whether PN and AB GCs represent two different classes of interneurons. Using GFP, RFP and Cerulean encoding AAV injections to label PNGCs, mABGCs and jABGCs, and correlative light - 3D EM microscopy, we are able to retrieve their synaptic connectivity and to test whether functional connectivity patterns can be also observed structurally. Finally, high-throughput single cell RNASeq will explore the molecular expression profiles of thousands of GCs, including PNGCs, mABGCs and jABGCs. Altogether those experiments will give us a complete picture of GCs and new insight into their role, and how it might evolve during development.

8:00 **Sleep-Deprivation Enhances Encoding Of Food Odors In Piriform Cortex And Promotes Food Intake Through Piriform-Insula Connectivity**

Surabhi Bhutani[1], James Howard[1], Jay Gottfried[1,2], Thorsten Kahnt[1]

[1]Northwestern University, Chicago, IL, United States, [2]University of Pennsylvania, Philadelphia, PA, United States

Sleep deprivation introduces a dietary shift toward energy-dense foods and may increase endocannabinoids, which regulate ingestive behaviors. Here we test the role of central olfactory processing in mediating the association between sleep loss, endocannabinoids, and food intake. Healthy-weight subjects participated in a crossover olfactory functional magnetic resonance imaging (fMRI) experiment. After one week of sleep stabilization, participants were assigned to one night of deprived sleep (SD, 4h) or one night of non-deprived sleep (ND, 8h; 4 weeks later, subjects completed the other condition). On the next evening, subjects underwent fMRI while smelling calorie-dense food and non-food control odors. Blood samples were also collected during the fMRI session. After fMRI, subjects had *ad libitum* access to high-calorie snack items. We used searchlight-based multi-voxel pattern analysis to identify brain regions encoding food vs non-food odors in the two sleep states. Acute SD enhanced consumption of energy-dense snacks and increased levels of the endocannabinoid-like compound 2-oleoylglycerol (2-OG). Importantly, both measures were correlated across subjects, suggesting that sleep-dependent food intake is driven by endocannabinoid signaling. Also, SD increased fMRI-based encoding of odors in the piriform cortex, but this effect was not related to food intake or 2-OG. In contrast, sleep-dependent food intake correlated with changes in functional connectivity between piriform and insular cortex. Most importantly, the relationship between 2-OG and sleep-dependent food intake was mediated by piriform-insula connectivity. These findings demonstrate that SD modulates odor-evoked piriform responses and highlight a endocannabinoid-related olfactory mechanism through which SD may alter dietary behavior.

8:20 **Structure Of Feedback Projections From The Entire Mouse Brain To The Main Olfactory Bulb And The Impact On Activity In The Bulb As A Function Of Animal Behavioral State.**

Emily Warner[1], Udaysankar Chockanathan[1], Loel Turpin[1], Krishnan Padmanabhan[1,2]

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Neuronal activity in sensory regions is modulated by attention, behavioral state, motor output, and learning and memory, often through direct feedback or centrifugal projections from higher processing areas. *The identity, organization and function of these feedback connections remain an open question in neural coding*. Using g-deleted rabies tracing and whole-brain reconstructions, we characterized the organization of feedback projections to the main olfactory. In addition to previously detailed centrifugal fibers from regions including the Anterior Olfactory Nucleus (AON) and the piriform cortex, we identified and characterized direct projections from the ventral CA1 region of hippocampus and the entorhinal cortex to the main olfactory bulb (MOB). Next, to determine the role of these projections, we used a custom 3D printed neural interface coupled to silicone probes (64-256 channels) to record activity in the awake behaving mouse. We isolated 10s to greater than 100s of single units (putative Mitral/Tufted cells) simultaneously while the animal moved along a running wheel. Single unit activity was highly structured across the bulb, with patterns corresponding to distinct network states. These network dynamics evolved in complex patterns depending on the animal's behavior, and independent of any odor stimuli that were presented. In summary, by blending whole brain tracing methods, high-density recording arrays, and optogenetics, we describe the identity and function of distinct feedback connections; including their ability to marshal networks into distinct states. Consequently, the 'effective circuit' processing a given odor in

the bulb may be highly variable, driven by the input of these and other feedback connections, and a signature of the impact that internal state has on sensory coding.

8:40 **Conditioned Taste Aversion Learning Drives Plasticity Of Gustatory Cortical Circuits And Amygdalo-Cortical Projections In L2/3 Of Rat Gustatory Cortex**

Melissa Haley, Alfredo Fontanini, Arianna Maffei
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Conditioned taste aversion (CTA) is a robust learning paradigm in which an animal learns to dislike a previously appetitive, novel taste after it has been paired with gastric malaise. This form of hedonic learning is hypothesized to depend on plasticity within the primary gustatory cortex (GC), as well as plastic changes between the basolateral amygdala (BLA) and GC. Here we used CTA and whole-cell patch clamp in acute GC slices to investigate the relationship between hedonic learning and changes in GC neuron and circuit excitability. Optogenetic stimulation of BLA terminal fields was used to examine plasticity of BLA-GC synapses in CTA and sham-CTA animals. Our results indicate that CTA learning increases the intrinsic excitability of L2/3 excitatory neurons. At the circuit level, inhibitory drive was decreased more than excitatory activity in CTA-trained animals, resulting in an E/I balance shift towards excitation. CTA learning also altered BLA-GC synapses - BLA-GC synaptic transmission was decreased after learning, and the ability to induce long term depression (LTD) with 20Hz BLA bursts was occluded. To ask whether LTD of BLA-GC synapses is sufficient for CTA learning, we replaced the US (LiCl ip injection) with the plasticity induction paradigm that is occluded in slices from CTA trained rats. *In vivo* 20Hz optogenetic stimulation of BLA afferents in GC was sufficient to induce a CTA in intact animals. Our results demonstrate that CTA learning induces multiple forms of plasticity in L2/3 of GC, and links LTD of BLA-GC synapses onto L2/3 EXC neurons with hedonic learning.

9:00 - 11:00 PM	Estero Ballroom

Poster Session II

D6 **Adults Use Non-Nutritive Sweeteners In Addition To Sugar, Not As Replacement**

Sheetal Malhotra[1], Ellen M Conway[1], Brent S Abel[1], Allison C Sylvetsky[2], Amber B Courville[1], Kristina I Rother[1]

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Non-nutritive sweeteners (NNS) are marketed as sugar alternatives to provide sweet taste with low/no calories, however, they may affect sweet taste preference, increase risk for metabolic syndrome, obesity, and cardiovascular disease. Objectives: In participants of a longitudinal obesity natural history study, we determined whether NNS use altered 1) calorie and sugar intake, and 2) weight and body composition. Methods: We selected subjects with baseline and 1-yr follow up data on 1) 7-day food records, 2) anthropometric measures (BMI, waist and hip circumference), 3) DXA scans (body fat %), and 4) diabetes status. NNS use was defined as consumption ≥ 6 fl. oz. of diet soda/week (or equivalent NNS in foods). Outcome measures included average 7-day food intake (total calories, carbohydrate, sugar, added sugar, protein, fat, sodium), and anthropometrics. Changes between groups and over time were assessed with independent and paired t-tests. Results: Complete data were available in 81 (45F) non-diabetic subjects. At baseline, 64% were NNS users; 84% remained users at follow-up. NNS users and non-users had similar mean age ±SD (46±12 vs. 45±14 years), BMI (34±10 vs. 33±9 kg/m^2), energy intake (2342±758 vs. 2243±762 kcal/d). Total and added sugar were also similar (116±64 vs. 118±47g/d, 78±63 vs. 80±46g/d). After 1 yr, reported energy intake decreased despite unchanged weight and body fat. There were no differences between NNS users' and non-users' total sugar intake (100±58 and 110±53g/d) and added sugar intake (61±46 and 71±49g/d). Conclusions: NNS are used in addition to sugar instead of replacing sugar and are not associated with reduced sugar or total energy intake, body weight or body fat.

D7 **Striatal, But Not Olfactory Bulb D_2/D_3 Receptor Availability Is Changed After 6-Ohda-Induced Hemiparkinsonism In Rats**

Teresa Mann[1], Veronica Antipova[2], Andreas Wree[1], Alexander Hawlitschka[1], Jens Kurth[3], Jan Stenzel[4], Tobias Lindner[4], Stefan Polei[4], Alexander Hohn[3], Bernd Krause[3], Martin Witt[1]

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Olfactory dysfunction is a very early non-motor symptom of idiopathic Parkinson´s disease (IPD) in humans. We tested the hypothesis that an experimentally induced hemiparkinsonism by intoxicating the medial forebrain bundle (MFB) with 6-hydroxydopamine (6-OHDA) may be suitable for describing olfactory deficits in IPD. Because of the dopaminergic deafferentiation between substantia nigra (SN) and striatum (CPu) we speculate that in the olfactory bulb (OB) dopaminergic imbalance may lead to alterations in the expression of dopamine (D_2/D_3) receptors. Also, the effect of intrastriatal injection of botulinum neurotoxin A (BoNT-A) on dopamine (D_2/D_3) receptors in the OB was analyzed, as it normalizes pathologically increased dopamine (D_2/D_3) receptors in the CPu of hemi-PD rats and reverses rotational motor symptoms. Longitudinal [^{18}F]fallypride-PET/CT studies were performed in 3 experimental animal groups: 6-OHDA lesioned rats (sham treatment), 6-OHDA lesioned rats (BoNT-A treatment) and control rats. Successful 6-OHDA lesioning as well as the therapeutic effect of BoNT-A injection was verified using the apomorphine rotation test. Behavioral testing applying a burial food test was conducted to check if animals were actually hyposmic. In contrast to significant changes in the CPu, no dopamine (D_2/D_3) receptor density differences were observed in the OB between 6-OHDA-lesioned and control rats indicating that no or insufficient connectivity exists between CPu and OB. However, BoNT-A application led to an 8.5% increase of the D_2/D_3 receptor availability of the OB, which may account for compensatory dopamine (D_2/D_3) receptor increase and could be explained by the diffusion of BoNT-A into the ventricular system.

D7 **Cyclodextrin Treatment May Change Olfactory Receptor Expression In An Animal Model Of Niemann-Pick Disease Type C1 (Npc1)**

Anja Meyer[1], Anne Gläser[2], Jörg Strotmann[3], Anja U. Bräuer[2,4], Andreas Wree[1], Martin Witt[1]

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Niemann-Pick disease C1 (NPC1) is a rare neurovisceral lipid storage disorder with accompanying olfactory dysfunction. Previous findings in a transgenic mouse model (NPC1$^{-/-}$) showed severe morphological and electrophysiological alterations of the olfactory epithelium (OE) and the olfactory bulb (OB) that ameliorated under therapy with combined 2-hydroxypropyl-ß-cyclodextrin (HPßCD)/allopregnanolone/miglustat or HPßCD alone. In order to investigate the dynamics of the OB, we determined proliferative and apoptotic activities using a BrdU protocol. Further, we performed immunohistochemistry for microglia (Iba1), astroglia (GFAP) and neuronal markers (OMP and TH). qPCR for olfactory key markers and several olfactory receptors was

performed to determine if their expressions were changed under treatment conditions. Further, a food burial test was conducted. The behavior test revealed a significant olfactory deterioration in NPC1$^{-/-}$ mice, which was reversed to normal values after treatment. Immunohistochemistry for Iba1 and GFAP in the OB showed increased microgliosis and astrogliosis in untreated NPC1$^{-/-}$ mice, which was reduced after treatment. However, treated NPC1$^{-/-}$ animals retained elevated numbers of Iba1+ and GFAP+ cells compared to controls. Surprisingly, also HPßCD - treated NPC1$^{+/+}$ showed a high BrdU proliferation rate, which was accompanied by regulation of some olfactory receptor genes (e.g., mOR256-17 and mOR37C). The results show a successful treatment in NPC1 condition with respect to normalization of olfactory cues, however, treatment with HPßCD renders complex alteration in the homeostasis of involved neuronal and glia cells as well as a differential regulation of olfactory receptor genes, which needs to be investigated in future studies.

D9 **Development Of Full Sweet, Umami, And Bitter Taste Sensitivities Requires Regulator Of G Protein Signaling-21 (Rgs21)**

Adam Schroer[1], Catherine Anderson[2], Joshua D. Gross[1], Shane Kaski[1], Kim Wix[1], David P. Siderovski[1], Aurelie Vandenbeuch[2], Vincent Setola[1,3]

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The mammalian tastes of sweet, umami, and bitter are initiated by activation of G protein-coupled receptors (GPCRs) of the T1R and T2R families on Type II taste cells. GPCRs signal via nucleotide exchange and hydrolysis, the latter hastened by GTPase-accelerating proteins (GAPs) that include the Regulators of G protein Signaling (RGS) protein family. We previously reported that RGS21, uniquely expressed in Type II taste cells, dampens bitterant-stimulated T2R signaling in cell culture, consistent with its *in vitro* GAP activity. However, the role of RGS21 in organismal responses to GPCR-mediated tastants was not established. Here, we characterized mice lacking the *Rgs21* fourth exon. Eliminating RGS21 expression left unaffected body mass accumulation (a measure of alimentation), fungiform papillae number and morphology, circumvallate papillae morphology and taste bud number and size. Two-bottle preference tests, however, revealed that RGS21-null mice have blunted aversion to quinine and denatonium, and blunted preference for monosodium glutamate and the sweeteners sucrose and SC45647. These reductions in GPCR-mediated tastant responses upon RGS21 loss are opposite to original expectations, given that loss of RGS21 -- a negative regulator of GPCR signaling -- should lead to increased sensitivity of tastant-mediated signaling (all else being equal). Yet, reduced organismal tastant responses are consistent with observations of reduced chorda tympani nerve recordings in RGS21-null mice. Reduced tastant-mediated responses and behaviors exhibited by adult mice lacking *Rgs21* expression since birth have thus revealed an underappreciated requirement for a GPCR GAP to establish the full character of tastant signaling.

D10 **Smelling Left From Right: Predicting Enantioselectivity Of Odorants From Their Molecular Structure**

Hannah C Shadmany[1], Harris N Shadmany[1], Richard C Gerkin[2]

[1]BASIS Mesa, Mesa, AZ, United States, [2]School of Life Sciences, Arizona State University, Tempe, AZ, United States

Models that predict odor from molecular structure have become increasingly accurate due to the collection of larger quantitative datasets and the development of more powerful statistical techniques. In the DREAM Olfaction Prediction Challenge, the consensus model predicted most perceptual descriptors to within test-retest discrepancy. However, most such models rely not on specific receptor-binding information, but on physiochemical features of molecules that can be computed by chemoinformatic software. Pairs of enantiomers, non-superimposable molecules of the same composition, should challenge these models, because their intrinsic physical properties (e.g. boiling point, lipophilicity, etc.) must be identical (due to mirror symmetry), yet their extrinsic properties (e.g. binding kinetics) can differ, due to the diastereomeric nature of ligand-receptor complexes. For example, S-(+)-carvone (caraway) and R-(-)-carvone (spearmint) have identical intrinsic properties but different odors, putatively due to differing affinity for one or more odorant receptor(s). We show that the DREAM model, which represents the frontier of structure-odor prediction, fails to distinguish between the intensity of differentially intense enantiomeric pairs. This is due to (1) an underrepresentation of enantiomers in the training data, (2) the poor availability and/or computability of extrinsic molecular features, and (3) the tendency of models to rely upon usually-variance-maximizing intrinsic features. We present a refinement to this model that uses extrinsic features to improve upon odor intensity prediction for enantiomers. We also identify a pressing need for the collection and/or calculation of more extrinsic molecular features in order to solve the structure-odor problem for such challenging cases.

200 **(Achems Undergrad Award Finalist) Impact Of Olfactory Loss On Food Aroma And Taste Perception**

Sophie Burghardt[1], Pengfei Han[1], Antti Knaapila[1,2], Valentin Schriever[1,3], Thomas Hummel[1]

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The aim of the present study was to examine the impact of olfactory dysfunction on the perception of foods. Patients with olfactory dysfunctions (n=57) and controls (n=58) evaluated food items of similar texture (dark chocolate, peanut butter, lemon curd and caramel paste) in two stages. First, participants smelled and rated the

food odors for their pleasantness, intensity, familiarity and desirability (on 9-point scales). Resting and odor-induced saliva flow rates were measured. In the second phase, food items were tasted and the intensity for basic taste qualities (sweet, bitter, salty and sour) and pleasantness were rated. Olfactory and gustatory functions were assessed by the Sniffin' Sticks battery and the Taste Strips test. Additionally, a questionnaire on food with different sensory qualities was administered at the end of the experiment. Patients with olfactory loss had significantly lower Sniffin' Sticks test score, but their taste functions were normal. Compared to controls, patients rated the food and non-food odors as less pleasant, intense, familiar and desirable ($p<0.05$). In patients, the increase of salivary flow from baseline was also attenuated for all food odors, and the decrease was most pronounced in response to chocolate and peanut butter odor ($p<0.05$). Additionally, patients reported all food items as less sweet and pleasant ($p<0.05$). These findings suggested an impact of olfactory dysfunction on both the anticipation (odor-induced salivary flow) and intraoral perception of food, which will impact the overall eating experience. The alteration of flavor perception shows the importance of olfactory-gustatory interactions during food consumption. The current results may also provide the basis for a new behavioral means to investigate the impact of olfactory loss on patients.

202 **Asymmetric Olfactory Deficits In Hoehn & Yahr Stage-1 Parkinson&Rsquo;S Disease**

Rachel S. Stanford, Thyagarajan Subramanian, Qing X. Yang, Jianli Wang
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Objective: Olfactory deficits are prevalent in the early-stage of Parkinson's disease (PD), and the central olfactory system is highly affected by PD pathology. The clinical motor symptoms are always asymmetric at the diagnosis of Hoehn & Yahr (H&Y) stage-I early onset PD. We hypothesize that there is hemispheric asymmetry in olfactory deficits in the patients at this stage. Methods: The smell identification ability of 10 H&Y stage-1 idiopathic PD patients (4 with motor symptoms on the right body side) and 9 age/sex-matched healthy control subjects (HC) were evaluated using the 40-item University of Pennsylvania Smell Identification Test (UPSIT). Each nostril was tested with 20 items. Results: There was significant impairment of smell identification function in stage-1 PD compared to the HCs (two-sample t-test, left nostril $p = 0.001$; right nostril $p < 0.001$). There was no significant difference in UPSIT scores between the left and right nostrils in either PD and HC group (paired *t*-test, PD $p = 0.496$; HC $p = 0.426$). Compared to the nostril ipsilateral to the body side with hemiparkinsonism, the functional deficit in smell identification was significantly worse in the other nostril (paired *t*-test, $p = 0.045$). Conclusions: These preliminary data support the hypothesis of asymmetric functional deficits in olfaction between the two hemispheres in stage-1 PD.

203 **Olfactory-Visual Interference Effect In Patients With Autism Spectrum Disorder**

Susanne Stickel[1], Pauline Weismann[1], Ute Habel[1, 2, 3], Natalia Chechko[1, 2], Jessica Freiherr[2, 4, 5]
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Interaction with the environment is multimodal in nature. The altered olfactory processing in Autism Spectrum Disorder (ASD) may be due to a disrupted integration of multimodal stimuli; however, neither the multimodal exposure nor the underlying neural processes are thoroughly investigated in ASD. In this fMRI study, olfactory and visual stimuli were simultaneously applied to depict an olfactory-visual interference conflict with incongruent vs. congruent stimulus combinations. Twenty adults with ASD and 18 healthy controls (HC) were examined using fMRI. Odors were applied utilizing an air-dilution olfactometer. Two pleasant and two unpleasant odors and images were used for unimodal (only odor, only image) or bimodal (congruent or incongruent odor-image combination) presentation. Subjects were asked to rate the pleasantness of the odor or the image. In both groups, pleasant as well as unpleasant odors were rated as more pleasant when combined with pleasant images. Compared to HC, ASD showed stronger neural recruitment of the fusiform gyrus during visual stimulation and of the orbitofrontal cortex during olfactory stimulation. During the interference conflict of the bimodal stimulation, HC displayed more activation in the dorsal anterior cingulate cortex and the precuneus compared to ASD. We conclude that bimodal exposure seems to strongly influence olfactory pleasantness ratings in both groups. The stronger recruitment of the visual and olfactory networks during unimodal stimulation in ASD may be the consequence of abnormal sensory processing. The diminished response to the interference conflict in ASD may be related to reduced conflict processes during incongruent information processing. The unimodal perception may therefore be influenced by the cognitive conflict of a multisensory exposure.

204 **Central And Peripheral Electrophysiological Response To Trigeminal Stimuli In Parkinson&Rsquo;S Disease**

Cécilia Tremblay[1], Rosa Emrich[2], Annachiara Cavazzana[2], Johannes Frasnelli[1,3], Thomas Hummel[2], Antje Haehner[2]
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Olfactory dysfunction is a highly sensitive pre-motor symptom of Parkinson's disease (PD). In order to use

olfactory testing to screen for PD, it is important to differentiate olfactory dysfunction associated with PD from other olfactory dysfunctions. One potential avenue to do so is the measurement of the trigeminal sensitivity. While there is evidence that patients with olfactory dysfunction show a reduced trigeminal sensitivity compared to controls, previous studies suggested that the trigeminal system does not seem to be impaired in PD. Our objective was, therefore, to measure peripheral (from the mucosa, negative mucosal potential, NMP) and central (event-related potential, ERP) electrophysiological responses to the trigeminal stimulus carbon dioxide in patients with Parkinson's disease and compare them to patients with non-parkinsonian olfactory dysfunction and to healthy controls. Our preliminary results show that patients with non-parkinsonian olfactory dysfunction show longer NMP latencies than controls and patients with Parkinson's disease. This was despite the fact that olfactory function was significantly diminished in both groups of patients compared to controls. These results suggest a specific pattern of chemosensory impairment in patients with Parkinson's disease.

205 **Inpp5E Controls Ciliary Localization Of Phospholipids And Odor Response Kinetics In A Mouse Model Of Joubert/Morm Syndrome**

Kirill Ukhanov, Warren W. Green, Cedric R. Uytingco, Lian Zhang, Jeffrey R. Martens
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Ciliopathies are a class of congenital disorders that exhibit penetrance in multiple organs, including the olfactory system, resulting in the loss or disruption of cilia. Growing evidence suggests that ciliopathies manifest in part by dysregulation of membrane lipids. Specifically, the dysfunction of several phosphoinositide 5'phosphatases contribute to Lowes syndrome, Dent disease 2 and Joubert/MORM syndromes. We asked if deficiency in 5'-phosphatase INPP5E activity, previously implicated in maintenance and functioning of primary cilia in Joubert disease models, also affects olfactory cilia. Olfactory sensory neuron (OSN) specific deletion of INPP5E (*Inpp5e*^{osnKO}) led to a radical redistribution of PI(4,5)P_2 and enrichment of PI(3,4,5)P_3 in cilia. However, we did not observe concurrent ciliary depletion of PI(4)P. Phospholipid redistribution accompanied cilia length elongation in *Inpp5e*^{osnKO} mutants. Remodeling of lipid composition and cilia length however did not affect intraflagellar protein trafficking as measured by IFT particle movement. Overall, phospholipid remodeling in the *Inpp5e*^{osnKO} mice resulted in altered odor response kinetics where the rate of decay of the EOG and a single-cell response was accelerated. GCaMP6f imaging of the response to a brief odor pulse revealed a faster rate of Ca^{2+} clearance in *Inpp5e*^{osnKO} OSNs. These findings implicate PI-dependent regulation of the odor-evoked Ca^{2+} extrusion in OSNs knobs, which may control the rate of sensory adaptation. Finally, viral delivery of the full-length *INPP5E* gene restored wild type distribution of phospholipids and the odor response kinetics supporting a potential of gene therapeutic restoration of the ciliopathy related condition.

206 **Oral Pressure Point Sensitivity, But Not Roughness Sensitivity, Is Related To Particle Size Perception In Chocolate**

Scott P Breen[1,2], Nicole M Etter[3], Christopher T Simons[4], John E Hayes[1,2]
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Texture is a contributor to flavor and plays a major role in the acceptance or rejection of many foods. Although the mechanisms of oral texture perception remain poorly understood, recent work suggests individual differences in surface roughness discrimination are related to oral astringency of epigallocatechin gallate. Here, we assessed two conceptually distinct measures of oral somatosensory function – oral point pressure sensitivity and surface roughness discrimination – and tested whether these phenotypes were related. Further, to assess the relevance of these measures, we explored whether either one might predict differences in the perception of chocolate texture. In 51 adults, detection and discrimination threshold estimates for oral pressure point sensitivity were measured with Von Frey Hair Monofilaments (8mg to 10g) and discrimination threshold estimates for surface roughness were measured with stainless steel blanks ground to different levels of roughness (Ra; 0.535-0.722 um), both using staircase procedures. Two commercial samples of dark chocolate differing in mean particle size (19 v. 26 um) were evaluated for differences in grittiness via a 2AFC task. Consistent with prior work, we were able to divide participants into high (RHi) and low (RLo) sensitivity groups for roughness; we also saw variation in point pressure sensitivity, and divided participants into high (PPHi) and low (PPLo) groups. There were no significant relationship between the two oral phenotypes. Across all participants, the group successfully discriminated between chocolates, but this effect was driven almost entirely by those more sensitive to pressure from VFH: 85% of the PPLo group correctly identified the grittier chocolate, versus chance performance (50%) for PPHi. No effect was seen for the two roughness groups.

207 **Quantitative Sensory Description Of Strain-Specific Cannabis Aroma Profiles**

Avery N. Gilbert[1], Joseph A. DiVerdi[2]
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Although classified as a restricted substance under Federal law, cannabis is legal for adult recreational use in Colorado and a few other states. The aroma of dried cannabis flower varies markedly from strain to strain. While cannabis volatiles have been studied by chemical analysis, there have been few attempts to characterize strain-

specific aromas using sensory methods. We have begun to develop an empirically validated cannabis olfactory lexicon analogous to those for coffee, wine, and beer. We previously found that untrained consumer sniff panelists using check-all-that-apply descriptor ballots were able to differentiate the aroma of different strains (Gilbert & DiVerdi, 2018). Here we report the characterization of strain-specific aroma profiles using quantitative rating (Likert) scales based on a subset of the 48 CATA odor descriptors from the previous study. Untrained sniff panelists (n = 52) rated 1 g samples of dried flower from 10 strains, purchased from local dispensaries in Colorado. Cluster analysis confirmed a basic division into Earthy/Herbal/Pungent/Woody and Citrus/Pungent/Sweet groupings, and suggests a possible intermediate grouping. Rating scale methodology appears to hold promise as a technique for establishing strain-specific cannabis aroma profiles for use in quality control, plant breeding, identification of consumer preferences, and development of ancillary products.

208 **The Effects Of Olfactory Training On Odor Mixture Analysis**

Daphnee Poupon-Pourchot[1], Salome Archambault Boisvert[1], Pauline Fernandez[2], Johannes Frasnelli[1,3]
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Identifying odors in mixtures is not an easy task. According to literature, we are able to discriminate and identify up to five odors in a mixture. Our aim was to further the analysis by testing whether olfactory training could improve the capacity to analyze odor mixtures. We tested three groups of 20 people: 1. Sommeliers; these experts in wine are known to have superior olfactory abilities compared to average. Our group was composed of 10 experimented sommeliers and 10 sommelier students. 2. Trained controls; healthy university students who underwent a 5-day olfactory training before being tested. 3. Untrained controls; healthy university students who were still naive to the task by the time they were tested. The task consisted of identifying odors in mixtures. 7 odorants (i.e. limonene, carvone, ethyl octanoate, pinene, acetic acid, eugenol, benzaldehyde in isointense concentrations) were used to create 36 different olfactory stimuli composed of a variable number of components from 1 to 7. Participants smelled each mixture and indicated the presence of each of the 7 components. As expected, the ability to correctly identify the components decreased significantly with the number of components within the mixture. We also found that, for monomolecular stimuli, both sommeliers and trained participants performed better than untrained participants. For bimolecular stimuli, sommeliers performed better and there was no significant difference between trained and untrained participants. With mixtures of three or more odorants, there was no difference between any of the three groups. These findings show that olfactory training can improve the ability to identify odors in simple mixtures, but the task remains difficult for both naive and experimented people when three or more odorants compose the mixture.

210 **Rapid Estimation Of Gustatory Sensitivity Thresholds**

Kathrin Ohla[1,2], Richard Höchenberger[2]
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The ability to taste enables detection of nutrients and toxins in the oral cavity and is therefore a crucial determinant for decisions as to whether to consume or reject a food. The assessment of taste function is pertinent to identify selective (for one taste) or generalized (for all tastes) taste impairment, as it may lead to deviant eating behavior and malnutrition. Sensory sensitivity is a good measure of the overall function of a sensory system. It can be most efficiently assessed with adaptive algorithms that have been, however, tailored to the non-chemical senses. We modified 3 adaptive methods (QUEST, SIAM, quickYes-No) to rapidly estimate taste thresholds for 4 basic taste qualities in a yes-no-task. We compared thresholds obtained with QUEST and SIAM (study 1) and QUEST and quickYes-No (study 2) using within-subject test-retest designs and assessed further QUEST thresholds (studies 3 and 4) resulting in an overall sample of N=163. Tastants were dilutions series of aqueous solutions of sodium chloride, quinine, sucrose, and citric acid presented via spray bottles to anterior taste bud fields. We found that gustatory thresholds can be obtained fastest with QUEST (Mean 6.5 min). All methods yield acceptable (SIAM) to good (quickYes-no, QUEST) test-retest correlations (0.4-0.8). Thresholds were highly correlated between QUEST and quickYes-No ($r>0.63$) indicating that the procedures measure similar perceptual properties. Notably, quickYes-No can detect fluctuations of the response criterion (at the expense of testing time). Our data indicate, however, that participants were able to maintain a relatively stable criterion even in QUEST through instructions alone. Together, the findings suggest that adaptive methods are suitable for the quick and reliable measurement of gustatory sensitivity.

211 **Human Sensitivity To Warning Odorants In Natural Gas**

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Various sulfur compounds are added to otherwise odorless natural gas to warn people of leaks. The gas industry must select concentrations of warning agents most people can readily detect, yet avoid the constant false alarms associated with over-odorization. Odor thresholds are useful data in this regard. Unfortunately, published thresholds for many warning odorants span several orders of magnitude and often provide little or no information on individual differences. In the current project, we used precision, air-dilution olfactometery to measure forced-choice detection (psychometric) functions via a modified method of constant stimuli. Participants (n = 40) were healthy adults selected to vary widely in odor sensitivity (according to the Sniffin' Sticks™ butanol threshold test). Detection functions were measured for tetrahydrothiophene (THT), t-butyl mercaptan (TBM), and for a mixture of the two. Cumulative logistic functions were fit to individual subject data to estimate thresholds. As is often the case when using precision olfactometry, average thresholds were at the lower end of the range of previously reported values (0.003 ppb for TBM, 0.1 ppb for THT), suggesting that existing compendia may

underestimate average sensitivity. Individuals varied considerably (~400-fold range for TBM, ~230-fold for THT), though sensitivity to model warning odorants did not correlate well with butanol thresholds. Thresholds for the mixture were approximately additive relative to thresholds for the unmixed components according to an isobole model. These results, which are intended as the first step toward an updated data-base on human sensitivity for gas odorants, will be discussed both in terms of implications for odorization and measurement of human odor sensitivity more generally.

212 **Taste-Smell Congruency Does Not Impact Flavor Preference**

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Food is perceived as a multisensory combination of taste and smell known as flavor. It is thought that congruency —the association between odor and taste formed through past eating experiences—plays a key role in flavor integration. Evidence for this idea comes from psychophysical human experiments. For example, congruency decreases detection times/thresholds. After detection, flavor must be further evaluated to inform food choice. However, previous work studying the effect of congruency on perceptual evaluations impacting food choice have yielded mixed results. Some show positive effects (e.g., addition of congruent fruity odors to sucrose increased pleasantness), some show no or negative effects (e.g., addition of congruent bacon odor to a salty solution resulted in decreased pleasantness). Inconsistencies observed in human studies may be due to lack of control over eating experience. Second, perceptual judgments of flavor stimuli are only indirectly related to food choice. Here, rats were used as an animal model to investigate the effect of congruency on food choice. Long-Evans rats were exposed to pairs of taste (saccharin, NaCl) and odor (amyl acetate, 2-hexanone) stimuli, creating experimentally-controlled (in)congruent flavors. After exposure, a two-bottle testing paradigm was used to directly evaluate food choice (relative preference) using pairs of bottles containing taste only, odor only, or taste-odor mixtures. Overall, animals did not prefer congruent mixtures over incongruent ones. Data further show no effect of adding a congruent taste on odor preference, or vice versa. This indicates that flavor components may not be processed jointly to inform food choice. We will discuss our findings in the context of a model weighing unisensory flavor components to inform food choice.

213 **Temperature Is Sufficient To Create Flavor Preference For A Cold-Paired Solution.**

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The cold suppression hypothesis posits that cold water is more satiating than warm. Two pieces of evidence contribute to this hypothesis: 1) thirsty rats and humans drink less cold water than warm water and 2) water restricted rats prefer 10°C water over warmer water and sucrose (0.03 -1M at 30- 40°C). The hypothesis reasons that if the animal prefers cold water over warm but consumes less than warm, perhaps intake is limited because cold is more satiating. To test this, we asked if a thirsty rat would acquire a preference for a flavor paired with cold temperature. We offered Long Evans rats (n=8) 2 Kool-Aid solutions (grape and cherry); each solution was offered 7 times at either 10°C or 40°C, in a counter balanced design. After the pairings, rats were given 2 days of 2-bottle preference testing with solutions presented at the assigned temperature (10 or 40°C). Three animals had to be removed from the sample for showing a strong side preference, which suggested that after extensive experience with the solutions the cold preference was not strong for all animals. In the remaining 5 animals, cluster size, bout size, and total licks were significantly higher for the cold flavor (p's<0.05). Next, rats were presented with a preference test where both solutions were presented at room temperature (22°C). In the first 10 minutes, animals preferred the flavor that was associated with cold; cluster size, total licks (p's<0.05), and bout size ($p=0.06$) are larger in the cold-paired flavor during this time period. There was, however, no effect of previous temperature pairings after 30 minutes of licking (p's>0.5). These data suggest that temperature alone is capable of establishing a flavor preference but that the association is transient.

214 **Free Fatty Acid Taste Perception Of The Domestic Cat (*Felis Catus*): Determination Of Behavioural Responses Of Cats To Free Fatty Acids.**

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Historically, the perception of fat in foods was thought to be only due to mouth feel and texture, however, more recently the free fatty acid taste receptor GPR120 (also called FFAR4) was identified in research on taste perception of mice and humans (Cartoni et al., 2010; Galindo et al., 2012; Martin et al., 2011). The domestic cat (*Felis catus*) is an obligate carnivore and so has likely evolved to recognise and metabolise compounds from meat sources, including free fatty acids. Using a recombinant cell line (see abstract by McGrane *et al*. for further details) we identified several free fatty acids as agonists of the cat GPR120 receptor. Here we determined if cats had a behavioural response to the taste of four free fatty acids, including three agonists of cat GPR120 [lauric acid (C12:0), oleic acid (C18:1) and linoleic acid (C18:2)] and one non-agonist of cat GPR120 [palmitic acid (C16:0)]. Palatability of the free fatty acids was tested at varying concentrations up to 1.0% (w/ w) using a panel of cats at the WALTHAM Centre for Pet Nutrition. The response of the cats to the three GPR120 agonists was concentration-dependent, having a maximum intake at 0.1% - 0.2% (w/ w). This was consistent with the data from a GPR120 *in vitro* assay, where the three free fatty acids had similar EC_{50} values $<10\mu M$. However, there was no concentration-dependent response obtained for the non-agonist of cat GPR120. Indeed, there was no significant difference in the intake of all concentrations of palmitic acid tested compared to the control. These results suggest that GPR120 is involved in the taste detection of free fatty acids by cats. Cartoni et al.2010. J Neurosci, 30, 8376-82. Galindo et al.2012. Chem Senses, 37, 123-39. Martin et al.2011.PLoS One, 6, e24014.

215 **4Th Ventricular Infusion Of The Dopamine D2 Receptor Antagonist Raclopride Decreases**

Psychophysically Assessed Detectability Of Sucrose By Rats.

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Peripherally injected raclopride (RAC) decreases sucrose intake in rats, and we previously demonstrated that it blunts sucrose taste detectability in a 2-response operant signal-detection task. Here we sought to assess if these sensory effects are mediated by D2 receptors in taste-related hindbrain regions. Water-restricted male Sprague-Dawley rats (n=10) were trained to associate one response spout with sampling water and the other with sucrose; licking the correct response spout produced a water reinforcer. Once performance was high and stable, a 4^{th} ventricular cannula was implanted, and we assessed the impact of RAC on the rats' ability to discriminate the taste of water and sucrose. Five sucrose concentrations were chosen to represent the dynamic portions of a previously established psychometric function, and performance at these concentrations versus water was measured after saline (1μl) and RAC (11μg) infusion. The overall percentage of accurate responses across sucrose concentrations was analyzed via 2-way repeated measures ANOVA, and curves were fit to the data to determine asymptotic performance, slope, and taste detection threshold (concentration at half-maximal performance). RAC significantly decreased percent correct responding at the 3 highest sucrose concentrations tested and asymptotic performance, but did not impact performance at threshold or slope. This suggests that RAC in the hindbrain disrupts discrimination between the taste of sucrose and water at above-threshold concentrations; importantly, responding under RAC remained above criterion levels and was concentration-dependent, suggesting a sensory-related impact. This suggest that the effects of D2-receptor antagonism on sucrose intake and taste sensitivity could be mediated, at least in part, by the hindbrain.

216 **Do Food Odors Induce Saliva Secretion And Changes In Its Composition?**

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Olfaction plays an important role in eating behavior. It has been shown that exposure to food odors can induce congruent appetite, known as sensory specific appetite, inferring that food odors may signal macronutrient composition of their associated foods, and may even stimulate specific physiological responses in anticipation of food intake. Several studies have shown that olfactory cues, mainly irritating and food odors, could stimulate saliva secretion. The aim of this study was to determine the influence of macronutrient-related odors on salivary biomarkers. A total of 59 normal-weight healthy participants were exposed to 6 different conditions: no odor (water), non-food (fresh green or wood), carbohydrates (bread or honey), protein (beef or chicken), fat (cream or butter) and low energy (cucumber or melon) odors. Whole saliva was collected by the 'spitting method' during 5 minutes of odor exposure. Flow rate was measured by weighing the total amount (and subtracting unstimulated flow rate for analysis); α-amylase activity was assessed by fluorescence-based enzymatic activity assay; mouth-watering perception was rated (100mm VAS). Mixed model analyses showed that saliva flow rate significantly increased by food odor exposure compared to no odor ($F=7.8$, $p<0.0001$; no odor -0.12g, carbohydrates 0.18g, low energy 0.32g, fat 0.38g, protein 0.39g), while it did not modify α-amylase activity ($F= 0.43$, $p=0.85$). Mouth-watering perception was higher in all food odors compared to no odor and non-food odors ($F=38.2$, $p<0.0001$). Odor exposure enhanced saliva secretion and mouth-watering perception, mainly for food odors compared to no odor. These results shed new light on the role of odors in anticipatory eating responses that could further affect appetite and food choice.

217 **Saliva Factors As A Potential Explanation For Different Mouth Behavior Styles: A Pilot Study**

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Salivary amylase cleaves starch, and prior work suggests copy number variants for *AMY1* result in differential amylase activity, with potential downstream influences on texture. Elsewhere, Jeltema et al report individuals can be grouped into 1 of 4 preferred 'mouth-behavior' styles. Because these styles are reportedly seen across cultures, we were interested in whether they may have a basis in biology. As a first step, we tested if differences in oral residence time of starch and non-starch containing foods (a presumed consequence of differential amylase activity) varied across mouth-behavior groups. Healthy adults (n=~100) were given fixed amounts of commercially available starch thickened yogurt, pectin thickened yogurt, and pretzels; they were asked to chew normally, and indicate via computer when they were ready to swallow. Between stimuli, they completed validated personality instruments for variety seeking (VARSEEK) and sensation seeking (AISS). After all stimuli were eaten, participants completed an online questionnaire (the JBMB® typing tool) to classify them into 1 of 4 groups: crunchers, chewers, smooshers, or suckers. All 4 styles were found in our cohort, with more chewers (52%) and crunchers (32%), and fewer smooshers (14%), and suckers (2%); no relationships were seen with personality. We observed a strong correlation of swallow time between yogurts, but no correlation between pretzel and starch thickened yogurt; this suggests factors beyond amylase activity likely influence oral residence time. Also, both yogurts were swallowed extremely quickly (means <4s), which presumably minimizes the ability of amylase to influence the rate of bolus breakdown prior to swallowing. Additional work with thicker samples (to avoid floor effects), and other salivary measures (e.g., flow) is ongoing.

218 **Associative Learning Alters Neurotransmitter Release From The Primary Olfactory Sensory Neurons**

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Associative learning, the process that the brain assigns predictive values to sensory stimuli, is essential for the survival of animals in a dynamic environment. In addition to neuroplasticity in the cortical and limbic regions, the potential contribution from altered sensory inputs has recently been recognized, but the underlying mechanism remains elusive. The mammalian olfactory system is an excellent model for such investigation as primary olfactory sensory neurons (OSNs) project their axons directly to the olfactory bulb (OB) glomeruli making their synaptic release subject to cortical influence and neuromodulation. In this study, pairing optical stimulation of a single M72-ChR2 (channelrhodopsin-2)-EYFP glomerulus with foot shock during the conditioning session led the mice to freeze to the optical stimulation alone during the retrieval session 24hrs later. We then compared OSN release probabilities by recording light-evoked synaptic events in genetically-labeled, glutamatergic external tufted cells (Vglu1-tdTomato^{+}) innervating the M72 glomeruli in the OB slices. We observed a significantly higher release probability of OSNs projecting to the M72 glomeruli that were fear conditioned (pair pulse ratio in percentage: 28.01±6.96, n=8) than the control ones (unstimulated: 54.44±4.28, n=21 or stimulated but unpaired with footshock: 60.08±2.73, n=4; one-way ANOVA, $p<0.01$), along with a significant increase in the spontaneous excitatory postsynaptic events, suggesting a change in the presynaptic release from fear-conditioned M72 OSNs. Furthermore, a positive correlation between the release probability and freezing behavior was evident in these mice. These results suggest that associative learning alters the peripheral olfactory inputs, which may contribute to the desired behavior.

219 **Sensory Gating Deficits Mediate Threat Encoding Of Olfactory Stimuli And Intrusive Re-Experiencing Symptoms In Combat-Exposed Veterans**

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Human olfaction represents a unique sensory system where sensory and affective information merges across the processing hierarchy, resulting in synthetic percepts imbued with emotion and memory beyond odorant chemical inputs. This quality of olfaction is particularly relevant to posttraumatic stress disorder (PTSD), characterized by intrusive re-experiencing of traumatic memories triggered by trauma-related stimuli, such that a trauma-related odor could activate trauma memories and elicit a visceral threat response. In a sample of 37 combat-exposed veterans, we found total PTSD severity was related to perceived threat of presented combat odors (r = .46, p = .01), but not non-combat odors, implicating PTSD symptomatology in exaggerated affective responses to trauma-related odors. Furthermore, intrusive re-experiencing symptoms alone were related to the perceived combat-relatedness of combat and non-combat odors (r's > .35, p's <.03), suggesting a re-activation of traumatic memories by perceived trauma-relatedness, but not general familiarity, of broad olfactory stimuli. Importantly, using resting-state electroencephalogram (EEG), we found deficits in posterior alpha (8-12 Hz) power and posterior-to-frontal alpha connectivity were related to the combat-relatedness of both combat and non-combat odors (r's

220 **Retro- And Orthonasal Olfaction Interaction In Rats**

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An odor molecule can bind to the nasal epithelium orthonasally (via the nares) or retronasally (via the mouth). Yet, whether two olfactory routes generate similar perceptual qualities and how they interact has not been extensively investigated due to the technical difficulties in separating the two types of olfaction in animal research. To address the role of retronasal experience in odor learning, we pre-exposed rats to odors retronasally by using a specially designed lick spout with a concentric vacuum during the consumption of odorized solution. The vacuum adjacent to the lick spout prevents odor from entering orthonasally, rendering the experience purely retronasal. Then we tested the rats in an orthonasal Go/No-Go odor discrimination task using the same or different odor sets from the retronasal pre-exposure. If the same odor was perceived qualitatively similar regardless of the routes, the animals should be better at discriminating the retronasally pre-exposed odors. Preliminary results showed a marginal interaction of odor volatility and retronasal experience, suggesting the importance of volatility in communicating odor information between two routes. Further electrophysiological studies including local field potential recordings will compare the neural mechanisms associated with orthonasal and retronasal olfaction.

221 **Odor Identity Expectations In Human Orbitofrontal Cortex Are Updated By Sensory Prediction Errors**

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Prediction error signals, computed as the difference between expected and experienced rewards, have been proposed as a fundamental mechanism by which reward expectations are learned and updated. However, investigations into the implementation of these error signals in the brain have primarily utilized violations in reward value, with little attention paid to how the specific sensory features (i.e. identity) of reward expectations are learned to support goal-directed behavior. To test how reward identity expectations are updated by prediction error signals, we conducted an experiment in which human participants (N=23) learned associations between abstract visual cues and appetitive food odor rewards in an instrumental reversal learning task while undergoing functional magnetic resonance imaging (fMRI). Throughout the task either the value of an expected odor reward (but not its identity), or the identity of the expected odor reward (but not its value) was changed. Analysis of odor-evoked fMRI activity revealed dopaminergic midbrain responses to violations in both odor reward value and identity. Multivoxel pattern analysis of cue-evoked fMRI activity revealed that expectations of reward value

were encoded in amygdala, while expectations of reward identity were encoded in orbitofrontal cortex (OFC). Intriguingly, the magnitude of identity-based midbrain prediction error signals was significantly correlated with the change in OFC identity expectations across participants. These findings indicate that dopaminergic midbrain contributes to learning of reward features beyond mere value by signaling violations in the sensory identity of expected odors. They further suggest that these identity prediction errors serve as a "teaching signal" to downstream representations of expected odor reward identity in OFC.

222 **Sex Separation Induces Differences In The Olfactory Sensory Receptor Repertoires Of Male And Female Mice**

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Neurons within the mammalian nervous system display plasticity in their connectivity and identity based on an individual's environment and internal state. Within the olfactory sensory epithelium, experience-dependent changes in the rate of neuronal turnover can alter the relative abundance of neurons expressing distinct chemoreceptors. We sought to investigate the scope of cellular and molecular changes within a mouse's olfactory system as a function of its exposure to complex and salient sets of odors: those emitted from members of the opposite sex. To do so, we housed mice either separated from members of the opposite sex (sex-separated) or together with members of the opposite sex (sex-combined) until six months of age and then analyzed olfactory tissues via RNA-seq and histology. Within both the main olfactory epithelium and vomeronasal organ, we observed significantly more numerous gene expression differences between males and females when mice were sex-separated as compared to sex-combined. Chemoreceptors were highly enriched among the genes differentially expressed between males and females in sex-separated conditions, and these expression differences were found to reflect differences in the abundance of the corresponding sensory neurons. An *in vivo* neuronal activity assay revealed that several of the differentially expressed receptors detect either male- or female-specific odors. Our results indicate that sex separation induces substantial differences between male and female mice in the relative numbers of olfactory neurons that express specific chemoreceptors and that these differences arise through selective changes in the turnover rates of affected neurons.

223 **Modeling Associations Between Weight Loss, Bariatric Surgery Type, Food Preferences And Dietary Behaviors**

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Background Weight loss from bariatric surgery is attributed to stomach restriction alone or with malabsorption. Of interest, is if food preferences and eating behaviors interact with surgery type to influence weight loss. Nance et al. (2017) showed reduced sweet preference with weight loss, independent of surgery type. We assessed if food preferences mediated effects of bariatric surgery on 1-yr weight loss and if diet behaviors influenced the preference effects on weight loss. Method 1-yr post- surgery, 72 females (36 Sleeve Gastrectomy, SG; 36 Roux-en-y Bypass, RYBG) survey-reported food preferences and three factor eating questionnaire (TFEQ). The preference survey was formed into reliable food groups. Confirmatory factor analysis tested the TFEQ original factors (dietary restraint, disinhibition, perceived hunger). Multivariate analysis was used to predict 1-year percent weight loss. Results 1-yr %wt loss averaged 28% (RYGB>SG). In simple regression, greater %wt loss was seen among women with less preference for sweets, sugary drinks, alcoholic beverages (p's<.05). Original TFEQ factors had poor fit. Revised factors were formed with factor analysis. Perceived hunger associated significantly with sweet drink (p=.01) and sweet (p=.03) preferences. Multivariate models showed significant direct effects of surgery type and sweet/carbohydrate preference on %wt loss, without mediation of preference on the surgery effects. The revised TFEQ factors did not change the preference effects on weight loss. Conclusion Aligned with prior studies, sweet/carbohydrate preference contributes beyond bariatric surgery type to 1-yr weight loss. These findings were seen with survey-reported preference. Usual diet behavior constructs are different in bariatric patients but did not associate with 1-year weight loss.

224 **Multivariate Modelling To Explain Adiposity In Chronic Smokers: Effects Of Dietary And E-Cigarette Flavor Preference And Use Of Cigarettes For Appetite/Weight Control**

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BACKGROUND: Chronic smokers show elevated obesity risk via less healthy diet behaviors. Smoking also is used to control appetite and intake. E-cigarettes may be used to reduce negative effects of cigarette smoking. We aimed to model associations between food preference, smoking-related weight control behaviors, sweet e-cigarette juice preference and adiposity in chronic smokers. METHODS: 135 chronic cigarette smokers (mean age=37±1y, 70 female) reported preference for vaped e-cigarettes with cherry+nicotine juice and were measured for weight/height. Collected via survey, statistically-reliable composite variables were formed for smoking-related weight behaviors (Brief Wisconsin Inventory of Smoking Dependence Motives Survey) and food preference. These variables, with gender and age, were tested in moderated mediation analysis with preference for sweets and fats. RESULTS: By body mass index (BMI), 69% were overweight/obese; 51% used smoking for appetite/weight control (females>males). Greater BMI was seen in those who used smoking for appetite/weight control and reported greater preference for sweets and fats. In the most explanatory model, smoking-related

weight behaviors mediated the association between fat preference and adiposity. Preference for cherry e-juice mediated the association between fat food preference and adiposity. Males, not females, who reported greater fat preference also reported greater cherry e-juice preference, which moderated the relationship between fat preference and e-juice preference. CONCLUSION: Since chronic smokers with elevated adiposity report using cigarettes to control appetite/intake and greater preference for less healthy foods, e-cigarettes with preferred and sweet e-juices may assist in weight control with lower risk than tobacco cigarettes.

226 **Weight Gain And Diet Exposure Differentially Impair Taste Responsiveness**

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Previous research has suggested that weight status affects food preference. However, this research often fails to disentangle the contribution of body weight from the contribution of previous diet on future food preference. To do this, we used captopril (CAP) to restrict weight gain. We compared mice on a high-fat diet, with (HF mice) and without CAP exposure (HFCAP mice), and mice on a control chow diet with (LCAP mice) and without CAP (L mice). The HF mice were significantly heavier ($p<0.001$) than the other three groups, which did not differ. In a brief-access taste test we saw effects of both weight and diet exposure on licking to sucrose (LCAP, L > HFCAP > HF, p's <0.02). Body mass affected licking to AceK (L, LCAP, HFCAP, > HF, $p<0.001$) while diet exposure altered licking to both saccharin (L, LCAP > HF, HFCAP $p=0.021$) and denatonium benzoate (HF, HFCAP > L, LCAP, $p=0.003$). Immunohistochemistry of the circumvallate papillae demonstrated a reduction in the expression of PLCb2 in HFCAP mice ($p<0.05$) and gustducin in HF mice ($p<0.05$). Additionally, live cell imaging confirmed that HF mice were less responsive to sucrose, saccharin, and denatonium (p's<0.05) and HFCAP mice were less responsive to saccharin and denatonium ($p<0.05$). No differences in responsiveness to AceK were seen. These experiments suggest a complex relationship between taste and obesity and in some cases, a high-fat diet alone without the onset of obesity is sufficient to impair the peripheral taste system. Supported by NSF 1256950

227 **Bariatric Surgery Does Not Affect Food Preferences When Assessed By An Ad Libitum Buffet Meal, However Individual Variations May Still Be Important For Successful Weight Loss**

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Roux-en-Y gastric bypass (RYGB) and Sleeve gastrectomy (SG) surgery have been associated with changes in food preferences. However, the evidence relies on verbal reports, which are prone to reporting bias. To address this limitation we investigated changes in food preferences using an *ad libitum* buffet meal. We found no shift in food preferences 6 months after surgery. However, the prevailing view is that changes in food preferences following surgery may be due to conditioned taste avoidance. Thus, we speculated that energy intake at 6 months was so low, that intake of high-fat and sweet foods was below a threshold that would trigger conditioned taste avoidance. Using an *ad libitum* buffet meal targeting direct behavior, we investigated if RYGB and SG surgery lead to changes in food preferences 18 months after surgery when more food is consumed. Furthermore, we investigated whether individual changes in food preferences for high-fat foods predict weight-loss outcomes at 18 months. Thirty-nine subjects (BMI: 45.0±6.8kg/m^2) were included. Energy intake at the buffet meal decreased with 41% (4470±209 kJ vs. 2618±209 kJ, $P<0.001$). However, no change occurred in relative energy intake from the following food categories: high-fat, low-fat, sweet, savory, high-fat savory, high-fat sweet, low-fat savory and low-fat sweet (all $P\geq0.23$). Macronutrient intake was also unchanged following surgery (all $P\geq0.28$). Decreases in relative intake of high-fat foods was, however, associated with weight loss at 18 months ($\beta=-0.17$ & $P=0.01$). When investigating food preferences using direct measures of behavior, we found no overall change 18 months following RYGB and SG surgery. However, those individuals with the largest decreases in preferences for high-fat foods lost the most weight.

228 **Non-Invasive Vagal Nerve Stimulation Shifts Liking To Lower Fat Stimuli And Increases Striatal Brain Response In Humans**

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The effectiveness of bariatric surgery, which disrupts vagal innervation to the gastrointestinal tract, suggests a role for gut-brain signaling in obesity. The invasive nature of this intervention results in significant adverse effects and is associated with higher morbidity and mortality rates. We propose to use a non-invasive approach to electrically stimulate the auricular branch of the vagus nerve (ABVN), which supplies the skin of the concha in the ear. ABVN stimulation (ABVNS) activates the nucleus of the solitary tract (NTS) similarly to cervical vagal nerve stimulation. In diet-induced obese rats ABVNS has been successfully used to prevent weight gain. We used ABVNS during various food perception tasks in participants with healthy weight (n=10). ABVNS shifted liking towards lower fat stimuli compared to sham stimulation. We validated activation of NTS by ABVNS vs sham in an fMRI scanner (n=4). We also observed increased response to milkshake (fat % similar to low fat solutions in the food perception tasks) vs tasteless in hypothalamus and dorsal striatum. This corroborates animal studies pairing vagal stimulation with choice for solutions containing different fat concentration, in which vagal

stimulation increased both preference for low calorie fats, and potentiated striatal dopamine release in response to low fat. As ABVNS is entirely non-invasive this may be a promising intervention that can be used at an earlier stage of obesity than bariatric surgery or perhaps for prevention of overweight individuals tracking to obese status.

229 **Activation Of Mouse Olfactory Receptor 544 Decreases Adiposity By Altering Fuel Preference To Fats**

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Olfactory receptors (ORs) comprise the largest mammalian protein superfamily and are ectopically expressed in various tissues; however, the biological functionality of ectopic ORs are largely unknown. Mouse Olfr544 was expressed in liver, muscle, and adipose tissues and regulated cellular energy metabolism and obesity. Activation of Olfr544 by its ligand azelaic acid (AzA) specifically induced protein kinase A-dependent lipolysis in adipocytes, mitochondrial biogenesis in muscle, and fatty acid oxidation and ketogenesis in liver, thus, shifting fuel preference to fats. Six weeks of administering AzA significantly reduced adiposity in high-fat diet (HFD)-fed C57/BL6J mice. PPAR-α and fatty acid oxidation gene expressions were induced in the liver and *Ppargc1a* and *Ucp1* gene expressions were induced in brown adipose tissue. AzA stimulated CREB-PGC-1α-ERK1/2 signaling axis and induced mitochondrial DNA content in mouse skeletal muscle. The insulin sensitivity index and ketone body levels increased after administering AzA. Indirect calorimetry revealed that AzA reduced the respiratory quotient increasing fatty acid oxidation rate. AzA showed similar anti-obesogenic effects in HFD-fed *ob*/*ob* mice. However, these metabolic effects of AzA were completely abrogated in HFD-fed *Olfr544* deficient mice. Thus, Olfr544 is a novel receptor that orchestrates the metabolic interplay between the liver, muscle, and adipose tissues, mobilizing stored fats from adipose tissue, and shifting the fuel preference toward fats in the liver, muscle, and brown adipose tissue.

230 **The Correlation Of Coat Color On Olfactory Bulb Layering In The Female American Mink (*Neovison Vison Var. Spec.)***

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The neuronal system is only in a few areas a „colored“ system, such as the substantia nigra, which received its name by the dark color based on the neuromelanin of dopaminergic neurons. Melanin is a pigment of skin and hair, so the question arose, if there might be a correlation of the coat color and brain areas containing dopaminergic neurons such as the olfactory bulb. Therefore we investigated the olfactory bulbs of female American minks bred specifically for their coat color and measured the absolute layer volumes of the four color varieties: dark black “standard” (*Neovison vison var. atratus, a*), light black “silverblue” (*Neovison vison var. glaucus, g*), light brown “pastel” (*Neovison vison var. suffuscus, s*), dark brown “wild” (*Neovison vison var. carinum, c*) using a morphometric system. The volume of the glomerular layer, including the periglomerular dopaminergic neurons, revealed a significant difference between the pale brown variety (*suffuscus:* 20.68±4.73mm^3) versus the black varieties (*glaucus:* 14.79±0.91mm^3 and *atratus:* 15.35±1.21mm^3). Significant differences were also observed in the mitral cell layer (including passing periglomerular cells) of *suffuscus* (5.30±1.55mm^3) versus the black varieties *glaucus* (3.54±0.65mm^3) and *atratus* (3.78±0.37mm^3) and in the internal plexiform layer (*s:* 5.36±0.86mm^3; significant different vs *g:* 3.54±0.65 mm^3 and *a:* 2.90±0.33mm^3). No differences were found among any of the color varieties in the volumes of the fila, external plexiform, granule cell and subependymal layer, which are all composed of much fewer or no dopaminergic neurons. Our results indicate that, based on gene expression, the coat color might reflect neuronal structures.

232 **A Deep Learning Pipeline For Investigating Olfactory Bulb Molecular Anatomy At Genomic Scale**

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The olfactory bulb (OB) receives molecularly heterogeneous and topographically organized sensory inputs. While the zonal organization of the OB's inputs is well established, we understand comparatively less about whether this organization is maintained, elaborated, or discarded in the bulb’s intrinsic circuitry. To understand the bulb’s genomic anatomy -- especially the possible molecular heterogeneity of its mitral cells -- we have registered thousands of in-situ-hybridization (ISH) experiments from the Allen Brain Atlas (ABA) to a set of common OB templates. Doing this at scale requires robust and automated tissue classification for groupwise registration. Here, we describe our use of convolutional neural networks to classify OB sections from the ABA in both supervised and unsupervised contexts. We observe expert-level classification of tissue sections, with accuracy approximately equal to the reproducibility of human-raters (~85% on a 6-class classification task). In preliminary analyses in which we have performed non-negative-matrix factorization based dimensionality reduction on 1,000 registered data sets, we find that gene expression in the mitral cell layer is well-described by 3 non-overlapping spatial modes that explain >90% of expression variance. Intriguingly, two of these modes

strongly resemble the dorsal and ventral domains of the bulb defined by OCAM labeled inputs, suggesting that the topographic specialization of bulbar inputs may also be evident in second-order olfactory system neurons.

233 **Peripherally- And Centrally-Driven Oscillatory Activity In Periglomerular Cell Populations In The Mouse Olfactory Bulb**

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The olfactory system receives an inherently phasic peripheral input as airflow in the nose regularly draws odorants across the olfactory epithelium via respiration and sniffing behavior. This pattern is reflected in the respiration-coupled activity of the olfactory sensory neurons (OSNs) and the mitral and tufted cells that compose the output of the olfactory bulb. However, it remains unclear how much of this oscillatory activity is directly driven by phasic peripheral input and how much by centrifugal input reaching the olfactory bulb from elsewhere. For instance, tracheotomy, which eliminates airflow through the nasal epithelium, also eliminates respiration-coupled activity in OSNs, but mitral cells reportedly maintain their respiration-locked activity (Ravel & Pager, 1990). Periglomerular (PG) cell activity in the glomerular layer of the olfactory bulb is strongly driven by OSN input but is also shaped by centrifugal projections from cortical and neuromodulatory centers. We used optical neurophysiology to observe the oscillatory activity of populations of GABAergic PG cells throughout the olfactory bulb before and after tracheotomy. In intact mice, the population of PG cells in the olfactory bulb exhibited strong activity during each inhalation, even in the absence of explicit odor presentation. After tracheotomy, this strong oscillation disappeared, but a higher frequency population-level oscillation persisted, that was also coupled to the respiratory cycle despite the absence of peripheral airflow. Local application of tetrodotoxin eliminated all oscillations, confirming that these signals were of neural origin. We conclude that respiratory phase information reaches the glomerular layer of the olfactory bulb through centrifugal inputs.

234 **Glucagon Like Peptide-1 Action In The Mouse Olfactory Bulb**

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Given its actions on insulin sensitivity and glucose homeostasis, the glucagon-like peptide-1 (GLP-1) signalling pathway constitutes a promising target for treating type *2 diabetes mellitus*. Building upon our previous findings of a GLP-1 microcircuit in the olfactory bulb, we used an *in vitro* approach to heterologously express the potassium channel Kv1.3 and the GLP-1 receptor in HEK293 cells, and recorded changes in voltage-activated currents in response to 10 μM GLP-1. GLP-1 stimulation significantly decreased Kv1.3 mediated currents, while immunoprecipitation of phosphorylated proteins following the GLP-1 stimulation suggested serine residues as a possible site of post-translational modification of the channel. Because endogenous activation of GLP-1-expressing neurons is unknown, we used an *ex vivo*, brain slice approach to investigate potential sources for GLP-1-expressing neuron activation. We found that acetylcholine predominately elicited a 1.9 ± 0.6-fold increase in firing frequency (n=21). We found that neurons were also modulated by cholecystokinin (CCK), but not by leptin. Bath application of CCK (0.8 μM) led to either a cessation in firing (n=10) or an increase in firing of 1.7 ± 0.4-fold (n=11). Bath application of synaptic blockers suppressed the response to CCK (n=3), suggesting an indirect modulation. Follow up immunolocalization of CCKA and CCKB receptors confirmed an indirect mechanism because the receptors were expressed in MCs but not in GLP-1 neurons. Finally, mice were injected (i.p. 400 nmol/kg) with the GLP−1 analog exendin-4 or control saline and tested in a habituation-dishabituation odor test 30 min post injection. Mice receiving exendin-4 failed to significantly dishabituate, suggesting its ability to dampen odor discrimination.

235 **The Anterior Olfactory Nucleus Mediates Task-Relevant Contextual Information To The Early Olfactory System**

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The anterior olfactory nucleus (AON) is extensively interconnected with the olfactory bulbs and the piriform cortex, but also receives strong projections from CA1 principal neurons of the ventral hippocampus (vHC) and from the subiculum. The vHC in particular is required for some types of contextual learning, including contextual odor learning. Specifically, rats are able to learn multiple, conflicting odor discrimination rules when each rule is associated with a different spatial context; bilateral lesions of the vHC disrupt rats' ability to use this contextual information to solve this task. Based on the substantial projection from vHC to AON, we investigated the role of the AON in mediating contextual odor learning. We show that the AON is necessary to express a contextually-dependent odor discrimination, but is not required for a contextually-dependent tactile discrimination task or for non-contextual odor discrimination. Moreover, optical stimulation of AON pyramidal cells can serve as a contextual cue, enabling rats to learn conflicting odor discrimination rules within a single physical context. Odor perceptual similarities are significantly modulated by contextual information after task acquisition, which led us to hypothesize that AON inputs to the OB modulate odor representations. We use a computational model to show that contextual information conveyed to OB inhibitory (granule) and excitatory (external tufted) interneurons by the AON can modulate odor representations enough to create context-dependent similarities. Our results propose a novel role for the AON as a mediator of task-relevant contextual information to the early olfactory system, by which odor representations are substantively modified by non-olfactory contextual cues.

236 **A Genetically-Defined Class Of Trigeminal Fiber Communicates With A Subpopulation Of Taste- And Somatosensory-Active Parabrachial Neurons**

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Interactions between oral trigeminal and gustatory neurons in the brain are discussed to contribute to flavor perception. However, mechanisms supporting such interactions are undefined. Here, we used optogenetic and electrophysiologic methods applied to a mouse model expressing Channelrhodopsin-2 in TRPV1-lineage trigeminal fibers to probe connections between this fiber class and parabrachial nucleus (PbN) neurons sensitive to taste and oral somatosensory input. PbN cells were recorded under anesthesia during oral chemical and thermal stimulation and during optical excitation of TRPV1-lineage fiber terminals in the trigeminal subnucleus caudalis (Vc), which projects to the PbN. Taste responses (spikes) were indexed using temperature-controlled solutions of (in mM) 100 NaCl, 500 sucrose, 10 quinine, 0.1 cycloheximide, 10 citric acid, and an umami mixture. Somatosensory stimuli included oral 14° and 46°C, 1 mM allyl isothiocyanate (AITC; agonist of TRP ankyrin 1 [TRPA1] and TRPV1), and 1 mM capsaicin (TRPV1). Analyses of 47 taste-active PbN neurons identified 29 (62%) fired in response to optogenetic activation of TRPV1-lineage fiber terminals in the Vc. These TRPV1-lineage positive (VR1+) PbN taste cells showed higher responses to oral somatosensory stimuli (oral 14°C, 46°C and AITC) than VR1- units. For VR1+ cells, firing to the irritant stimuli oral 46°C and AITC was positively correlated (P <0.05) with firing to cycloheximide but not sucrose. Further, activity to oral capsaicin arose only in VR1+ PbN taste cells sensitive to cycloheximide. Thus, neural signals about aversive oral trigeminal stimuli preferentially reach VR1+ PbN taste neurons responsive to aversive gustatory stimuli. Such cells may contribute to trigemino-taste integrative processes associated with flavor.

237 **Dynamical Structure Of Cortical Taste Responses Revealed By Precisely-Timed Optogenetic Perturbation**

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Variability is a hallmark of neural responses to sensory stimuli. It is common practice to average neural responses across repeated presentations of the same stimulus, thereby minimizing this trial-to-trial variability and dismissing it as “noise”. However, in the context of a naturalistic decision to swallow or expel a taste in the mouth, we recently demonstrated that inter-trial variability in responses of taste cortex neural ensembles correlates strongly with the latency of ingestion-egestion orofacial movements. Sudden transitions of sensory cortical ensemble activity into a previously-described “palatability-related response state”, despite emerging anywhere between 0.5-1.5 sec post-stimulus, reliably preceded choice behavior by 0.2-0.3 sec. For the current work, we probe the rich and behaviorally-relevant dynamic structure in these ensemble taste responses using a combination of precisely timed optogenetic perturbations, chronic multi-electrode recordings, jaw EMG and probabilistic graphical modelling. We show that brief (0.5 sec) optogenetic perturbation of a random subset of taste cortex neurons affects the timing of the animal’s orofacial expression of the swallow/expel decision – but only on trials where the perturbation arrives before the neural population shifts into decision-related firing. Early perturbations delay this decision whereas late perturbations have no impact; identical perturbations delivered during the heart of taste processing, meanwhile, had no impact on trials in which the ensemble state had already emerged, and strongly delayed decisions on trials in which it had not. These results provide evidence for a distributed sensory-motor attractor network in taste processing, characterized by stochastic shifts into a behaviorally-relevant stable state.

238 **Optogenetic Activation Of Type-1 Cells In Fungiform Papillae Preferentially Activates Nacl-Best Neurons And Drives Consumption Of &Ldquo;Blue&Rdquo; Water In Na^+-Deprived Mice**

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Na^+ appetite is a powerful behavioral phenomenon, where Na^+ depleted animals voraciously consume high concentrations of Na^+ salts. It is generally thought that the taste of Na^+, which is essential for driving Na^+ appetite, is mediated through NaCl-best neurons, which utilize Epithelial Sodium Channels (ENaCs) for transduction. While a consistent pattern of taste research indicates the existence of ENaC-mediated NaCl-best neurons, the specific taste-bud cell playing this role has yet to be conclusively identified. Recent optogenetic data from our laboratory shows that GAD65 positive Type 1 taste-bud cells may communicate with NaCl-best neurons, transducing an ENaC-mediated Na^+ response to NaCl-best neurons in the rostral nucleus tractus solitarius. NaCl-best neurons responded faithfully and robustly to 1ms light pulses over a range of intensities (0.03—2mW) and frequencies (1—10Hz) with short latencies (21ms), whereas NH_4Cl-best and Sucrose-best neurons, responded to light pulses with longer latencies (31ms) and with markedly less spikes. In fact, spike rates to 2mW at 10Hz in NaCl-best neurons were similar to their responses to 0.1M NaCl, whereas spike rates to light in Sucrose-best and NH_4Cl-best neurons were 66% and 50% less than those to 0.2M sucrose and 0.1M NH_4Cl, respectively. To further explore this hypothesis, we used two-bottle preference tests to examine the behavioral impact of optogenetic stimulation of GAD65 positive Type-1 cells of Na^+-deprived mice and Na^+-replete mice. Preliminary findings indicate that preference for "blue” water (470nm) increases dramatically under Na^+-deplete

conditions, suggesting that Type-1 cells play a substantial role in the detection of Na^+ salts. To our knowledge, this is the first behavioral evidence to support the role of Type-1 cells in Na^+ appetite.

239 **State-Dependent Olfactory Information Processing**

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In many animals, including humans, external stimuli typically lead to sensory perception in the wake state, but not during sleep states. Such state-dependent gating of information flow likely involves the thalamus for most sensory modalities; however, olfactory information, originated in olfactory sensory neurons (OSNs) and transmitted to the olfactory bulb, can reach the olfactory cortices such as the piriform cortex and subsequently the orbitofrontal cortex without the relay of the thalamus. Previous studies suggest that olfactory gating occurs in the piriform cortex as odor-evoked responses are reduced during the anesthesia-induced slow-wave state or natural sleep, but interpretation of these studies may be confounded by either the use of anesthesia or different odor stimulations due to state-dependent changes in breathing patterns. To ensure consistent peripheral inputs under different brain states, we used an optogenetic approach by expressing channelrhodopsin-2 (ChR2) in all mature mouse OSNs (OMP-ChR2) or a subset of OSNs (M72-ChR2). We optically stimulated these neurons while recording local field potentials (LFPs) and single-unit activities from olfactory areas in freely behaving mice that naturally switch between brain states. In contrast to previous studies, we surprisingly found similar or larger stimulation-evoked responses in the piriform and orbitofrontal cortices for M72-ChR2 (n=4) or OMP-ChR2 (n=6) mice, respectively, during the sleep state compared to the wake state. These findings suggest that rather than reduced information flow into the olfactory cortex, the lack of smell perception during sleep is likely due to other mechanisms, which are currently under investigation.

240 **Effects Of Type Iii Cell Activation By Light On Taste Responses**

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Studies have suggested a communication between taste cells that shapes the signal before transmission to the brain. To further explore this possibility, we adopted an optogenetic approach to stimulate Type III cells with blue light (470nm) using mice expressing Cre recombinase under a specific Type III cell marker, PKD2L1 (Polycystic kidney Disease-2-Like 1) and crossed them with Cre-dependent Channelrhodopsin mice. The application of light onto the tongue allows the specific stimulation of Type III cells and circumvents the non specific effects of acid application. We conducted a brief-access 2 bottle test to assess a possible alteration of taste preferences. Mice were presented with 2 bottles containing a tastant and blue or amber light. The amber light does not activate Type III cells and controls for any visual aversion to light. Our preliminary results show that PKD2L1Cre Channelrhodopsin mice avoid sucrose or quinine+blue light more than sucrose or quinine+amber light. Control mice show no preference for sucrose or quinine+blue light or amber light. To understand whether a modulation in peripheral taste signaling is responsible for these results, we performed chorda tympani nerve recordings. Light activation of Type III cells produces a robust response on the chorda tympani. When comparing nerve responses to tastants with or without light, our results show that the experimental response obtained in the presence of light is generally less than the arithmetic sum of the individual responses to light and the tastant. Results were particularly significant with quinine, MSG, MPG+imp and NaCl and suggest that the activation of Type IIII cells modulates Type II cell output. Additional recordings are necessary to confirm the initial results and identify the mechanism involved.

241 **Spike Timing Properties Of Olfactory Bulb Principal Neurons During Gamma Oscillations**

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Gamma oscillations are generated within the earliest central circuits of the olfactory system, and reflect synchronized activity across ensembles of principal neurons, such as the mitral and tufted cells (collectively, MTCs) of the olfactory bulb. The regulation of spike timing in these neurons – particularly including the synchronization of spikes in activated ensembles – and the phase of these spikes with respect to the underlying gamma oscillations are potentially critical bases for neural information coding. Understanding the fundamental mechanisms underlying these phenomena is therefore essential for understanding the construction of olfactory representations. We investigated the spike-timing properties of MTCs using an *in vitro* bulbar slice preparation mounted on a 60-channel planar multielectrode array (MEA). Activation of the OB network, either pharmacologically or via the optogenetic stimulation of sensory afferents, evoked long-lasting gamma oscillations in the local field potential and also narrowed the phase constraint of MTC action potentials with respect to gamma. Notably, individual MTCs varied considerably in their responses to stimulation; while the mean phase-constraint across all recorded MTCs increased significantly, clearly some MTCs were strongly phase constrained while others were relatively unaffected. We present and discuss several alternative metrics for the spike timing-dependent analysis of MTC activity.

242 **(Don Tucker Award Finalist) Behavioral Responses To Optogenetic Activation Of Type Iii Taste Cells.**

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Type III cells in the mammalian taste bud are required for the transmission of sour taste information (Huang et al, 2006), but have also been implicated in the detection of water (Zocchi et al, 2017). To better elucidate the role of Type III cells in taste bud signaling, we developed a mouse that expresses light activated Channelrhodopsin (ChR2) under a Type III cell-specific Cre driver. This mouse features an IRES-Cre recombinase construct following the Polycystic Kidney Disease 2-Like 1 (*Pkd2l1*) stop codon. Thus, ChR2 is expressed only in PKD2L1 positive Type III cells. Immunohistochemical studies confirm that ChR2, which features a YFP tag, is not expressed in either Type II taste cells or innervating taste nerves. Optogenetic activation of PKD2L1+ cells in anterior or posterior tongue produces a robust nerve response in the chorda tympani or glossopharyngeal nerves, respectively. To test whether these nerve responses are involved in thirst-driven licking behavior, as suggested by a recent paper from Zocchi et al., we measured licks from water deprived mice in response to water, light alone, and neither water nor light. Contrary to previous findings, these mice did not display robust licking behavior when water was absent. We also tested behavioral preferences to blue light in the presence of water in two bottle preference tests. Unlike littermate controls, Pkd2l1-Cre, ChR2 mice consistently avoided blue light in comparison with amber light, which does not elicit a nerve response. The avoidance of blue light we observed was similar to that of low concentrations of citric acid. For these mice, optogenetic activation of PKD2L1+ Type III taste cells is a slightly aversive stimulus, and does not drive licking behavior.

243 **Foliate Taste Bud Volume Following Neonatal Chorda Tympani Transection**

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When adult rats (> P40) undergo injury to the chorda tympani (CT), observed losses in fungiform taste bud number and volume is temporary due to CT regeneration. We showed that chorda tympani nerve transection (CTX) in young rats (≤ 10 days of age; P10) leads to a permanent loss of fungiform taste bud number and volume. Since the CT also innervates foliate taste buds, we now examined whether CTX in P10 rats had similar effects on taste buds in foliate papillae. We categorized the trenches as anterior, middle, and posterior. In addition to CT innervation, taste buds located in the foliate are also innervated by the glossopharyngeal nerve (GL), particularly in the posterior and middle trenches. Sprague-Dawley rats received CTX at P10 and tongue tissue was collected 50 days post-surgery. Foliate taste bud volumes were compared between the transected and SHAM sides using Neurolucida (MBF Bioscience). No overall differences in taste bud volumes were found between CTX and SHAM sides, nor was there a difference in number of taste buds as a result of CTX (*ps* > .10). Independent samples *t*-tests were conducted to compare SHAM to cut sides for each trench category. While there was a trend towards greater taste bud volume in the SHAM posterior trenches compared to the cut posterior trenches ($p = .065$), no differences were observed in the anterior and middle trenches ($p > .10$). The effect of neonatal CTX on foliate taste buds appears in stark contrast to the permanent elimination of fungiform taste buds after neonatal CTX. Results suggest that support from the GL may be sufficient to maintain taste buds across all anterior-posterior trenches of the foliate. We are examining whether the results are indicative of regeneration after CTX or whether taste buds are maintained in the foliate in the absence of the CT.

244 **Nicotinic Acetylcholine Receptor (Chrn) Expression And Function In Human Taste Cells**

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In rodents, CHRNs are involved in bitter taste transduction of nicotine and ethanol. Currently, the information regarding CHRN expression and function human taste cells is lacking. Accordingly, we investigated the expression and functional role of CHRNs in cultured human adult fungiform (HBO) taste cells. Using molecular techniques, we demonstrate that a subset of HBO cells express CHRNs that also co-express TRPM5, T1R3 or T2R38. Exposing HBO cells to nicotine or ethanol acutely or to nicotine chronically induced a differential increase in the expression of CHRN mRNA and protein in a dose- and time-dependent manner. Acutely exposing HBO cells to a mixture containing nicotine plus ethanol induced a smaller increase in CHRN mRNAs relative to nicotine or ethanol treatment alone. A subset of HBO cells responded to nicotine, acetylcholine and ATP with a transient increase in $[Ca^{2+}]_i$. Nicotine effects on $[Ca^{2+}]_i$ were mecamylamine sensitive. Brain-derived neurotrophic factor (BDNF) protein was detected in HBO cells using ELISA. Acute nicotine exposure decreased BDNF in HBO cells and increased BDNF release in the medium. CHRNs were also detected in HEK293 cells by RT-PCR. Unlike HBO cells, CHRNs were localized in most of HEK293 cells and majority of HEK293 cells responded to nicotine and ethanol stimulation with a transient increase in $[Ca^{2+}]_i$. BDNF levels in HEK293 cells were significantly higher than in HBO cells but the nicotine induced release of BDNF in the media was a fraction of the BDNF cellular content. We conclude that CHRNs are expressed in TRPM5 positive HBO cells. CHRN mRNA expression is modulated by exposure to nicotine and ethanol in a dose- and time-dependent manner. Nicotine induces the synthesis and release of BDNF in HBO cells.

245 **Temperature Influences Action Potentials In Taste Bud Cells**

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Temperature profoundly influences perception of five basic tastes, but the molecular mechanisms have not been completely understood. Taste bud cells (TBCs) fire action potentials (APs) in response to taste stimulation, which either activate voltage-gated CALHM1/CALHM3 channels in type II cells to directly release transmitters, or open voltage-gated Ca^{2+} channels in type III cells to trigger synaptic vesicle release of transmitters. Notably, whether temperature influences the electrical excitability in TBCs has not been previously determined. Here, we investigated the effects of temperature on APs in TBCs. In type II TBCs, we found that increasing temperature shortens single AP width and reduces the overshooting voltage, and significantly enhances AP firing frequency, but the number of overshooting APs has a biphasic relation with temperature, a maximum achieved ~ 25°C. To gain insight into the effects of temperature on the voltage-gated conductances contributing to APs, APs and ionic conductances were recorded from the same single cell by switching between whole-cell current-clamp and voltage-clamp modes. Cooling temperature from an ambient temperature (~ 20 °C) slowed activation and inactivation of Na^+ currents, as well as slowed activation of K^+ currents. In contrast, increasing temperature enhanced activation and inactivation of Na^+ currents with maximum inward Na^+ currents at ~ 25°C. Increasing temperature also enhanced K^+ current activation, but further increasing temperature reduced steady-state K^+ currents by its inactivation appearing. Temperature also significantly affects APs in type III TBCs. Thus, temperature-dependent electrical excitability in TBCs may provide a possible general role in temperature-dependent tastes perception including sweet, bitter, umami, salt and sour.

246 **Sophorolipids: Novel Bitter Taste Blockers**

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Sophorolipids (SLs) are a class of glycolipids produced by selected non-pathogenic yeast species of Candida from renewable substrates by fermentation. SLs are typically composed of a disaccharide (sophorose) and a fatty acid. The hydroxy groups of the sophorose are acetylated, and the fatty acid chain may be saturated or unsaturated. SLs are being used by industry in formulations for laundry and dishwashing detergents. In order to broaden the application potential of SLs, their sensory properties were assessed using both in-vitro and in-vivo physiological techniques and psychophysics. We here describe for the first time the bitter blocking effect of SLs. We demonstrated that pre-application of SLs successfully blocked intracellular calcium changes in response to a mixture of bitter compounds in cultured human taste papillae (HBO) cells. Pre-application of SLs also inhibited whole-nerve chorda tympani (CT) responses to application of the bitter mixture to the tongues of mice. We further successfully demonstrated that SLs significantly reduced the rated bitterness intensity of the bitter mixture in humans. Taken together, the results suggest that sophorolipids might block bitter taste. This opens possibilities for practical applications of sophorolipids, for example, to ameliorate bitter taste of foods and drugs.

Thursday, April 19, 2018

7:30 - 9:00 AM	Estero Foyer
Continental Breakfast	

7:30 - 8:15 AM	Pine
AChemS Undergraduate Presenters Panel	

This event is designed for undergraduate attendees of AChemS. During this event, a panel of individuals who have attended AChemS as undergraduates previously will share their experience and offer advice on how to make the most of the meeting to the current undergraduate attendees. Additionally, undergraduates can ask any questions they have.

8:00 - 10:30 AM	Estero Ballroom
Poster Session III	

D11 **The Interaction Between Olfactory And Trigeminal Perceptions**

Lu Jiaming[1,2], Krish Sathian[3], Sebastian Rupprech[1], Lauren Spreen Lauren Spreen[1], Bing Zhang[2], Bin Zhu[2], Qing X. Yang[1,4], Prasanna Karunanayaka[1]

[1]Radiology, Center for NMR Research, Penn State University College of Medicine, Hershey, PA, United States, [2]Drum Tower Hospital, Medical School of Nanjing University, Nanjing, China, [3]Neurology, Penn State University College of Medicine, Hershey, PA, United States, [4]Neurosurgery, Penn State University College of Medicine, Hershey, PA, United States

It is known that the human odor perception is influenced by the intranasal trigeminal information. In contrast, the influences of olfactory information on trigeminal perception remains largely unknown. Thus, the goal of this study was whether the localization of weak puffs of odorless air to each nostril could be enhanced by a suprathreshold, pure odorant in humans. Studies of multisensory integration states that crossmodal binding should enhance measures of behavior, especially when a stimulus in one modality is degraded or ambiguous. Ten subjects (mean age 31.78 ± 8.97 years, 8 males) with normal smell function took part in the “odorless-air-puff” behavioral experiment. Air puffs with a flow rate 2L/min and 100 ms duration were delivered either to the left or right nostril with or without concurrent odorant (PEA) randomly, with an inter stimulus interval of 15 sec, and for a total duration of ~10 min. Visual cues were used to inform the subject to hold their breath to localize incoming weak air-puffs embedded in a constant flow of odorless-air, delivered bilaterally at a rate of 1 L/min. An MR compatible ETT-olfactometer was used to deliver continuous air as well as the weak air-puffs. When the weak puffs were delivered alone, an average localization accuracy rate of 64% was observed, just above chance. When pure odor was delivered (without air-puffs), the accuracy rate was to 48%, indicating minimal trigeminal stimulation. However, there was a significant improvement in the localization accuracy of an air puff in the presence of a pure odor: 1) puff and odor in the same nostril (82.5%, $P<0.05$), and 2) puff and odor in different nostrils (70%, $P> 0.05$). Our results demonstrated behavioral evidence for the integrative nature of olfactory and intranasal trigeminal networks.

D12 **Detection And Spatial Organization Of Bile Acid Information In The Early Mouse Accessory Olfactory System**

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Murine animals rely heavily on the accessory olfactory system (AOS) for social and reproductive behaviors such as territorial aggression and mating. The initial detection of olfactory stimuli is mediated by the vomeronasal sensory neurons (VSNs) that relay the signal to the glomerular cell layer in the accessory olfactory bulb (AOB). The output neurons of the AOB, mitral cells, receive and process excitatory signals from VSNs before relaying the information to limbic brain regions. Our understanding of the natural ligands for the AOS (typically secretions/excretions from other animals) is increasing rapidly. However, our understanding of how the AOS encodes and processes olfactory information is still severely limited. Fecal bile acids (BAs) are a new, incompletely understood class of natural AOS ligands. To better characterize the BA sensory space and the spatial representation of these signals in the brain we performed *ex vivo* volumetric GCaMP6f/s Ca^{2+} imaging in VSNs and their axon terminals in the AOB. VSNs responded reliably to both natural ligand blends (e.g., mouse feces) and individual BAs. While some VSNs showed broad BA tuning, others were highly selective for specific

BAs at concentrations as low as 300 nM. In the AOB, VSNs tuned to mouse feces and BAs targeted their axons to prominent glomerular clusters in the anterior AOB, consistent with previous results and indicating that V1R/$G_{\alpha i}$-expressing VSNs are the most likely BA sensors. These data provide new insights into sensory processing in the vomeronasal organ, and will guide future inquiries into mammalian social chemosensation.

D13 **Co-Activation Of Dopamine D1 And D2 Receptors In The Piriform Cortex Modulates Beta Oscillations In The Olfactory Bulb**

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Odor-evoked beta (15 – 30 Hz) oscillations in the mammalian olfactory bulb (OB) occur during odor sensitization and learning, yet we lack a full understanding of their generation mechanism and function. Previous modeling work from our laboratory predicted that increase in OB granule cell (GC) excitability supports the transition from gamma (40 – 100 Hz) to beta oscillations. We previously tested the model by pharmacologically manipulating the excitability of GCs in the OB. Centrifugal cortical input from higher order areas, such as the piriform cortex (PC), targets GCs near their somas and activates them strongly. This input also drives GC excitability and is likely to mediate the state change that enables beta oscillations. However, specific synaptic interactions between the PC and the OB that may change the olfactory system oscillatory mode remain unclear. In the present study, we used the dopamine system to investigate the role of excitability in PC neurons in gating beta oscillations. Rats were infused with low and high dose D1/D2 cocktails, agonists and antagonists separately, in the anterior PC, followed by odor presentations. D1/D2 agonist cocktail (SKF38393 + quinpirole), known to increase pyramidal cell firing in the PC, enhanced beta power in the ipsilateral OB in response to both strong and weak odors, with a more salient effect under the weak stimulus condition. D1/D2 antagonist cocktail (SCH23390 + raclopride) did not affect beta power. Our findings support the hypothesis that DA release into the PC causes pyramidal neurons that project axons to the OB GC layer to fire at a higher rate, which in turn increases GC excitability, enhancing beta oscillations under conditions when they are not normally strong.

D14 **Apical Microstructure Of Mouse Taste Buds Based On Serial Blockface Em Reconstruction**

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Mammalian taste buds contain 3 types of elongate cells extending from the base of the bud to the taste pore: Type I, Type II and Type III. Type I cells are glial-like often enwrapping the other cells and nerve fibers and producing the ectoATPase characteristic of taste buds. Type II cells express the transduction cascades for bitter, umami or sweet, and form unconventional synapses with nerve fibers characterized by the presence of large mitochondria with tubular cristae. Type III cells transduce sour and perhaps some ionic tastes and form classical synapses with presynaptic vesicles at points of functional contact with the nerves. In our serial blockface EM data sets of mouse circumvallate taste buds, we relied on the presence of key structures – presynaptic vesicles, atypical mitochondria, cytoplasm density, and nuclear shape -- to definitively make cell type identifications. Our reconstructions reveal differences in the nature of the microvillar apical extensions of the different cell types. The Type I cells displays multiple, short, branched microvilli, which usually end halfway up in the taste pore. In contrast, Type II and Type III cells extend a single apical process reaching high in the taste pore, although the microvillus of Type III cells is thicker and somewhat longer than that of the Type II cells. These details are different than as described based on the single plane EM images for other species, even for rats, suggesting the possibility of species-related differences in apical microstructure. Our serial reconstructions also demonstrate the difficulty in identifying taste cell types on the basis of single plane sections, as key identifying features may appear in only a few of the scores of sections through a single cell.

D15 **Food Consumption Is Not Required For Mice To Acquire Socially-Transmitted Odor Preferences Via Stimulation Of Gc-D-Expressing Olfactory Sensory Neurons**

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Conspecifics use olfactory stimuli to communicate information that is critical for health and survival. For example, many mammals acquire food preferences in a social context via the paired detection of a food odor (a.k.a., the “demonstrated” odor) and one of several semiochemicals (e.g., CS_2, guanylin or uroguanylin) that stimulate olfactory sensory neurons (OSNs) expressing the non-canonical olfactory receptor guanylyl cyclase-D (GC-D+ OSNs). This olfactory-dependent behavior, known as the social transmission of food preference (STFP), requires a functional chemosensory transduction cascade (including GC-D) within GC-D+ OSNs and results in the acquisition of a highly stable preference for foods containing the demonstrated odor. Previous studies have suggested that consolidation of the preference requires the recipient animal not only to detect the demonstrated odor and the semiochemical but to also execute a choice between two foods – one with the demonstrated odor and one without – typically assessed by a measure of food consumption. However, it is unclear whether this preference formation requires food consumption (or any orosensory stimulation). Here we report that upon exposure to a saline droplet containing a food flavoring (2% cocoa or 1% cinnamon) plus a GC-D+ OSN agonist (guanylin or uroguanylin, 50 nM; e.g., Arakawa et al, 2013), GC-D +/+ and +/- mice, but not GC-D -/- mice,

form a significant preference for the demonstrated odor over a novel odor in a two-port odor preference test. This preference is maintained when the mice are subsequently given a choice between food with the demonstrated odor vs. food with a novel odor. Together, our results suggest that STFPs that depend on activation of GC-D+ OSNs may more properly be understood as socially-transmitted odor preferences.

300 **Assessment Of Mouse Navigation In A Virtual Reality Odor Environment**

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Navigation using odor to locate and identify key resources is essential to an animal's survival. Animals rely on olfactory cues to efficiently and accurately move along an odor plume to find food sources, mates and also to avoid predators. Although several behavioral paradigms have elucidated mechanisms with which animals can successfully navigate, this remains unclear in mammals. To study this further, we have developed a virtual reality odor environment for the controlled presentation of a realistic odor plumes directly to the nares of transgenic, olfactory receptor neuron specific, GCaMP6 mice. Mice are head-fixed and allowed to walk on a foam ball. The ball rotation is tracked using an optical mouse and registered by a custom Labview virtual interface (VI). The VI generates a 1x1 meter virtual arena where the odor source and relative start position of the animal can be defined. The VI controls the odor intensity to each individual nare as the animal moves through the virtual odor plume. This plume was established by imaging acetone vapor using planar laser induced fluorescence (PLIF) in a defined flow chamber with differing release heights z = 5mm (bound plume) and z = 10cm (unbound plume). Distance, velocity and tortuosity of 6 mice were measured during the presentation of both bound and unbound plumes presented both dynamically (15 frames/s) and statically (1 frm). The spacing of the virtual mouse nares was manipulated to an inter-nare distance of 8 mm, 16 mm or 64 mm as they moved within the plumes types. In addition, light and wind direction cues are also available to the mouse to explore multi-modal cue presence alongside the odor information presented to each nare. Virtual odor navigation is a powerful new approach to understand the neuro-behavioral basis of natural odor navigation.

301 **Odor Detection Latency: Measurement Method And Relationships With Other Olfactory Attributes**

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As part of IFF Sensory Research, we have developed a new method to accurately measure odor detection latency (i.e., speed with which a scent is detected). The method combines 3 ways of minimizing potential sources of noise in the data. First, we present odorants at the beginning of a panelist's inspiration phase rather than at an arbitrary point in the respiration cycle. We achieve this by ensuring that the panelists can synchronize nose respiration with a rhythmically changing visual stimulus on the computer monitor before they begin the main part of the study. Once the digital output from a respiration sensor and the stimulus shows adequate synchronization, the panelist continues breathing 'in sync' with the stimulus which allows a digitally controlled olfactometer to deliver odorants at the beginning of an inspiration phase. The panelists press a button as soon as they detect a scent. The visual synchronizing stimulus is presented before every trial to ensure that the synchronization is maintained. Second, we use a photo-ionization detector to measure differences in stimulus-onset times (i.e., time between scent onset trigger from the computer and odorant detection at the end of a cannula) between odorants, ensuring that these differences do not confound odor latency measurements. Finally, we further reduce measurement noise by utilizing an olfactometer with highly reliable stimulus-onset times (mean SD = 37ms for a given odorant). We are examining the relationships of odor detection latency with other variables. Preliminary results show an association between latency and the odor detection threshold of a fragrance ingredient. These results and their implications for our understanding of factors underlying detection threshold and/or other psychophysical measures will be discussed.

302 **Central Sources Of Variation In Taste Intensity Perception**

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Individual differences in taste intensity perception due to genetic variation in taste receptors or variance in peripheral taste physiology are well established. The possible influence of central mechanisms, however, is much less well explored. Here, we used a whole-brain data-driven method, connectome-based predictive modeling (CPM), to test if we could identify a neural fingerprint of taste intensity perception. 30 participants ages 18-45 underwent fMRI scanning while tasting sweet, sour, salty, and bitter tastants. Intensity perception was assessed separately using the generalized Labeled Magnitude Scale (gLMS). Intensity ratings for sweet, salty, and sour tastants were correlated ($r>0.73$, $p<0.01$), consistent with the existence of a central modulator of taste intensity perception (Green et al. 2005), but bitter ratings did not correlate with the ratings of other tastants. We next calculated mean intensity rating across all tastants and entered this into the CPM algorithm. We found a network, including amygdala and OFC, that was able to predict mean intensity ratings ($r=.388$, $p=0.041$) after covarying a measure of movement. Analysis of individual tastants, however, revealed that this effect was driven primarily by

responses to bitter taste, as a CPM with just sweet, sour, and salty data was not predictive of mean intensity ratings. In contrast, an analysis restricted to bitter data was able to predict mean bitter intensity ratings ($r=0.60$, $p<0.001$). Since perceptual correlations existed for sweet, sour and salty, but not bitter taste, these data suggest that CPM is unable to identify a common central mechanism for taste intensity perception. Further analyses, perhaps restricted to regions of interest such as amygdala and insula, are needed to better isolate a central mechanism.

304 **Receptor Specificity Of Thermal Sweet Taste And Its Interaction With Chemical Taste**

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Evidence from in vitro studies suggest that sweet thermal taste (swTT) results from the heat sensitivity of the sweet taste receptor TAS1R2/TAS1R3. We tested this hypothesis using a temperature-controlled flow gustometer (TFG) and the TAS1R2/TAS1R3 inverse agonist lactisole. 13 swTTs (8 F) immersed the tongue tip in either dH_2O or an 8mM lactisole solution that was flowing at 3ml/s and heated from 20°C to 37°C at 1°C/s. At the end of each trial Ss rated the intensity of any sweet, salty, sour, or bitter tastes on the gLMS. The hypothesis was supported: lactisole completely blocked the swTT. Given that heating the tongue tip can excite TAS1R2/TAS1R3, it is unclear why swTT is not universally perceived, or why those who perceive it do not always do so consistently. One possibility is that compared to most chemical agonists of TAS1R2/TAS1R3, heating produces a more ambiguous pattern of sweet stimulation, e.g., bitter and umami taste (T2Rs, TAS1R1/TAS1R3) are also heat-sensitive. We therefore hypothesized that swTT might be disrupted if trials containing the prototypical TAS1R2/TAS1R3 agonist sucrose were intermixed with thermal taste trials. 25 Ss (10 F) rated taste intensity as before in an experiment in which solutions of 56 and 180mM sucrose (or 0.018 and 0.056mM QHCl) were presented pseudo-randomly with dH_2O thermal taste trials. The results showed that both taste stimuli reduced swTT, but that the reduction by sucrose was significantly greater than by QHCl. We propose that the less selective activation of TAS1R2/TAS1R3 by heat results both in a lower probability of perceiving sweet taste and a greater susceptibility to disruption in the context of other tastes, particularly sweetness produced by more selective activation TAS1R2/TAS1R3.

305 **The Effect Of Orthonasal And Retronasal Odorant Delivery On Multitasking Stress**

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In America, excessive multitasking leads to acute stress that is harmful but has few relief mechanisms. Aromatherapy may reduce stress, but previous studies have reported variable results and no study has assessed how odorant delivery route may affect aroma stress reduction. Odorants can be delivered orthonasally (nostrils) or retronasally (oral cavity). Prior research indicates delivery route impacts olfactory processing, potentially dictating aromatherapy effectiveness. Presently, we studied the ability of linalool (12%; from lavender) and vanillin (25%; from vanilla), when delivered orthonasally (6 LPM) or retronasally (8 LPM), to reduce physiological and subjective measures of stress. Air, delivered in the same way, was used as a control. Thirty-one subjects underwent a baseline period (10 min) where they were instructed to "sit quietly and relax" followed by a multitasking computerized stressor (10 min) and finally a recovery period (10 min). For each condition (orthonasal or retronasal) 30 minutes of aroma (linalool or vanillin) or ambient air inhalation occurred. Objective measures (α -amylase, heart rate variability, and mean heart rate), and subjective measures (NASA Task Load Index and overall stress perception) were recorded. Compared to air, linalool was found to have significant effects on physiological stress markers whereas the impact of vanillin was generally not different. Retronasal linalool exhibited the highest effect when compared to orthonasal administration. Subjective stress responses were unaffected by linalool or vanillin exposure. This study suggests linalool reduces stress physiologically, and is more effective when delivered retronasally, likely due to a higher concentration in the bloodstream.

306 **The Impact Of Wakefulness On Olfactory Ability**

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Introduction: The degree of wakefulness has been demonstrated to impact a multitude of sensory and cognitive systems including hearing and interpretation of sounds, visual acuity and perception (Braun, et al., 1998), and somatosensory sensation (Glynn & Lloyd, 1976). Chronobiological influences on olfactory ability include the olfactory cycle (Frye 2003), menstrual cycle, and diurnal cycle (Koelega,1994). In regards to the latter, olfactory ability tends to be greatest when first arising in the morning, less after the evening meal, and lowest in sleep (Carskadon & Herz, 2004). How much of this is due to fasting induced olfactory enhancement, as opposed to olfactory intensification due to enhanced alertness after a night's sleep, is unknown. If olfactory ability is dependent on degree of wakefulness, then this factor may be important in accurately interpreting the results of olfactory testing. It was hypothesized that like other sensory modalities, when more alert, there will be greater olfactory acuity. Methods: On a convenience basis, twenty subjectively normosmic and normogeusic college students (13 male, 7 female) rated their degree of wakefulness on a visual analog scale followed by olfactory threshold testing for phenylethyl alcohol dirhinously. This was repeated with each subject after an interval of at least two hours on the same day. The data was categorized based on the participant's smell threshold scores for when they were more awake and less awake. The mean values were evaluated and significance determined based on Pearson correlation. Results: No statistically

significant (p=0.2) correlation between degree of wakefulness and olfactory ability was found. Further evaluation in those with greater degrees of difference of wakefulness between olfactory tests is warranted.

307 **Computational Characterization Of Piriform Cortical Semilunar And Superficial Pyramidal Cell Intrinsic Properties**

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The anterior piriform cortex (aPC) integrates odor inputs from the olfactory bulb (OB) with inputs from other olfactory and non-olfactory areas. It has been characterized as an associative memory network and provides extensive feedback to the OB. Two classes of aPC principal neurons directly receive afferent input from OB mitral cells: semilunar (SL) and superficial pyramidal (SP) cells. These cell classes are morphologically and physiologically distinct, and only SPs are also substantially innervated by associative fibers. How SLs and SPs differently integrate input from the OB cannot be understood without addressing their intrinsic properties within a coherent framework. We built biophysically detailed compartmental models of SLs and SPs, combining experimental data from different laboratories. We inferred additional intrinsic properties by parameter space exploration, validating model output against experimental data. We thereby reproduced the characteristic firing patterns of SL and SP neurons under different experimental conditions, along with correct action potential forward- and back-propagation properties. The model neurons are driven by simulated OB inputs in the gamma/beta frequency ranges, with varying degrees of synchrony and sparseness, and with the topology of OB projections constrained by known experimental findings. We use these detailed models of aPC principal neurons to assess how their intrinsic neural properties transform the features of OB ensemble spike trains, particularly with respect to frequency modulation and spike synchrony patterns. This early version of our model of aPC can be seen as the first step towards the systematic construction of a fully generative model of piriform cortex and its interactions with the OB.

308 **18F-Fdg Micro Pet Study Of The Association Between Odor Stimulation And Brain Activation In Rats**

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Objective: Using [^{18}F]- fluorodeoxyglucose (FDG) and microPET/CT, to test the feasibility of FDG PET for validation of olfactory function of rats with standard Phenethyl Alcohol (PEA) and Common Valeric Acid (CVA) odors stimulation. To verify the possibility of FDG PET as a new objective examination method for evaluating olfactory function. Methods: 6 healthy Sprague-Dawley (SD) male rats (250-300g) were used. First of all, Buried Food Pellet Test (BFT) was used to confirm the normal olfactory function of rats. Then, in the next 3 days, after the intravenous injection of FDG (18 MBq/100g), awaken rats were placed in a ventilated Plexiglas cage for 30 min. Subsequently, pure air (the first day), PEA (the second day) and CVA (the third day) were delivered. After odor stimulation for 30min, rats underwent static PET scan for 10min under anesthetic condition. Images were reconstructed, and assessed by SPM and VBM method. Results: 1) The time of BFT was (49.28 + 13.69) s. All rats completed the test within 300s, which showed that these rats had normal olfactory function. 2) Activation of rat brain regions after PEA stimulation: insula, bed nucleus. Activation of rat brain regions after CVA stimulation: olfactory bulb, anterior olfactory nucleus, entorhinal cortex, olfactory cortex, piriform cortex, amygdala, insula, corpus callosum, prefrontal cortex ($t=4.03$, $p<0.005$, Ke = 20voxels). Conclusion: Olfactory stimulation with different odors can induce metabolic activation in different brain regions of rats, which was in concordance with olfactory regions, and the olfactory related brain regions of rats have strong responses to odor stimulation of CVA. FDG PET could be used as an effective imaging tool for studying olfactory function and may have a great potential application in early olfactory assessment.

309 **The Insula And Bodily Processing: An Examination Of Gustation And Rectal Distention In The Anesthetized Macaque**

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The body constantly processes information about the outside world and the world inside itself. The mouth serves as a vital sensing gate for the taste, temperature and texture of food. Oral receptors relay sensory information about ingested contents to the insular cortex, which harbors the primary cortical center for gustatory information processing (Small, 2010). The insula receives afferent inputs not only from the mouth but also from the entire body, including the digestive system. The processing of bodily (or interoceptive) information in the insular cortex gives rise to subjective bodily sensations (e.g., taste, hunger, thirst, fullness, warmth) and, in turn, regulates bodily functions (Craig, 2003). Given the importance of these bodily feelings in metabolic wellness and in psychosomatic integration, mapping where each bodily process is represented in the insula is clearly needed. In several 7T fMRI studies with the anesthetized macaque monkey (n=12), we introduced taste and rectal distention paradigms while measuring the sensory information relay to key subcortical and cortical network processing hubs. The insula, in particular, was consistently activated. Analyses of low- and high-intensity sweet, sour and salty taste stimuli disclosed tastant-specific activations across the mid-anterior dorsal insular cortex where other oral sensory afferents are represented, thereby alluding to a potential gustotopic map embedded within a full mouth representation. Rectal distention, on the other hand, activated specifically the ventral anterior

insula, suggesting that purely sensory (e.g. taste, temperature and texture of food) and sensory-motor (e.g., distention and contraction of the gut) processing may be represented in two distinct insular territories.

310 **(Achems Undergrad Award Finalist) Exploring Centrifugal Innervation Of The Olfactory Bulb From The Olfactory Tubercle**

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The inter-regional connectivity of sensory structures in the brain provides opportunity for the modulation of sensory processing in manners important for perception. Olfactory corticofugal innervations, those originating in a cortex and synapsing within the olfactory bulb, have been reported to arise from numerous olfactory cortices, including the olfactory tubercle. Indeed, previous reports have suggested the olfactory tubercle even functionally modulates the olfactory bulb. Here we sought to explore the possibility for this corticofugal innervation and the cell types involved. We performed unilateral olfactory bulb injections of either retrobeads or retrograde adeno-associated virus into mice. Following, we collected the brains and sectioned them for analysis. Preliminary results reveal, particularly in the retrobead-injected mice, robustly labeled neurons in the ipsilateral piriform cortex, anterior olfactory nucleus, and diagonal band of Broca. These results indicate the successful retrobead-mediated labeling of structures known to centrifugally innervate the olfactory bulb. Surprisingly, no retrobead-labeled soma were detected in the olfactory tubercle. These preliminary findings, which are contrary to previously published results, suggest that the olfactory tubercle is unique among other olfactory cortices, specifically in that it does not centrifugally innervate the olfactory bulb. Additional analyses are underway with retrograde viruses to confirm and extend this result.

311 **Nasal Respiration Is Modulated By Electrical Stimulation Of Human Amygdala**

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The neural mechanisms underlying human olfactory sampling behaviors are not well understood. Smelling requires breathing, and breathing imposes rhythmic activity in olfactory cortex, facts that together suggest overlapping neural mechanisms for sniffing and smelling. The relationship between olfaction and respiration appears reciprocal. For example, electrical stimulation of the rodent olfactory bulb can induce sniffing (Monad 1983), and in rabbits synchrony between respiratory movements and autonomic respiratory control centers is lost when sniffing begins, suggesting olfactory brain regions exert control over autonomic respiratory centers to allow sniffing (DuPont 1987). The neural networks and mechanisms that allow olfactory brain regions to both modify sniffing behavior and exert control over autonomic respiration areas in the brainstem are unknown. Emerging research from rodents and humans suggests a potential role for the amygdala in respiratory control (Dlouhy et al; Zelano et al), but whether its role is related to olfactory sampling is unknown. The amygdala receives direct projections from the olfactory bulb, and is an integral part of primary olfactory cortex as such. It also projects heavily to brainstem respiratory centers via the bed nucleus of the stria terminalis (BNST), part of the extended amygdala, making it a prime candidate for a central hub in sniffing control mechanisms. Here we used direct electrical stimulation of the human amygdala to test the hypothesis that this region plays a role in nasal respiratory control. Preliminary results indicate that electrical stimulation of the amygdala induces respiratory arrest exclusively during nasal (and not during oral) breathing. These results support the hypothesis that the human amygdala is integral in nasal respiratory control.

312 **Age- And Experience-Dependent Changes In The Rodent Gustatory Cortex**

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Experience-dependent plasticity is a key regulator of post-natal development in an array of sensory cortices. How early life experiences with taste affect the development of the gustatory cortex (GC) and taste-guided behaviors later in life is currently unknown. However, studies in rodents and humans indicate that experience with tastes in utero or as an infant can influence later perception of tastes (Galef, 1985; Hepper, 1988; Menella et al, 2001). Using acute whole-cell electrophysiology in mice, we examined whether developmental changes occur in GC neurons around the peri-weaning period (from P17 to P35), and if experience affects GC circuit maturation. Our data show a decrease in intrinsic excitability of GC neurons from P17 to P35. In agranular GC, age-dependent changes included an increase in rheobase matched with a more depolarized threshold to fire action potentials, and a decrease in firing frequency. These findings were mostly unchanged following post-weaning taste-enrichment. In the granular and dysgranular GC, age-dependent changes included a decrease in firing rate which was further depressed following taste enrichment. Taste experience shifted the action potential threshold to a more depolarized voltage compared to control animals. We are currently investigating possible age- and experience-dependent changes in synaptic transmission onto GC pyramidal neurons. Ultimately, the goal of this study is to determine how differences in GC activity between control and enriched taste experiences early in life may affect taste-guided behaviors in adulthood. These studies will be the first to examine the effects of early taste experience on the development of GC.

313 **Topographical Variation In Perceived Intensity Of Multiple Bitter Stimuli In Humans**

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Taste receptors are found throughout the oral cavity, including on the soft palate, pharynx, larynx, and anterior and posterior tongue. Despite widespread and persistent myths of a tongue map, all five commonly accepted taste qualities are sensed all over the tongue. However, modern psychophysical data also suggest there may be more nuanced differences in suprathreshold intensity across loci, especially for bitterness. Here, we test whether bitter stimuli matched for whole mouth intensity differ in perceived intensity across regions of the oral cavity. Adults (n=63) were given 4 intensity matched solutions – sucrose, quinine HCl, sucrose octaacetate (SOA; a GRAS bitterant), and Tetralone® (from hops) – in a whole mouth sip and spit paradigm. After orientation to a general Labeled Magnitude Scale (gLMS), they rated overall intensity for 5 different regions: front, middle, back of tongue; roof of mouth; and lip. Temporal effects were explored by obtaining in-mouth and aftertaste ratings, but in-mouth ratings were the primary endpoint. As expected, the bitter stimuli were rated near moderate on gLMS for all regions that contain taste papillae; the lip, included to control for demand characteristics, showed mean intensities below weak. In ANOVA with region and bitterant (fixed) and panelists (random) for in-mouth data, there was a main effect of region (expected due to the lip) and no effect of bitterant (suggesting intensity matching was successful). Critically, we also observed an interaction of bitterant by region, suggesting their intensity differed across region. This effect was driven entirely by lower ratings for Tetralone on the anterior tongue. Reasons for this effect are not known but it may suggest differential expression of TAS2R1, TAS2R14, and TAS2R40 across regions in the oral cavity.

314 **Intensity And Pleasantness Ratings Of Sugar And Fat In Hispanics And Non-Hispanic Whites**

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There are more than 40 million Hispanics in the US and 64% are of Mexican origin. Studying Hispanics of Mexican origin and non-Hispanic whites, we recently observed a blunted brain response in reward areas in Hispanics rating the pleasantness of sucrose (Szajer et al., *Brain Research*, 2017). In that sample fMRI detected robust effects of ethnicity but differences in psychophysical ratings of intensity and pleasantness of sucrose were not significant. Given previous research and the nature of the measures, we suspected that a larger sample size would be required to observe psychophysical effects than fMRI effects. There is little information comparing psychophysical ratings of sucrose in Hispanics and non-Hispanics. One important study found higher intensity ratings of sucrose in Hispanics than non-Hispanic whites, particularly males (Williams et al., *Chemical Senses*, 2016). Here we compared both intensity and hedonic ratings in a large sample of Hispanics and non-Hispanic whites. Participants tasted sucrose (0%, 2%, 4%, 8%, 16%, and 32%), in backgrounds with varying levels of milk fat (0%, 1%, 2%, 4%, and 10%) and all possible two-component combinations and rated intensity and pleasantness on modified general Labeled Magnitude Scales. Repeated measures mixed-model ANOVA revealed that Hispanics produced higher intensity ratings for sucrose, as in Williams et al. ANOVA also revealed significant differences in hedonic ratings. Importantly, Hispanics rated the pleasantness of sucrose lower than non-Hispanics did. These data support the fMRI findings of a blunted reward response to sucrose in Hispanics. Thus, although a larger sample size was required to detect differences in sucrose pleasantness using psychophysical methods than using fMRI, the psychophysical data nicely complemented the fMRI findings.

315 **All Mints Are Not Created Equally: Effects Of Mint Variety Scent Administration On Objective And Subjective Measures Of Physical Performance, Cognitive Processing, Physiology, Mood And Alertness**

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Past research indicates peppermint scent administration can alter physical performance, cognitive processing, physiology, mood and alertness. The present study assessed the effects of Mentha Piperita (MP) vs. Mentha Gracilis (MG) vs. Mentha Spicata (MS) scents on those factors. 41 participants (24 male/17 female) aged 18-44 years old completed tests of cognitive performance (Impact Neurological Testing) and physical performance (treadmill stress test) while experiencing the three scent varieties and a non-scent control condition. During testing, measures of mood (Profile of Mood States), workload (NASA Task Load Index), alertness and physiology (heart rate, blood pressure) were recorded. Scents were administered at 1.3L/min via an oxygen concentrator through a nasal canula. MP was associated with decreased fatigue and increased vigor. Mental demand was lower in the MP and MS conditions. MP resulted in decreased physical demand. The combination of MG and cognitive testing produced the perception of the slowest movement of time, while the combination of MP and cognitive testing produced the perception of the fastest movement of time. MP resulted in decreased effort and increased performance. MG was associated with the greatest frustration. During cognitive testing, visual memory composite score for the MP condition was highest. MP was associated with faster reaction time and MG was associated with slower reaction time. Participants receiving MP exhibited greater impulse control, while MG was associated with the least amount of impulse control. Diastolic blood pressure was greatest in the MP condition and pulse was more consistent. These results suggest that the particular variety of mint is important in achieving a particular effect, and that all mints are not created equally.

316 **Importance Of Olfactory Information In Adolescents**

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Aim: Olfactory information plays an important role in every-day life like food choice, warning signal, and social communication. In addition olfaction is closely linked to emotions. Most studies regarding these topics were

conducted in adults. This study aimed to observe which odors are of importance to adolescents and which odors are linked to emotions. Material and methods: A total of 211 high-school students (102 girls, 109 boys) with an average age of 14.4±1.7 years participated in this questionnaire-based study. Two questions were asked, I: "Please list up to 10 odors, which are of importance to you". II: "Please answer the following six questions: 1) I get happy smelling . 2) I get disgusted smelling ., etc.". The emotions were selected according to Ekman's basic emotions. The odors were grouped in seven categories: i) nature, ii) plants, iii) animals, iv) humans, v) culture, iv) death and waste, vii) food. Results: The students reported on average 7.6±2.5 odors. Odors in the culture (32.8%) and food category (23.6%) were named significantly more often than odors in the other categories (Chi^2-*test* all $p<0.001$). Girls reported more odors than boys belonging to plants (Chi^2-*test* $p=0.04$). 96.2% of the adolescents reported an odor evoking happiness and 97.6% disgust, respectively. Odors evoking all other emotions were named significantly less frequently (Chi^2-*test* $p<0.001$). Odors eliciting happiness were mostly food (32%) and nature (26%). Odors related to the emotion disgust were in the death and waste category (68%). Conclusion: Odors related to culture and food are of importance to adolescents. Emotions, especially happiness and disgust are linked to odors.

317 **Novel Approach For Characterizing &Ldquo;Product Temperature-Dependent Sensory-Attribute Variations&Rdquo; Of Hot Or Cold Food And Beverages**

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In most sensory studies that showed influences of serving temperatures on chemosensory intensities of hot foods or beverages, the number of attributes evaluated at specific serving temperatures has been limited since product temperatures quickly change over time. Using a rapid sensory profiling technique, the Check-All-That-Apply (CATA) method, this study aimed to characterize a profile of chemosensory attributes with decreasing or increasing temperatures of hot or cold foods and beverages. The "Product Temperature-Dependent Sensory-Attribute Variations" (PTDSAV) were determined with respect to cooked rice (Study 1), brewed coffee (Study 2), and green tea (Study 3) samples. In each study, samples were randomly presented at specific temperatures, respectively: cooked rice (70, 60, 50, 40, and 30 °C), brewed coffee (70, 55, 40, and 25 °C), and green tea (65, 25, and 5 °C). Participants were asked to select all the CATA terms that they considered appropriate to characterize attributes of the samples presented at each temperature. Multivariate analysis characterized the PTDSAV for cooked rice, brewed coffee, and green tea samples, respectively. Results showed that 13 out of 35 attributes in cooked rice samples differed among five temperature conditions. In addition, 24 out of 49 attributes in brewed coffee samples were found to vary as a function of product temperature. Product temperatures were also found to affect not only a profile of sensory attributes, but also emotional responses toward green tea samples evaluated at different temperatures. In conclusion, our findings show that the PTDSAV, generated using a rapid method of sensory profiling technique, can draw a big picture view as to how chemosensory attributes can vary with temperatures of hot or cold foods and beverages.

318 **Verbal Description As An Implicit Measure Of Anthropomorphized Odorant Gender**

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Odors can be anthropomorphized as male or female, and assessment of these odorant qualities is typically performed via explicit ratings on psychophysical scales. The present study investigated whether simply asking people to describe an odorant could provide similar information about an odorant's gender implicitly. Of the 55 participants in this study, 29 received the odorants in bottles labeled with the correct name, while 26 received unlabeled odorants for evaluation. In the implicit task, each participant was presented with 16 odorants one at a time, and was asked to write down the first 3 adjectives that came to mind that describe it. Afterwards, participants gave explicit ratings of masculinity, femininity, pleasantness, and intensity for each odorant on either a Visual Analogue Scale or a variant of the gLMS (Bartoshuk et al, 2004). The adjectives from the implicit task were judged as male or female by 5 naïve participants, yielding a % feminine score for each word. Results showed that the explicit measure of femininity was highly correlated with the implicit % feminine score ($r = .46$ $p < .01$). Moreover (as previously shown with explicit ratings by Doty et al, 1978), the implicit % feminine score was also correlated positively with the explicit rating of pleasantness ($r = .51$, $p < .01$) and negatively correlated with perceived intensity ($r = -.28$, $p < .01$). Regression models also indicated that the explicit rating of femininity less strongly affects the implicit % feminine score in the unlabeled than in the labeled group, and pleasantness is more important. These results suggest that verbal descriptions of an odorant, even in participants who do not know the identity of an odorant, carry implicitly information similar to explicitly gathered information regarding odorant gender.

319 **The Influence Of A Semantic Tool On Spontaneous Odor Characterization**

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Olfaction is a very powerful sense in connection with memory, learning and emotion. However, we are able to recognize and distinguish scents even after long times, it is difficult to identify them by names. What makes the "naming" of odors more complex is the fact that the odorant profile of a product might cover a wide range of olfactory notes. To facilitate odor description, ISIPCA developed a tool in order to enable panelists to determine the odorant profile of a product, regardless of the product category. This tool takes the form of a four-level wheel, from odorant families (fruity, floral …), through sub-categories (for the fruity family: berry, tropical…) and sensory descriptor (for the berry sub-category: strawberry, raspberry…). The fourth and last level of the wheel

consists in raw materials corresponding to the descriptor previously identified, and defined within the panel as a benchmark for the training. Since presenting sensory descriptors can induce semantic priming two conditions of product characterization are compared to assess to which level the spontaneous odor processing is influenced by semantic context. This study involves evaluation of 2 different odorant accords by 10 highly trained panelists in the presence of "ISIPCA' smell" tool and in absence of the tool by "Free comment" approach. The presented study assess the differences between the panelists' results using the two approaches in order to investigate to which level the spontaneous odor perception and characterization can be influenced by semantic context. The products profiles obtained through the through the both approaches are also compared to investigate if the odor description rests more on global semantic discriminations for free comments approach.

320 **A Computational Model Of Oxytocin Modulation Of Social Recognition In The Olfactory Bulb**

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Social olfactory recognition memory is probed by allowing an animal to interact with a conspecific and testing recognition at a later time. Recognition is expressed as a lack of olfactory investigation during the second encounter. Experiments to date strongly suggest that processes in the olfactory bulb (OB) are at least partially responsible for this type of non-associative odor memory: formation of odor memories are impaired when local NMDA receptors are blocked; OB responses to repeatedly presented odorants mimic the time course and specificity of behavioral memory and are dependent on NMDA receptors; odor recognition memory can be modulated by local manipulations of OB processing. We have recently shown that the duration of social recognition memory can be modulated by oxytocin (OXT) release in the anterior olfactory nucleus (AON), a structure providing abundant feedback input to the OB. Release of OXT into the AON changed signal-to-noise ratios at the output of the OB by modulating inhibitory and excitatory local interneurons. Drawing from the experimental data presented above, we here present a first model of neural mechanisms of olfactory recognition memory, its enhancement by OXT and the role of the feedback loop between the OB and the AON in maintaining this memory. Our simulations suggest that NMDA dependent synaptic plasticity between AON pyramidal cells and OB inhibitory granule cells mediate adaptation of MC odor responses reflected in behavioral odor object recognition. A simple plasticity rule can reflect the duration and specificity of this memory as well as its modulation by OXT in the AON. Our model is a first to suggest a neural mechanism for OB recognition memory compatible with available data.

321 **Olfactory Certainty As A Function Of Learning And Cholinergic Modulation**

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Olfactory perception can be modulated by a number of factors, including experience with the stimuli, learning, stimulus concentration and neuromodulation. Studies from our lab have shown that the certainty of a specific odor being associated with a reward is modulated by the amount of learning as well as activation of cholinergic receptors in the olfactory bulb (OB). We here directly compare the effect of learning to the effects of muscarininc and nicotinic receptor activation. Using an odor-reward association task which allows us to measure the strength of an odor association as well as its certainty, we show that blockade of muscarinic receptors slows down learning by decreasing the strength of the formed association and its certainty. Mice trained with a muscarinic antagonist infused into their OB performed similar to saline treated mice trained for 4 trials only after 12 trials. Both the strength of the association as well as the certainty recognizing the conditioned odor increase more slowly in mice with muscarinic receptor blockade. In contrast, mice with nicotinic receptor blockade performed similarly to saline treated rats for all odors except the most similar pair, which they never discriminated. These results (1) confirm our previous hypothesis about the respective roles of muscarinic and nicotinic receptors for odor – reward association learning and certainty; (2) show that increased amount of learning can overcome the lack of functioning muscarinic receptors, suggesting a role in speed of learning and degree of plasticity for these receptors. Computational modeling shows that indeed, both increased synchrony due to muscarinic receptor activation and increased number of trials lead to the same degree of synaptic weight changes in olfactory cortex.

322 **Retronsal Habituation: Characterization And Impact To Flavor Perception Using Time-Intensity.**

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Olfactory habituation results from a prolonged exposure to an odor leading to perceptual changes defined by several characteristics. To date, human habituation research has focused on orthonasal olfaction which is perceived externally while ignoring internal routes of odor perception related to flavor. In our study, we conducted two experiments to characterize retronasal olfactory habituation and measure its impact on flavor perception. In Experiment 1, 22 participants rhythmically breathed a food odor (lime oil), non-food odor (lavender oil), and blank (propylene glycol) that was presented with an orally-adhered strip while rating the odor intensity using the time-intensity procedure. After a 10-minute exposure, the participants ate a lime-flavored gummy and rated the lime flavor. In Experiment 2, the same procedure was performed for a low-level lime odor and a simple (lime oil) and complex (lime oil + sucrose + citric acid) beverage as the flavor stimuli. Our results demonstrated two principles (P) of habituation for retronsally presented odors: P1) prolonged exposure lead to decreased perception, P5) weaker stimuli lead to more rapid habituation. Additionally, we show that context matters with the non-food odor habituating slower than the food odors; however, the food odors seem to recover simultaneously upon a food and beverage consumption leading to no change in flavor perception.

323 **An Olfactory-Hippocampal-Prefrontal Network For Odor-Place Associative Memory.**

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Rodents can form associations between odor cues and locations and use these associative memories to seek reward and avoid danger in different contexts. The mechanisms underlying such odor-place associative memories are thought to involve a brain-wide network, and in particular, the hippocampus. Additionally, both the hippocampus and the prefrontal cortex (PFC) are known to be crucial for memory retrieval and associative memory. However, the physiological mechanisms that may coordinate activity across the olfactory, hippocampal, and prefrontal regions for odor-place associative recall are unclear. The present study seeks to address the role of an olfactory-hippocampal-prefrontal network in an olfactory cue-guided T-maze task. In this task, rats recalled familiar associations between odors and reward locations on the maze arms, with behavioral performance at 75-90%. Neural activity in the olfactory bulb, PFC, and the dorsal CA1 region of the hippocampus was recorded in freely-behaving rats as they performed this task. Individual neurons in both hippocampus and PFC exhibited stimulus-selective responses, implicating their involvement in recall of odor-place associations. During the period of acute olfactory recall, beta oscillations (15-35 Hz) were prominent in olfactory bulb, hippocamps, and PFC, and beta coherence was enhanced between the three regions as well. Further, phase locking of PFC neurons to hippocampal beta was also observed, suggesting coordination of these regions as part of a functional network. These results point to an olfactory-hippocampal-prefrontal network underlying the recall of familiar olfactory associations. Future work will address the directionality of this relationship, and investigate ensemble activity in hippocampal-PFC regions underlying odor-place recall.

325 **Functional Identification Of Olfactory Bulb Glomeruli *In Vivo***

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Mapping sensory space to neural activity is critical to understanding how sensory information is processed in the brain. In olfaction, odors are first encoded by the activation of odorant receptor (OR)-specific olfactory sensory neurons (OSNs) within olfactory bulb glomeruli. Prior efforts to map odors to glomeruli have used arbitrary and often high odor concentrations evoking widespread glomerular activation, in part to overcome the limited sensitivity of intrinsic signal and early generation calcium indicator imaging. Knowledge of how odors map to glomeruli is thus restricted to a few genetically tagged ORs (e.g., M72) and combinatorial fingerprinting of glomeruli across many odors. Here, we perform 1- and 2-photon imaging of glomerular activation in mice expressing ultrasensitive GCaMP6f in OSNs, permitting the unique activation of single glomeruli by odors at near-threshold concentrations to be detected. Implementing a novel high-throughput olfactometer with negligible cross-channel contamination, we further densely sample sensory space by screening ~100 chemically diverse odors per animal. Using this approach, we routinely map odor responses in ~100 dorsal glomeruli, of which dozens are uniquely and often exclusively activated by distinct high affinity odors. Surprisingly, several odors (e.g., acetophenone derivatives) identified *in vitro* as common ligands for individual ORs (e.g., M72) uniquely activate distinct glomeruli *in vivo*. We additionally map several novel odors, including food- and predator-derived pyrazines. Collectively, our results provide a key resource by identifying maximally diagnostic odors for efficiently studying conserved glomeruli, and further establish an extensive dataset of how sensory space maps to neural activity in the olfactory system.

326 **A Site-Specific Cas9 Approach To Investigate The Role Of Olfactory Kv1.3 Channels In Metabolism**

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Voltage-gated potassium channels control neuronal excitability, as well as the ability to perceive external sensory cues. Of these, the Kv1.3 subfamily is highly expressed in the piriform cortex and the olfactory bulb (OB), where it carries 80% of voltage-activated outward currents in mitral cells (MCs). The excitability of MCs is modulated by metabolic changes in insulin and glucose that target the Kv1.3 ion channel. We have demonstrated that reducing Kv1.3 conductance through pharmacological block or genome-wide gene deletion generates a phenotype in mice that shows an increase in total energy expenditure (TEE), a resistance to diet-induced obesity (DIO), and an enhanced olfactory discrimination ability. Given the prevalence of Kv1.3 in the OB and the synaptic proximity to the hypothalamus, we hypothesized that modulation of MC excitability may in tandem regulate whole-body metabolism and that a targeted-gene deletion of Kv1.3 (*Kcna3*) will also increase TEE and allow resistance to DIO. We identified three protospacer adjacent motif sequences in *Kcna3* near the N-terminus that are recognized by the spCas9 endonuclease. When co-transfected in Human Embryonic Kidney cells (HEK293 cells), we confirmed using fluorescence microscopy that the C-terminal trafficking domain of Kv1.3-GFP was altered or deleted by frameshift mutation. We then quantified the effectiveness of each gRNA construct to reduce Kv1.3 current magnitude using patch-clamp electrophysiology. Current knock-down ranged from 61-87% depending upon gRNA sequence but did not change channel inactivation or deactivation properties. Because gRNA 1 was most effective, we will package it into AAV particles and intracranially inject into tbet-cre/rosa-cas9 mice to achieve a MC-specific knockout of Kv1.3.

327 **Characterization Of Dopamine Neurons And Their Electrophysiological Profile In The Rat Olfactory Bulb**

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The mammalian olfactory bulb (OB) is the first brain region to transduce and process odor signals. With its neuronal circuitry and variety of neurotransmitters and modulators, the OB is capable of processing billions of odor signals. One of these neurotransmitters is dopamine (DA), which is endogenous to the OB's glomerular layer (GL). DA, a largely inhibitory neurotransmitter, modulates odor sensitivity. While DA's synaptic mechanisms in the OB are well known, the neuronal identity of its cells and their electrophysiological profiles, especially in the rat, are not. In this study, we used a transgenic rat line (hTH-GFP) to identify the cell type of dopaminergic OB neurons and determine their electrophysiological profiles. Our data show that DA neurons have different cell morphologies, suggesting that OB DA neurons consist of multiple cell types. We also show that DA neurons do not express the marker calretinin, and are, therefore, not likely to be Type-2 periglomerular cells. Electrophysiology data show that rat OB DA neurons may be different from mouse neurons, because, in contrast to mouse neurons, rat DA neurons do not have spontaneous action potential activity. Our data also show that rat DA neurons typically produce a single action potential per stimulus and are likely gated by a low-pass filter, which may allow for DA to increase odor sensitivity by inhibiting tonic odors. We are currently exploring whether the localization of DA neurons within the GL determines their neuronal identity and electrophysiological profiles. We believe this study provides evidence that there may be more than one dopaminergic cell type in the OB, that these different DA neurons may have different electrophysiological profiles, and that there exist differences in DA neuron identity and function among species.

328 **Direct Comparison Of Odor-Evoked Calcium Responses Of Identical Glomeruli In The Medial/Lateral Maps Of The Mouse Olfactory Bulb.**

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Axons of olfactory sensory neurons (OSNs) that express the same type of odorant receptor converge onto two glomeruli, one is located in the medial side and the other in the lateral side of the olfactory bulb (OB). Because these identical pairs of glomeruli are arranged symmetrically, it has been considered that there is a pair of medial/lateral glomerular maps in the OB. However, functional properties of the two maps including their difference remain unclear because the majority of the medial glomeruli are difficult to access in an intact brain. Interestingly, the identical pairs of glomeruli that expressed the trace amine-associated receptors (TAARs) are both located in the dorsal aspect of OB (Pacifico *et al*., *Cell Reports*, 2012). In this study, we simultaneously recorded the odor responses of these identical pairs of glomeruli and compared the temporal patterns of activity such as the onset latency, rise time, and decay time. To stimulate the TAARs glomeruli, we used odorants including beta-phenylethylamine and isopentylamine. To measure neuronal activity in various types of OB neurons (OSNs, GABAergic neurons, dopaminergic neurons and mitral/tufted cells), we used cell-type specific GCaMP3 expressing mice. Impressively the temporal patterns of each pair of glomeruli are quite similar and we could not see the clear differences between them. However, we found that respiration-locked fluctuation of the glomeruli in the medial map was significantly larger than those in the lateral map in post-synaptic neurons. The difference in the amplitude of fluctuation was enhanced by the odor stimulation. It suggests that the medial map is more sensitive to the respiration-locked olfactory inputs than the lateral map and may use the rhythm for the information processing.

330 **Human Chemosignaling Of Fear And Happiness: Replications In Western Caucasians And East Asians**

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A recent study hinted at a human capacity to implicitly emulate another's happiness based on body odor. As this was a single exploratory study using a Western Caucasian sample, the question is whether this phenomenon is robust enough to withstand a close replication, and universal enough to extend beyond particular genetic boundaries (i.e., ABCC11 gene-variant AA) potentially hindering the *species-wide* chemical communication of emotions. We followed the "replication recipe" (Brandt et al., 2014) and conducted a high-powered close replication ($N = 48$ Western Caucasians) and replication-extension study ($N = 48$ East Asians) using the original inclusion criteria, materials, procedures, double-blind design, and (pre-registered) analysis plan. Facial electromyography (EMG) was combined with an interocular suppression (IS) paradigm to examine *receivers'* subconscious behavioral, affective, and perceptual simulacrum of happiness and fear after exposure to *senders'* happy and fear odor (vs. neutral). Whereas happy odor caused both groups to perceive happy faces faster (IS-task), fear odor induced general vigilance, $F(1,85) = 12.41$, $p < .001$. Constrained by the original study's facial EMG results, *confirmatory* discriminant analysis (DA) was unsuccessful in classifying facial expressions into body odor conditions for both samples, as in: "no (different) man can step into the same river twice". However, a successful replication *was* achieved when *unconstrained* DA classified Western Caucasian and East Asian facial EMG data in a manner still consistent with the original research, and with theory. This study is the first to demonstrate the chemical communication of emotions extending beyond Caucasians to different-genotyped individuals East Asians, hinting at a potential species-shared capacity.

331 **Odorant Metabolism In Olfactory Mucus: Characterization And Impact On Olfactory Perception.**

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Lactating rabbit females emit in their milk a particular odorant, the mammary pheromone (MP) which elicits specific orocephalic movements in newborns and helps them to find the nipples and suck. Since the mother nurses only once per day, it is essential for the pups to remain sensitive to the MP during the 5 min of maternal presence. In the olfactory perireceptor environment, Odorant Metabolizing Enzymes (OMEs) contribute to the clearance of odorants and to their detection. We recently showed that the MP is metabolized in the newborn rabbit olfactory epithelium (OE) by glutathione transferases (GST) which emphasizes the function of such metabolism for maintaining a high sensitivity to the MP. In vertebrates, the identification and the function of OMEs expressed in the OE have been documented, however only few studies focused on the olfactory mucus. Here, we used Proton Transfer Reaction Mass Spectrometry to measure real time variations of the MP concentration above the olfactory mucus corresponding to the metabolism activity toward this odorant. We demonstrated for the first time that the MP is significantly metabolized by the olfactory mucus. Moreover, we showed by liquid chromatography (HPLC) that MP metabolism in the mucus is supported by GST. A proteomic study comparing newborns and weanlings olfactory mucus suggested that the alpha-GST could be the candidate enzyme for MP metabolism in the newborns. Finally, by *in vivo* mucus cleaning and testing of the orocephalic response, we showed that this metabolism has an impact on newborns perception. These results attested that metabolism in the olfactory mucus can lead to changes in odor signals bioavailability and in their perception. OMEs appear to be good candidates for interaction with odorants in the first steps of peripheral odor processing.

332 **Smelling An Emotional Fingerprint**

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Body odors sampled from fearful donors have been shown to produce fear in receivers smelling these odors. We tested 2 alternative hypotheses, namely whether a *general negative evaluative state* or a *discrete emotion (i.e. fear)* was communicated, by having participants rate neutral and emotional face image clips (fear, anger, disgust) as either neutral or negative under neutral and fear odor conditions. If fear odor induces a general negative affective state, then all negative facial images should be processed equally fast in the fear odor compared to the neutral body odor condition. If fear odor induces a discrete fear state, then only the facial images of fear would be processed faster in the fear odor condition. Female recipients (n =24) were tested on in a within-subjects design involving exposure to fearful and neutral sweat odor collected from 12 male donors into which either state was experimentally induced. During task execution, facial ElectroMyoGraphy (EMG) activity of medial frontalis (unique to fearful expression) and corrugator supercilii (involved in negative emotional expressions) muscles was recorded in the participants. Results from planned contrast analyses showed that participants were *faster* in classifying *fear* facial images in the *fear* odor vs. neutral odor condition compared to angry and disgusted faces, $F(1,23) = 7.73$, $p = .011$, whereas they did not differ in classifying negative facial images in the fear odor vs. neutral odor condition compared to neutral images, $F(1, 23) = .03$, $p = .860$. Fear odor evoked greater medial frontalis activity than neutral odor (p's <.05) in line with fear expression. These results demonstrated discrete priming of fear emotion by fear body odor suggestive of a *discrete* - and not generally negative - emotional fingerprint of fear in fear sweat.

333 **Analysis Of Primer Pheromone Action On The Central Regulator Of Reproduction In Female Mice**

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Primer pheromones emitted by male mice induce and accelerate estrus cycling in group-housed female mice. The mechanism of central action of these primer pheromones remains largely unknown. In females, the estrus cycle is controlled by pulsatile secretion of gonadotropin releasing hormone (GnRH) from the hypothalamus, which is suggested to be under the control of the subpopulation of neurons in the arcuate nucleus (ARC) that express a neuropeptide kisspeptin encoded by *Kiss1* gene. Therefore, we envisioned that primer pheromones would modulate the activity patterns of ARC *Kiss1*$^+$ neurons. To test this hypothesis, we performed Ca^{2+} imaging of ARC *Kiss1*+ neurons in awake mice by combining Cre-dependent expression of GCaMP6s in *Kiss1*-Cre mice and fiber photometry. We observed sharp repetitive episodes of elevated calcium (pulses) within ARC *Kiss1*+ neurons. In ovariectomized mice, the pulses were detected at an approximately regular interval of about 10 min. In contrast, the inter-pulse-interval was changed from 0.5 hour to 4 hours in accordance with estrus cycle in intact females. By using male mouse urine as a pheromone source, we examined the effect of primer pheromones on activity patterns of the ARC *Kiss1*+ neurons. In ovariectomized female mice, exposure to male urine induced a pulse earlier than the expected timing of the next pulse, based on the average inter-pulse interval before sample exposure. We also analyzed the effect of male urine exposure on intact female mice. Through these analyses, we will discuss how the male primer pheromones modulate ARC *Kiss1*+ neurons in female mice.

334 **The Semiochemical Repertoire Of Wild *Versus* Inbred Mice**

Maximilian Nagel[1], Rohini Bansal[2], Pavel Stopka[3], Tali Kimchi[4], Yoram Ben-Shaul[2], Marc Spehr[1]

[1]RWTH Aachen University, Aachen, Germany, [2]School of Medicine, Department of Medical Neurobiology, The Hebrew University of Jerusalem, Jerusalem, Israel, [3]Biotechnology and Biomedicine Center of the Academy of Sciences and Charles University in Vestec, Prague, Czech Republic, [4]Department of Neurobiology, Faculty of Biology, Weizmann Institute of Science, Rehovot, Israel

In con- and heterospecific rodent communication, urine serves as a rich source of chemosensory signals that provide information about social, sexual and reproductive status, thus, regulating complex social behavior. In this context, however, little is known about to what extent signals from typical inbred laboratory mice reflect the semiochemical repertoire of wild animals. In this study, we systematically compared chemosensory responses to urinary signals derived from wild *versus* inbred laboratory strain animals. Both Ca^{2+} imaging and electrophysiological recordings from first and second order neurons in the vomeronasal organ (VNO) and the accessory olfactory bulb (AOB), respectively, allowed comparative analysis of signal detection and information processing along the accessory olfactory pathway. Large scale Ca^{2+} imaging in acute mouse VNO slices from C57BL/6 and BALB/c animals revealed distinct neural activity patterns in response to sex- (male *versus* female) and strain- (C57BL/6 *versus* BALB/c *versus* wild) specific urinary signals. Response profiles significantly differed on both the individual neuron and the population level. In addition, *in vivo* single- and multi-unit recordings from AOB mitral cells in anesthetized C57BL/6 and BALB/c mice provided insight into how such sex-/strainspecific differences in vomeronasal neuron activity is encoded in the brain.

336 **Sexing Up Human Pheromones**

Tristram D. Wyatt
University of Oxford, Oxford, United Kingdom

A corporation interested in patenting ‘human pheromones’ for profit created a long lasting myth that has drawn in many scientists as well as the general public. I describe what went wrong and what would be needed to establish that we do have pheromones (chemical signals within a species). As humans are mammals, we may have pheromones. However, there is no robust bioassay−led evidence for the widely published claims that four steroid molecules are human pheromones: androstenone, androstenol, androstadienone, and estratetraenol. The many positive results reported in the literature are highly likely to be false positives. However, in 2016 and 2017 the first negative results started to be published. To find real human pheromones we need to take the lead from Darwin and treat ourselves as if we were a newly discovered mammal, and use the rigorous methods already proven successful in pheromone research on other species. Chemical communication between mothers and babies may give the first success.

337 **An Optical Switch For Trpc2 And Other Diacylglycerol-Sensitive Trp Channels**

Katherin Bleymehl[1], Ursula Storch[2], Michael Mederos y Schnitzler[2], James A. Frank[3], David B. Konrad[3], Dirk Trauner[3,4], Thomas Gudermann[2], Trese Leinders-Zufall[1], Frank Zufall[1]

[1]Center for Integrative Physiology and Molecular Medicine, Saarland University, Homburg, Germany, [2]Walther-Straub-Institute for Pharmacology and Toxicology, Ludwig-Maximilians-University, Munich, Germany, [3]Department of Chemistry, Ludwig-Maximilians-University, Munich, Germany, [4]Department of Chemistry, NYU, New York, NY, United States

The Trpc2 cation channel is a central transduction element in sensory neurons of the mouse vomeronasal organ (VNO). The finding that Trpc2 is also expressed in sensory neurons of the main olfactory epithelium (MOE) where it is required in type B cells for the detection of low environmental oxygen has sparked renewed interest in its function. Despite two decades of research, the second messenger signaling mechanisms underlying activation of Trpc2 and its corresponding cellular responses are still debated. Here, we employ a unique family of light-sensitive, photoswitchable diacylglycerols (DAGs) termed PhoDAGs. The PhoDAGs are inactive in the dark and can be activated by UV light, an effect that can be quickly reversed by illumination with blue light. We show that PhoDAGs can be used to rapidly activate and deactivate DAG-sensitive TRP channels in living cells including native Trpc2 channels of mouse VSNs and human TRPC6 channels expressed in HEK cells. We have developed an approach for combined PhoDAG photoconversion and Ca^{2+} imaging based on confocal laser scanning microscopy that can even be employed in acute tissue slices, thus enabling both large-scale mapping of DAG-evoked neuronal activation and localized stimulation and mapping in small cellular subcompartments. We also demonstrate the existence of comparatively slow DAG-activated Ca^{2+} responses in type B cells and in the related type A cells of the MOE. Thus, a brief photoactivation of DAG (for less than 30 ms) is sufficient to activate native Trpc2 channels and produce a concomitant Ca^{2+} rise. PhoDAGs provide an optical switch to activate and deactivate DAG-sensitive TRP channels with unprecedented speed and precisison.

338 **Calcium-Dependent Conductances That May Mediate T2R And Tsh Signaling In Human Thyrocytes**

Yuriy Bobkov[1,2,3], Arthur D. Zimmerman[1,2], Steven D. Munger[1,2,4]

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The production of thyroid hormones must be tightly controlled to avoid the pathological consequences of metabolic dysregulation throughout the body. It is thus critical to elucidate the mechanisms by which thyroid

hormone production is controlled, particularly in the context of systemic or environmental signals, if more effective therapies for thyroid disease are to be developed. We recently reported that thyrocytes express type 2 taste receptors (T2Rs), and that activation of thyroid T2Rs inhibits thyroid stimulating hormone (TSH)-dependent Ca^{2+} signaling and subsequent iodide efflux, two key components of a pathway regulating thyroid hormone production. Even so, the mechanisms by which the T2R-modulated Ca^{2+} signal regulates iodide efflux remains unclear. Using patch clamp electrophysiological and pharmacological approaches, we have identified two novel conductances in the Nthy-Ori-3-1 human thyrocyte line and in human primary thyrocytes that appear essential for coupling increased $[Ca^{2+}]_i$ to increased iodide efflux. Increased $[Ca^{2+}]_i$ first evokes a rapid outward K^+ conductance consistent with high conductance, Ca^{2+}-activated (BK-type) K^+ channels. This is followed by a relatively slow anion conductance that can flux both Cl^- and I^- and is likely mediated by a volume-regulated anion channel (VRAC). RNAseq analysis of Nthy-Ori-3-1 cells indicates that the principal subunits of each channel (KCNMA1 and LRRC8A, respectively) are heavily expressed. We hypothesize that increased $[Ca^{2+}]_i$ may contribute to the generation of electrical gradients that enhance iodide efflux through the activation of BK- and VRAC-mediated conductances.

339 **Acid Induced Activation And Desensitization Of Trpv1 In Chickens And Mice**

Ruojun Liang, Yuko Kawabata, Fuminori Kawabata, Shotaro Nishimura, Shoji Tabata
Laboratory of Functional Anatomy, Faculty of Agriculture, Kyushu University, Fukuoka, Japan

To elucidate the chicken pain transduction system is meaningful because chicken is one of the most important industrial animals and a model animal among birds. Transient receptor potential vanilloid 1 (TRPV1) is a nonselective cation channel to transduce pungent, heat and acidic signals to brain. In this study, we firstly focus on the comparison of acidic sensitivity of chicken TRPV1 with mouse TRPV1 by electrophysiology in transfected cells. The cell-suspension of transfected cells was plated on poly-D-lysine-coated glass coverslips, and cultured at 37˚C and 5% CO_2. Whole-cell patch-clamp recordings were performed with *TRPV1*/pcDNA3.1 and *EGFP*/pCAGGS co-transfected HEK293T cells at room temperature (RT) between 24-48 h after transfection. Acidic stimuli were repeated 4 times to observe the desensitization. We found that chicken TRPV1 is less sensitive to low pH and hard to be desensitized compared with mouse TRPV1. In addition, to check the expression of TRPV1, we made FLAG-tagged mouse or chicken TRPV1, they exhibited comparable levels of FLAG-specific staining on the cell surface. On the other hand, we made a mutant cTRPV1 by changing calmodulin (CaM) binding site on C-terminal with that of mouse, and the result revealed that the desensitization of mutant cTRPV1 became more obvious compared with wild type, especially in tachyphylaxis. These results suggest that there are the differences in desensitization of TRPV1 between chickens and mice caused by the mutation of CaM biding site on C-terminal.

340 **Genetic Diversity In Oral Chemosensory Gene Pathways**

Vicente Ramirez, Stephen Wooding
University of California Merced, Merced, CA, United States

Oral chemosensory cues played key roles in human evolution. Because they provided our ancestors with information about foods' nutritional values, they were tightly tied to survival and reproduction. This placed the genes encoding them under pressure from natural selection. Such pressures leave signatures in genetic diversity. Here, we analyzed patterns of genetic diversity in genes encoding oral chemosensory systems to characterize patterns in humans today and the evolutionary processes that shaped them. We examined 56 loci in 2504 healthy individuals across 26 populations from the 1000 genomes phase III repository. We found a total of 41986 nucleotide variants, which were most abundant in African populations (20105 SNPs) and lowest in East Asians (12349), with other populations being intermediate. Nucleotide diversity (π), which measures variation relative to allele frequencies, was also highest in Africans (0.12%) and lowest in East Asians (0.09%). Differences in diversity were also found among genes. Fst, a measure of differences between populations, ranged from <0.03 to >0.20. The highest and lowest values, which are consistent with the largest and smallest population differences respectively, were all observed at *TAS2R* loci. Nucleotide diversity ranged from 0.01% to >0.20%, with the highest and lowest values being observed at *TAS2R* loci. Tests for natural selection using Tajima's D statistic averaged -1.75 across genes, which is indicative of ongoing adaptation to new environments, consistent with humans' global dispersal over the last >100,000 years. Taken together, our findings indicate that selective pressures on oral chemosensory systems have been pervasive, resulting in varying levels of diversity and differentiation among populations, and have been strongest on bitter perception.

341 **Digging Into Earthworm Chemoreception.**

Cecil J Saunders, James B Pease, Wayne L Silver, Erik C Johnson
Wake Forest University, Department of Biology, Winston-Salem, NC, United States

The ever-present, yet often unnoticed earthworm inhabits a subterranean environment where chemical signals are the only indication of food, sex, and danger. The present study examines the European nightcrawler (*Eisenia hortensis*), which is used in commercial and home composting. Recognizing that the chemosensory systems of this agriculturally essential animal are poorly characterized, we have developed robust behavioral assays to screen aversive or appetitive compounds and leveraged RNA-seq to identify chemosensory genes. We have identified several TRPA1 isoforms present in earthworm epithelium, which likely serve as a mechanism allowing for *E. hortensis* to avoid soil containing allyl isothiocyanate (AITC). Additionally, we identified several potential mediators of acid avoidance including ASIC and PKD2L1. Conversely, *E. hortensis* shows no aversive behavior when exposed to capsaicin and lacks obvious TRPV1 homologues. We also identified several homologs to vertebrate taste signaling genes including CA6, TRPM5, GNAT3 and IP3R3. In contrast, the only traditional

taste receptor homologues identified in the *de novo* assembled transcriptome are to *Drosophila* mGluR. However, our behavioral data suggests that *E. hortensis* can detect and avoid some bitter compounds, like denatonium. Finally, we will present differential expression analysis on RNA extracted from epithelium on midsection and rostral segments—where purported earthworm chemosensory organs are concentrated. Earthworms are fundamentally reliant on chemosensation, and our behavioral and sequencing studies are the first attempt to fully characterize the various molecular mechanisms of this agriculturally vital species.

342 **Evidence For Trpa1 Channels In The Earthworm, *Eisenia Hortensis.***

Karleigh A. Smith, Eileen Reed, Sophie A. Gonzalez, Patrick M. DeZego, Emily P. Adams, Cecil J. Saunders, Wayne L. Silver
Department of Biology, Wake Forest University, Winston Salem, NC, United States

An abundance of earthworms is a key component of a healthy soil ecosystem. A standard method to determine the number of earthworms in an area is the use of allyl isothiocyanate (AITC) as a chemical expellant. AITC is a prototypical agonist of transient receptor channel A1 (TRPA1). AITC is poured into 0.5 m^2 quadrats and worms are collected as they emerge from the soil. While this is the predominant assay in the field of soil science the mechanism earthworms use to detect the AITC is not known. Here we provide evidence that the earthworm, *Eisenia hortensis*, the European nightcrawler, uses TRPA1 channels to detect AITC. We used a behavioral assay consisting of plastic cups filled with soil mixed with mineral oil and water (control) or oil, water and AITC. Worms placed in the control cups quickly burrowed into the soil. Worms placed in the AITC cups quickly left the cups in a concentration-dependent manner. However, when worms were submerged in the TRPA1 channel blocker, H3-030031, before being placed in the AITC cups, the number of worms leaving the cups was significantly reduced. We also investigated RNA from *E. hortensis* for TRPA1 homologs using degenerate reverse transcriptase PCR (RT-PCR). The PCR products obtained using a leech TRP primer set were compared to the NCBI database. We have identified several RNA fragments that are similar to previously reported TRP channel sequences in related organisms including TRPA1. From our behavioral and molecular results we provide evidence that the earthworm, *Eisenia hortensis,* uses TRPA1 channels to detect AITC.

343 **Multiple PlcB Signaling Pathways In Taste Receptor Cells Contribute To The Detection Of Taste Stimuli**

Eric Benfey, Debarghya Dutta Banik, Laura Martin, Ann-Marie Torregrossa, Kathryn Medler
University at Buffalo, Buffalo, NY, United States

Taste receptor cells use multiple signaling pathways to detect chemicals. While salty and sour stimuli bind ion channels, bitter, sweet and umami stimuli activate a GPCR/PLCβ2/IP_3R3 signaling pathway. Current thinking is that all bitter, sweet and umami stimuli are detected by Type II cells via a PLCβ2/IP_3R3 pathway. Several studies have cast doubt on this model but no alternative has yet been proposed. Using live cell imaging on isolated taste receptor cells from mice lacking a functional Type II pathway, we find many taste cells still respond robustly to bitter, sweet and umami stimuli, including a subset of Type III taste cells. Pharmacological blockers indicate these responses depend on another PLC-dependent pathway. We demonstrate that PLCβ3-KO mice also exhibit a significant loss in taste cell responsiveness and have impaired behavioral responses to taste stimuli. Our data identify a critical, and previously unknown, role for PLCβ3 in peripheral taste transduction.

344 **(Don Tucker Award Finalist) Trpm4 And Trpm5 Are Both Required For Normal Taste Transduction**

Debarghya Dutta Banik, Laura E. Martin, Ann-Marie Torregrossa, Kathryn F. Medler
University at Buffalo, Buffalo, NY, United States

Peripheral taste receptor cells use multiple signaling pathways to transduce taste stimuli into output signals that are sent to the brain. Transient receptor potential melastatin 5 (TRPM5), a sodium selective TRP channel, functions as a common downstream component in sweet, bitter, and umami signaling pathways. In the absence of TRPM5, mice have a reduced, but not abolished, ability to detect stimuli, suggesting that a TRPM5-independent pathway also contributes to these signals. Here, we identify a critical role for the sodium-selective TRP channel transient receptor potential melastatin 4 (TRPM4) in taste transduction. Immunohistochemical experiments have shown that TRPM4 is highly expressed in both type II and III taste receptor cells. Using live cell imaging and behavioral studies in TRPM4-KO, TRPM5-KO, and TRPM4/5-DKO mice, we found that TRPM4 and TRPM5 are both required for normal taste-evoked signaling. Loss of either channel significantly impairs taste, and loss of both channels completely abolishes the ability to detect bitter, sweet, or umami stimuli. Thus, both TRPM4 and TRPM5 have critical roles in taste transduction.

345 **Sensory Characteristics Of An Anti-Malarial Drug By Human Taste Cell Assays**

Alvaro Garcia-Blanco, Areej Turkistani, Robert Margolskee, Mehmet Hakan Ozdener
Monell Chemical Senses Center, Philadelphia, PA, United States

Malaria and schistosomiasis are infectious diseases and affect people of all ages, but children under 5 years old are particularly vulnerable. The World Health Organization (WHO) recommends dihydroartemisinin as first-line treatments for malaria and schistosomiasis in the developing world. Non-compliance in children is high because of the strong unpleasant taste of these drugs and accompanying nausea. Because children often cannot swallow pills a commonly tried approach to mitigate noxious taste is to add sweeteners and flavors to medications in an attempt to mask their bitterness or other objectionable off-tastes with competing flavors. However, this approach has had very limited efficacy in pediatric populations. The most powerful approach is to pharmacologically block noxious taste signals at the taste receptor level before these signals reach the brain. However, there is no information about which particular taste receptor(s) and other taste-related receptors are responsible for the aversive noxious taste of these drugs. In this study, we used cultured human fungiform taste (HBO) cells to identify the cellular and molecular targets in the mouth responsible for the taste of these drugs. We used

dihydroartemisinin (DHA) as a model drug to identify the cellular and molecular targets in HBO cells which may be responsible for the unpleasant taste and nausea. We demonstrated that DHA activates bitter receptors and as well as TRPV1 and TRPA1 receptors. Identifying the receptors and signaling molecules that underlie the aversive tastes of oral-dosage pharmaceuticals being used to treat malaria, schistosomiasis and other diseases in children in third world countries is a much needed first step to ameliorate their aversive tastes and promote compliance.

346 **Measurement Of Taste Cell Responses Using A Genetically Encoded Calcium Indicator (Geci), Yc2.60.**

Takami Maekawa[1], Tooru Takahashi[1,2], Ken Iwatsuki[3], Yutaka Maruyama[1], Hiroshi Hama[4], Atsushi Miyawaki[4]
[1]Ajinomoto Co., Inc., Kawasaki-shi, Japan, [2]WDB Co., Ltd., Tokyo-to, Japan, [3]Tokyo University of Agriculture, Tokyo-to, Japan, [4]RIKEN, Wako-shi, Japan

Indicators for calcium are useful optical tools for monitoring the responses of living cells to a variety of stimuli. Genetically encoded calcium indicators (GECIs) have several advantages over synthetic indicators, such as Fura-2 and Fluo-8. For example, transgenic expression of a GECI using an appropriate promoter makes it possible to reproducibly analyze in vivo responses of a specific cell type under natural conditions. We generated a transgenic mouse line, in which yellow cameleon 2.60 (YC2.60), a calcium indicator based on FRET between CFP and YFP, is expressed under the control of the Gad-1 promoter. YC2.60 expression was observed in several cells in each soft-palate taste bud. Administration of a 100 mM NaCl solution over taste buds caused a change in the FRET signal of YC2.60 in those cells. Our pharmacological analysis has shown that the NaCl-responding cells can be classified with respect to the sensitivity to amiloride, the specific inhibitor of Epithelial Sodium Channel (ENaC). The transgenic mouse whose taste cells express YC2.60 is a useful tool for analyzing the molecular mechanisms of taste cell responses.

9:00 - 10:30 AM	Estero Foyer
Coffee Break	

10:30 - 12:30 PM	Calusa FGH
FUNCTIONS OF HUMAN OLFACTION: FRONTIERS AND CHALLENGES	

Chair(s): Veronika Schopf

10:30 **Introduction**

10:40 **Eating With The Nose?**

Sanne Boesveldt
Division of Human Nutrition, Wageningen UniversityNetherlands

The chemical senses, in particular smell and taste, are important determinants of (human) eating behavior, for creating flavor and driving our food preferences, but also as a more functional feature of food. Taste plays a crucial role during the consumption of food, in determining the nutrient content, and thereby how satiating a food is, and how much we will eat if it. Smell on the other hand, is more important during the anticipation phase of eating: it detects and attracts us to food, and triggers our (specific) appetite. However, how odors actually affect our eating behavior, and to what extent and under which circumstance they determine appetite, food choices and potentially intake, remains unclear.I will discuss recent insights into the role of smell for eating behavior, and how individual differences may affect this.

11:10 **Influence Of Social Odor Context On Cognitive Processes**

Cinzia Cecchetto[1,2], Florian Ph.S Fischmeister[1], Valentina Parma[3], Sarah Gorkiewicz[1], Deepika Bagga[1,2], Veronika Schöpf[1,2]
[1]Institute of Psychology, University of Graz, Graz, Austria, [2]BioTechMed, Graz, Austria, [3]SISSA – International School for Advanced Studies, Neuroscience Area, Trieste, Italy

Olfactory stimuli have been shown to be able to increase memory performance when the same odor is presented during both the encoding and the recognition/recall phases. Moreover, a recent study from our laboratory has revealed increased activation in the piriform cortex can be an indicator for successful encoding of stimuli when a congruent odor was presented during both encoding and recognition phases compared to incongruent presentation of odors. As only common odor effects on episodic memory have been examining so far, we have been investigating whether social odors (called also human body odors or chemosignals) can enhance the encoding and recognition of faces by resembling real-life strategies. Indeed, it has been demonstrated that social odors are type of communication among conspecifics that transfers socially relevant information: even when not consciously perceived, body odors are able to carry different types of social information regarding individuals' identities (e.g., age, gender, health status, sexual availability) and personal predisposition. I will describe our recent progress on the effect of social odors on the recognition of socially relevant stimuli.

11:30 **Communicating (Or Not) Via Chemosignals? The Case Of Autism**

Valentina Parma
SISSA - International School for Advanced Studies, Trieste, Italy

dktu jgwp;eg qej;g

12:00 **Chemosensory Cues Of Environmental Hazards**

Pamela Dalton
Monell Chemical Senses Center

The human olfactory system rapidly and accurately informs us about the presence of airborne odorous chemicals in our environment. But what information is actually available and processed from this olfactory 'scan'? Intensity and some aspects of quality can be readily apparent, but accurate identification of an odor is challenging, especially when no visual cues to a source are present. Moreover, the detection of a chemical presence by odor tells us almost nothing about its benign or hazardous properties, even if the chemical stimulates both olfaction and chemesthesis. In addition, our naive belief that the human olfactory system is relatively insensitive leads us to judge odors as representing higher concentrations of a chemical than may actually be present. Although the human nose is a sensitive and powerful chemical detector, features of the information-processing cascade in the olfactory system can cause humans to erroneously evaluate the attribution and hazard of environmental odors.

10:30 - 12:30 PM	Calusa ABC

TOWARD UNDERSTANDING THE MOUTH AS A MULTISENSORY SYSTEM

Chair(s): Robin Krimm and Christian Lemon

10:30 **Toward Understanding The Mouth As A Multisensory System**

Robin Krimm[1], Christian Lemon[2]

[1]University of Louisville School of Medicine, [2]Department of Biology, University of Oklahoma

The field of taste has focused for decades on the primary stimuli (sweet, sour, salt, bitter, and umami), but any stimulus entering the oral cavity also has somatosensory properties such as temperature, location, and texture. Furthermore, menthol, mustard oil and capsaicin are all detected in the oral cavity by somatosensory neuronal afferents. All of these stimuli combine with olfaction to determine the flavor of food. But while olfaction is really a separate sensory system until the information reaches the cortex, taste and somatosensation interact from the periphery and this convergence only increases as information proceeds along the ascending gustatory pathway. Therefore, there is no place in the nervous system where these two systems can effectively be separated. By thinking of taste and oral somatosensation as two different systems, have we impaired rather than enhanced our ability to understand how taste is coded? Rather than separating these systems, perhaps it is more advantageous to study them in parallel. The goal of this symposium is to take a look at some of the tools available to manipulate the somatosensory component of mouth sense, the receptors/neurons in the oral cavity which contribute to mouth sense, and see how taste and somatosensation are processed together in the nervous system. Perhaps these presentations can inform a larger discussion of how to better examine the role of taste in the larger context of mouth sense.

10:40 **The Molecular And Cellular Basis Of Thermosensation.**

David McKemy

Department of Biological Sciences, University of Southern California, Los Angeles, CA, United States

The ability to detect and respond to environmental temperature change is crucial to the survival of all animals. The discovery of temperature sensitive transient receptor potential ion channels, or TRPs, has advanced our understanding of mammalian mechanisms of thermosensation. Temperatures can be broadly classified as noxious heat (>43°C), warm (30°C-43°C), innocuous cool (15°C - 30°C), and painful cold (<15°C). TRP channels provide a framework for the molecular logic of sensing these temperature ranges. Moreover, they are markers of sensory neurons that underlie the cellular network of thermosensation. In this presentation, we will discuss these channels, as well as the latest approaches being employed to modulate modality specific subsets of sensory afferents to treat pain, particularly those involved in cold thermosensation.

11:10 **Mechanosensory Coding In The Oral Cavity**

Yalda Moayedi[1], Lucia Duenas-Bianchi[2], Chi-Kun Tong[1], Ellen Lumpkin[1,3,4]

[1]Department of Physiology and Cellular Biophysics, Columbia University Medical Center, New York, NY, United States, [2]SPURS Biomedical Research Program, Department of Physiology and Cellular Biophysics, Columbia University Medical Center, New York, NY, United States, [3]Program in Neurobiology and Behavior, Columbia University Medical Center, New York, NY, United States, [4]Department of Dermatology, Columbia University Medical Center, New York, NY, United States

Flavor is a multi-sensory percept involving taste, olfaction, thermosensation and mechanosensation. Such flavor profiles drive food consumption and nutritional intake in humans; however, mechanisms by which somatosensory neurons influence taste are poorly defined. We hypothesize that subsets of tactile receptors are tuned to encode specific textural qualities of foodstuffs and influence food choice and feeding abilities. To test this hypothesis, we mapped the distribution of anatomically distinct neuronal endings in the mouse and human oral cavity using molecular markers and quantitative histomorphometry. We found that the hard palate and gums are densely populated with four classes of putative tactile afferents that are organized in discrete patterns. These included Merkel cell-neurite complexes, Meissner's corpuscles, glomerular corpuscles and an unusual subset of afferents innervating superficial epithelial layers. By contrast, the murine tongue is equipped with unique putative mechanosensory afferents including end bulbs of Krause and perigemmal neuronal collars. Using a combination of live-cell imaging and behavioral analysis, we found that subsets of these neurons encode textural properties relevant to foods such as pressure and texture. These studies lay the groundwork for ongoing physiological and behavioral studies to define functional differences between anatomically distinct somatosensory neurons in the oral cavity.

11:30 **Overlap Of Taste And Somatosensory Processing In The Mouse Brain Stem**

Christian Lemon

Department of Biology, University of Oklahoma

The classic approach of studying neural and behavioral responses to taste separately from other sensory modalities has led to advances in gustatory neuroscience, but with some limitations. Such methodology cannot address the known interaction of taste with the other senses of flavor, particularly the somatosensory sense of the mouth. Oral somatosensory cues, such as temperature or touch, always accompany taste and interact with human taste perceptions and gustatory neural activity in animal models. Taste appears to work through a neural pathway

that interfaces in part with mechanisms and circuits for somatosensation. Probing this interface will provide clues to the functional organization of the gustatory and somatosensory nervous systems. However, our understanding of the biological substrates supporting such overlap is nascent. Recent and ongoing studies in my lab have used neurophysiological and optogenetic methods in mouse models to study neural links between taste and somatosensory pathways in the brain. Following leads from earlier papers, some of our efforts are focusing on potential connections between brain stem circuits for taste and nuclei of the trigeminal system, the primary mediator of craniofacial somatosensation and pain. Our studies have revealed evidence that in mice, circuits for taste and trigeminal processing come together in the parabrachial nucleus. Taste-active parabrachial neurons involved with this overlap can co-fire to agonists of transient receptor potential ion channels expressed by trigeminal fibers and show excitation and suppression in responding during electrical and photo perturbation of upstream trigeminal nuclei. This talk will discuss some of these data in the context of understanding the interactive organization of oral sensory pathways.

Somatosensory Factors In Human Taste

12:00 Barry Green
The John B. Pierce Laboratory

Taste is a specialized cutaneous sense of the mouth. During exposure to foods and beverages its chemical sensitivity is vulnerable to modulation by impinging thermal, mechanical, and other chemical stimuli, and its afferent signals are conveyed together with activity from mechanoreceptors, thermoreceptors, and nociceptors of the trigeminal nerve. The potential for modulation and integration also lies in the intrinsic thermal and mechanical sensitivity of both the chorda tympani and glossopharyngeal nerves. Examples will be given of how this multisensory stimulation and parallel signaling appears to influence human taste perception.

12:30 - 1:00 PM	Lunch On Own
Lunch On Own	

Lunch items will be available for sale in Calusa Foyer

1:00 - 2:00 PM	Calusa ABC
AChemS Business Meeting	

Get involved! Join us for reports from the society leaders on the state of the Association. All members welcome and encouraged to attend.

1:45 - 2:15 PM	Calusa Foyer
Coffee Break	

2:00 - 4:00 PM	Calusa ABC
CLINICAL SYMPOSIUM: TRAUMATIC BRAIN INJURY AND SIDE-EFFECTS IN VETERANS: IMPLICATIONS FOR CHEMOSENSORY RESEARCH	

Chair(s): Valerie Duffy and Sanne Boesveldt

2:00

Ptsd And Tbi In Oif/Oef/Ond Veterans: What&Rsquo;S Smell Got To Do With It?

Janine D Flory[1,2]

[1]Icahn School of Medicine at Mount Sinai, New York, NY, United States, [2]James J Peters VAMC, Bronx, NY, United States

Prior to the wars in Iraq (OIF) and Afghanistan (OEF and OND), the co-occurrence of Posttraumatic Stress Disorder (PTSD) and persistent post-concussive symptoms attributable to a history of mild Traumatic Brain Injury (mTBI) was not considered to be a common clinical syndrome. However, mTBI has been called the "signature injury" among this group of veterans, with a recent estimate of 19% of probable TBI. Because some of the symptoms of PTSD (e.g., insomnia, irritability, trouble concentrating) overlap with the persisting symptoms of a history of mTBI, it can be difficult to make accurate diagnoses and formulate treatment strategies. Olfactory functioning may provide clues for distinguishing between people whose symptoms reflect psychotraumatic versus brain injury. For people with PTSD, smells can represent reminders of a life-threatening environment, but are also used in treatment settings as a "grounding" aid or to elicit a traumatic memory with the goal of extinguishing the emotional and cognitive responses to the memory. In contrast, people with a history of traumatic brain injury show impairments in the ability to detect odors, even when they represent danger. This presentation will provide a comprehensive overview of symptoms and impairment associated with PTSD and TBI in veterans. Suggestions for olfactory research in these conditions will be provided.

3:00

Mild Myelin Disruption Elicits Early Alteration In Olfactory Behavior And Proliferation In The Subventricular Zone

Diego Restrepo[1,2,3], Elizabeth A Gould[1,2,3], Nicolas Busquet[4], Douglas Shepherd[5,6], Robert Dietz[7], Paco Herson[7], Fabio M. Simoes de Souza9[8], Anan Li[9], Nicholas M. George[1,2,3], Wendy B. Macklin[1,2,3]

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Myelin, the insulating sheath around axons, supports axon function. An important question is the impact of mild myelin disruption. In the absence of the myelin protein proteolipid protein (PLP), myelin is generated but with age, axonal function/ maintenance is disrupted. Axon disruption occurs in *Plp*-null mice as early as 2 months in

cortical projection neurons. Novel high-volume cellular quantification techniques revealed a region-specific increase in oligodendrocyte density in the olfactory bulb and rostral corpus callosum that increased during adulthood. A distinct proliferative response of progenitor cells was observed in the subventricular zone (SVZ), while the number and proliferation of parenchymal oligodendrocyte progenitor cells was unchanged. This SVZ proliferative response occurred prior to evidence of axonal disruption. Thus, a novel SVZ response contributes to the region-specific increase in oligodendrocytes in *Plp*-null mice. Young adult *Plp*-null mice exhibited subtle but substantial behavioral alterations, indicative of an early impact of mild myelin disruption.

Olfactory Dysfunction As A Consequence Of Traumatic Brain Injury

3:20

Johannes Frasnelli[1,2]

[1]UQTR, Department of Anatomy, Trois Rivières, QC, Canada, [2]Sacré-Coeur Hospital, Montréal, QC, Canada

In clinics specialized on chemosensory dysfunction, approximately one quarter of the patients suffer from anosmia or hyposmia following traumatic brain injury (TBI). Most of these patients present themselves months or even years after the trauma. However, some reports indicate that the prevalence of olfactory dysfunction is considerably higher in the first days, weeks and months following a TBI suggesting that an important degree of recovery of olfactory function may take place in the early phase. We set out to investigate the effects of TBI on olfactory function more closely in a series of studies, by using behavioral and imaging methods. We put a particular emphasis on (1) minimizing variability in the duration since the trauma at testing, (2) minimizing variability in the degree of TBI by focusing on mild TBI which represent 80% of TBI, (3) including appropriate control groups, and (4) including a longitudinal aspect. We found that quantitative and qualitative olfactory dysfunction are widespread in the early phases of mild TBI, possibly linked to structural alterations in neuroanatomy. Further, we observed recovery over time suggesting the importance of follow-up examinations when investigating olfactory dysfunction in TBI. Our results may have important clinical implications, with regards to nutrition and quality of life for patients with mild TBI.

The Smell Of War: Olfaction And Posttraumatic Stress Disorder

3:40

Deborah Beidel
University of Central Florida

The Smell of War: Olfaction and Posttraumatic Stress DisorderDeborah C. Beidel, Ph.D., ABPPUCF RESTORESUniversity of Central FloridaPosttraumatic Stress Disorder (PTSD) affects between 8% and20% of service personnel returning from Iraq and Afghanistan and at least 20% of the civilian population will experience PTSD at some point in their lives. Even years after the traumatic event, individuals with PTSD may suffer from flashbacks or re-experiencing of the traumatic event. Often, these memories are triggered by sights, sounds, or smells that were part of the trauma. Smell has been associated with very powerful and emotional memories, yet there are few data on the impact of smell on traumatic memories. In this presentation, pilot data on differences in blood brain volume in combat veterans with PTSD vs. combat veterans without PTSD vs. individuals with no history of PTSD will be presented. Additionally, the use of traumatic smells in the treatment of PTSD will be discussed. Finally, potential uses for the use of smell to better understand the role of olfaction in the etiology and treatment of PTSD will be presented.

4:00 - 5:00 PM	Calusa ABC

NEW CAREER DIRECTIONS IN NEUROSCIENCE: SCIENCE WRITING AND CITIZEN SCIENCE

4:00 **Scientists Are People Too: Breaking Barriers Through Communication**
Maryam Zaringhalam
AAAS Science & Technology Policy Fellow, Producer, The Story Collider

4:30 **Citizen Scientists & Chemoreception: From Contributing To Co-Creation**
Nicole Garneau
Genetics of Taste Lab, Denver Museum of Nature & Science

5:00 - 6:00 PM	Calusa Foyer

Career/Networking Social

The social is designed for all student and post doc attendees. The AChemS Career Networking Social is designed for networking and discussion about topics and issues important to junior chemosensory scientists. This year will feature two alternative career talks in addition to our Topic Tables discussions including; Grant Writing, Life Outside Academia (Industry), Equality in Science, Women in Science, Work/Life Balance, Working outside the US, Life in Academia, and more.

7:00 - 9:00 PM	Calusa ABC

PRESIDENTIAL SYMPOSIUM: BACK TO THE FUTURE: FROM PAST DISCOVERIES TO FUTURE DIRECTIONS

Sponsored By: Coca-Cola

Chair(s): Thomas Finger

7:00 **Back To The Future: From Past Discoveries To Future Directions**
Thomas E. Finger[1,2,3]
[1]University of Colorado School of Medicine, [2]Rocky Mountain Taste and Smell Center, [3]Department of Cell and Developmental Biology

In commemoration of the 40th Anniversary of the founding of AChemS, this symposium will feature both a retrospective and visions of the future. The speakers will offer a glimpse into their personal scientific journeys as well as thoughts about the nature of scientific inquiry and the future of the field.

7:10 **Achems And Olfaction: A Share In Two Revolutions Is Living To Some Purpose**
Gordon Shepherd
Yale Medical School

Modern research in olfaction began in the 1950s with the evidence that odors are represented as spatial patterns in the olfactory bulb. By the 1970s many new avenues had opened, but the field was fragmented. AChemS was founded in 1978 to provide an identity for taste and smell and better funding for the field. It was therefore the natural place for supporting the new directions that emerged with the discovery of the olfactory receptor genes in 1991. I will summarize this background and highlight the revolutions that have been brought about in AChemS and olfaction by the members and supporting agencies, and outline the challenges and opportunities that lie ahead for future revolutions.

7:40 **Behavioral Analysis Of Taste: Insights From Patients With Taste Disorders**
Linda Bartoshuk
University of Florida

Behavioral science, especially the study of patients with taste disorders, has been a rich source of insight about how taste works. Early support for this behavioral approach came from Carl Pfaffmann, known for his pioneering work on the coding of taste quality in the nervous system. Carl said, “Indeed it can be said that without behavioral study, hand in hand with physiological and anatomical methods, one gets only a partial insight: telling where, and to some degree how, but not for what!” Carl became perhaps the most distinguished taste patient. When he lost hearing in his left ear from Ramsey-Hunt Syndrome (reactivation of the chicken pox virus that damages the acoustic nerve, CN VIII) he was puzzled that his taste remained normal because the chorda tympani (CN VII) and glossopharyngeal (CN IX) taste nerves are next to the acoustic nerve and during Ramsey Hunt, the virus can move into those nerves. Pfaffmann asked me to test him. In fact, his tongue was devoid of taste on the left side, but taste was remarkably strong on the right and he was unaware of this. Over three years, we documented the return of taste on the left with accompanying reduction on the right

demonstrating inhibition between the two sides of the tongue. Pfaffmann presented his own case at AChemS in 1989 and 1990.

Keeping The Olfactory Pipeline Flowing, Or At Least Dripping

8:10 Stuart Firestein
Department of Biological Sciences, Columbia University

From molecules to perception has been an enduring trope in olfaction. We would like to explain how we get from chemical compounds to smelly qualia. This driving, or as we like to say in NIH jargon, overarching hypothesis, has included a significant contribution from chemistry and psychophysics – the two endpoints on the continuum. But it has notably not included as much biology. There are many reasons for that, the most prominent being that biology in this system was difficult for many years and required sometimes heroic commitments to physiological experiments. But that changed quite a bit with the discovery of the receptors in 1991 by Buck and Axel and the new molecular, cellular and physiological lines of inquiry that were opened by that discovery. However, counter intuitively, as these sorts of seminal discoveries often do, they may drive a field in a particular direction for a long time – sometimes excluding other lines of inquiry that were valuable, but left behind. This can be seen in vision with the work of Hubel and Wiesel driving visual system work in the direction of topographic organization for many decades. At this 40th anniversary of AChemS it might be good time to look at which of those fields should be revived and how the direction of research in the next decades should be driven, or not, by the many receptors view of the olfactory universe.

The Nose As A Window To The Mind

8:40 Ann-Sophie Barwich
Departments of the Biological Sciences & Philosophy, Columbia University

Our sense of smell has a remarkably bad reputation. Popular opinion has it that human olfaction is in evolutionary decline and a primitive, unsophisticated sensation that carries little importance to studies of the human mind. Nothing could be further from the truth. Over the past three decades, scientific insight has proven such pejorative beliefs about humans wrong. In fact, it turns out that smell might be key to understanding the workings of central cognitive processes; including language, memory, and learning. Still, two fundamental questions in olfaction remain unresolved: Is there a physical order to perceptual odor space? And how are odor percepts represented in the brain? Despite vast technological advances, like machine learning or optogenetics, we are as yet far from having a profound answer. So perhaps it is time to rethink our underlying understanding of perception. Because olfaction currently stands at a crossroad that offers a unique opportunity: contemporary scientific questions about odor perception resonate deeply with philosophical concerns; namely, what is the nature of smell experience, and what kind of information does it convey to the mind? This talk looks at the sense of smell from a historical and philosophical perspective to revisit our scientific assumptions which model how the brain makes sense of scents.

D16 **Axonal Regrowth Of Olfactory Sensory Neurons After Chemical Ablation With Methimazole**

Rudy T. Chapman, Katherine C. Burgess, Russ W. Brown, Diego J. Rodriguez-Gil
East Tennessee State University Quillen College of Medicine, Johnson City, TN, United States

The olfactory system is of great interest in research due to the olfactory epithelium's regenerative capability and as a potential as a source of neural stem cells. The olfactory sensory neurons are constantly being replaced by the stem cells that lie at the base of the olfactory epithelium. These stem cells also remain intact after an injury to the epithelium and lead to the regeneration of the olfactory epithelium. We have developed a fate mapping technique to trace axonal regrowth from newly born olfactory sensory neurons using an inducible Cre-ERT2 model after chemical ablation by the drug methimazole. Our data shows that newly generated olfactory sensory neurons labeled 1 day after chemical ablation by injection of 4-HO-tamoxifen extend an axon that reaches the olfactory bulb and extend to the glomeruli in a timeline that is consistent with control mice that received 4-HO-tamoxifen but were injected with saline 1 day prior. In addition, we assessed the functional recovery of the olfactory epithelium by testing the ability of mice to find a hidden cookie after methimazole injection. Mice were tested at 3 and 14 days post methimazole. There was a severe impairment in the ability to find a hidden cookie at 3 days post methimazole. The mice tested at 14 days post methimazole showed an improvement in the ability to find the cookie but the latency to find the cookie was still significantly higher than controls. In conclusion, while we demonstrate that axons extend to the olfactory bulb and the glomeruli earlier than 14 days, our behavioral data suggest that there must be a critical number of axons that must reach each specific glomerulus to regain function of the olfactory system.

D17 **A Comparison Of Hedonic And Emotional Responses To Common Odors Delivered By Qpods (Portable Olfactive Devices) And Traditional Sniff Jars**

Jessica M. Gaby, Beverly J. Tepper
Center for Sensory Sciences & Innovation and Department of Food Science, Rutgers University, New Brunswick, NJ, United States

qPODs (Portable Olfactive Devices, q Research-Tragon) are novel olfactory delivery systems. Participants evaluate odors by opening a port at the top of the qPOD and sampling a controlled air stream. Though they are often used in marketing studies, their potential for use in empirical research has yet to be investigated. We asked participants to smell citral, citronellol, geraniol, PEA, delta nonalactone, and vanillin delivered via qPODs and by traditional sniff jars, and compared both hedonic and emotional responses. Across 4 sessions, 31 participants evaluated the pleasantness and intensity of each odor in qPODs and sniff jars. Their emotional reactions to the odors were captured with the PANAS (Positive And Negative Affect Schedule) at the beginning of each testing session, and then again after exposure to each odor. They also completed the newly developed Mood Signature Questionnaire (Jin et al., 2017), which asks participants to assign a mood to each odor, rather than reporting how it makes them feel. Though odors presented in the sniff jars were rated significantly more intense ($p<.001$), there were no differences between presentation types for perceived pleasantness, changes in positive or negative mood following odor exposure, or which emotional descriptors (Mood Signatures) participants assigned to the odors. Participants reported higher negative affect ($p=.005$) after smelling PEA, regardless of presentation. Likewise, participants' responses to the Mood Signature Questionnaire differed based on odor identity rather than presentation type ($p<.001$). Our results suggest that responses to odor stimuli presented using qPODs are comparable to those using traditional sniff jars, thus establishing the qPOD as a potential new tool for empirical olfactory research.

D18 **Characterization Of The Trigeminal/Olfactory Interaction In The Main Olfactory Epithelium**

Federica Genovese, Johannes Reisert, Marco Tizzano
Monell Chemical Senses Center, Philadelphia, PA, United States

Most of the chemical stimuli that reach the nasal cavity can activate trigeminal and olfactory systems, which are both contributing to perception. Although the mechanisms are not clear, several sites of interaction have been identified in the nasal mucosa, the olfactory bulb and cortex. We characterized the trigeminal-olfactory interaction in the olfactory epithelium (OE) using the electro-olfactogram (EOG) technique, applying CO_2 (50%v/v in Air, 100ms) and phenylethanol (PEA, 100mM, 100ms), which are predominantly trigeminal and olfactory stimuli, respectively. EOG responses to PEA and CO_2 were characterized in C57BL/6 and TRPA1/TRPV1-double KO mice. The trigeminal modulation of the olfactory input was determined by delivering the odor either simultaneously, or at different time points after the CO_2 stimulation. The EOG recorded during the simultaneous application of CO_2 with PEA did not differ from the EOG obtained with the odor alone. A reduced PEA signal was recorded at 5 min after the CO_2 stimulation, suggesting a modulation of olfactory sensory neurons mediated by the trigeminal sensory fibers, potentially via inflammatory neuropeptides. Moreover, we determined the possible role of the microvillous cells in this modulation by using the Skn1A-ko mice line, which lack microvillous cells in the OE. In comparison to the wild-type, Skn1A-ko showed a bigger reduction of the PEA response after pre-stimulation with CO_2. In conclusion, we characterized the responses of the OE to CO_2 and determined the trigeminal and olfactory components to the olfactory response. Furthermore, we could determine the temporal dynamic of the trigeminal modulation of the olfactory response and the possible role of microvillous cells in such mechanisms.

D19 **Young Animal Models Of Late-Onset Alzheimer&Rsquo;S Disease Show Learning Impairments In Conditioned Taste Aversion Acquisition And Extinction Tasks.**

Ilona Har Paz[1,2], Nicole Roisman[2], Anan Moran[2,1]

[1]Sagol School of Neuroscience, Tel Aviv University, Tel Aviv, Israel, [2]Department of Neurobiology, Tel Aviv University, Tel Aviv, Israel

The ε4 allele of apolipoprotein E (ApoE4) is the most prevalent genetic risk factor of late-onset Alzheimer's disease (AD), however, its underlying core abnormalities and their link to AD are not fully understood. A recent hypothesis suggests that ApoE4 core abnormalities arise from disrupted vesicular flux. This implies that ApoE4 overall memory alterations should be: 1) not restricted to hippocampal pathways; 2) observed in any memory task that requires extensive synaptic modulations; 3) detected at a young age, before AD manifestation. We have tested these hypotheses using conditioned taste aversion (CTA) and its extinction protocols in young transgenic ApoE4 mice and rats carrying the human ApoE4 gene. Our results show that ApoE4 animals were impaired in learning the taste-malaise association and could not extinguish it once conditioning has occurred using a stronger aversion protocol. Additionally, molecular assessments revealed that ApoE4-carrying animals show down-regulated structural plasticity in the gustatory cortex and basolateral amygdala following CTA acquisition and extinction. The results of this study support the general, non-hippocampal-specific, disruptive role of ApoE4 in young animals' learning processes. Moreover, CTA may be found advantageous in the study of ApoE4 since it provides a system not masked by the accumulation of the known AD pathological residues and cell death. Further research will shed light on the link between the ApoE4-related anomalies that contribute to the memory deficits, and the manner in which they link to AD onset and progression.

D20 **Endoscopic Sinus Surgery Simulator To Optimize Surgical Outcomes: A Pilot Study On Conductive Olfactory Losses**

Guillermo Maza[1], Chengyu Li[1], Bradley Hittle[2], Hector J Medina-Fetterman[2], Bradley A Otto[1], Alexander A Farag[1], Gabriela Zappitelli[1], Gregory J Wiet[1], Don Stredney[2], Kai Zhao[1]

[1]Department of Otolaryngology - Head & Neck Surgery, The Ohio State University, Columbus, OH, United States, [2]Ohio Supercomputer Center, Columbus, OH, United States

Nasal sinus disease is one of the leading causes of olfactory losses, potentially due to obstructions that block the air and odor flow to the olfactory fossa (OF). Surgical remove of obstructions (e.g. polyps) often leads to olfactory improvement, but the outcome is highly variable. One reason is that predicting airflow based solely on CT or endoscopy can be difficult. A unique multi-disciplinary team of clinicians, computer scientists, and engineers was assembled to develop a virtual reality surgical planning tool that would simulate, predict and ultimately optimize the impact of various surgical approaches on the nasal air/odor flow. In this pilot study, virtual surgeries were performed on the simulator for four patients with confirmed olfactory losses. After each surgery, air/odor flow to OF was computed and the process reiterated until optimal result reached. A total of 12 isolated or combined procedures were performed that includes polypectomy (PP), partial middle turbinectomy (PMT), septal body reduction (SBR), etc. A normative range was established based on 22 healthy controls. *Results*: Two patients showed no improvement regardless of procedures performed, one of whom had normal OF airflow pre-surgery, indicating a likely sensorineural olfactory loss rather than conductive. For one patient, an isolated medial aspect PMT showed the best outcome and was better than traditionally performed lateral PMT, while SBR worsened air/odor flow to OF. For the last patient, just a PP restored airflow to OF while adding PMT didn't provide further benefit. In conclusion, this study suggests that some patients may obtain maximum benefit with targeted approaches, while for some restoring OF airflow surgically is impractical. This simulator could potentially be a valuable tool for personalized medicine.

400 **Treatment With Glucocorticoids And Ginkgo Biloba Extract For Olfactory Dysfunctiontreatment With Glucocorticoids And Ginkgo Biloba Extract For Olfactory Dysfunction**

Yichen Guo [1], Yongxiang Wei[1], Jayant M. Pinto[2], Linyin Yao[1], Jia Liu[1], Zhifu Sun[1]

[1]Department of Otorhinolaryngology, Beijing Anzhen Hospital, Capital Medical University, Beijing, China, [2]Section of Otolaryngology-Head and Neck Surgery, Department of Surgery, the University of Chicago, Chicago, IL, United States

Objective To evaluate the effect of glucocorticoids and extract of Ginkgo biloba for the treatment of olfactory dysfunction. Methods Adults (n=66) were diagnosed with post-viral and post-traumatic olfactory dysfunction by standard criteria (Group V [n=50] and Group T [n=16]). In each group, patients were randomized to receive either a tapering dose of prednisone (GC) or this regimen plus Ginkgo biloba extract (GBE) for 4 weeks. All patients underwent olfactory testing, including T&T olfactometry and the Sniffin' Sticks (SS) test, at baseline, monthly during treatment, and at the conclusion. Subjects were followed for at least 3 months. Results Fewer subjects with post-viral olfactory dysfunction receiving prednisone alone (25%) showed improved olfaction compared to those receiving combination therapy with GBE (38.46%) using the T&T test, with similar results for the SS (25% and 30.77%, respectively). Fewer patients with post-traumatic olfactory dysfunction improved with either treatment (12.5% in either mono or combination therapy). Treatment effects were better at 3 months compared to 1 month. Conclusions GBE enhances the clinical effect of glucocorticoid treatment for postviral olfactory dysfunction, but does not appear to be effective in post-traumatic smell loss. Prolonged treatment is helpful for olfactory function recovery. Further studies may shed light on the mechanism of these salutary effects.

401 **Enhanced Neural Processing During Odor Imagery In Olfactory-Loss Patients: An Fmri Study**

Pengfei Han[1], Ilona Croy[2], Claudia Raue[3], Moustafa Bensafi[4], Maria Larsson[5], Annachiara Cavazzana[1], Thomas Hummel[1]

[1]Department of Otorhinolaryngology, TU Dresden, Dresden, Germany, [2]Department of Psychosomatics, TU Dresden, Dresden, Germany, [3]Department of Neuroradiology, TU Dresden, Dresden, Germany, [4]Lyon Neuroscience Research Centre, University of Lyon, Lyon, France, [5]Gosta Ekman Laboratory, Department of Psychology, Stockholm University, Stockholm, Sweden

Perception of olfactory information is mediated by both bottom-up (from molecules to percepts) and top-down (e.g. odor imagery) processes. Acquired olfactory loss is a frequent disorder which is typically due to changes in the bottom-up pathway. However, it is unclear how top-down modulation of olfactory processing is affected by olfactory impairment. Our study aimed to compare the top-down olfactory processing in patients with acquired olfactory loss and participants with normal olfaction. Using a functional MRI - odor imagery paradigm, words with olfactory associations (OW) (e.g. “Rose”) and control words (NW) (e.g. “video”) were presented to 14 patients and 16 controls. The “odor imagery” condition (contrast between OW and NW) was associated with stronger neural activations in the amygdala, hippocampus, insula, and orbito-frontal cortex (OFC) in patients compared to controls. Duration of olfactory loss among patients was negatively associated with activations in hippocampus, lateral OFC, and the superior temporal gyrus in the “odor imagery” condition. Furthermore, odor identification performance was positively correlated with activation in the hippocampus among patients. Taken together, these findings suggest an enhanced olfactory top-down modulation in patients with olfactory loss. The function of this enhanced cognitive processing in patients is discussed in terms of compensatory mechanisms.

403 **Etiology Of Subjective Taste Loss**

Joseph D. Hunt, Evan E. Reiter, Richard M. Costanzo
Virginia Commonwealth University, Richmond, VA, United States

In clinical practice patients presenting with complaints of abnormal taste commonly have no measurable deficit in taste. A variety of etiologies may impact patient’s perceptions of taste, the most common of which is olfactory dysfunction. Patients with an alteration in smell may recognize the inability to appreciate the aromas of foods and thus seek treatment for alteration in taste. Failure to recognize the prevalence of this issue may delay diagnosis and management. To determine the functional deficits associated with subjective impairment of sense of taste, we examined the records of 1108 patients evaluated at the VCUHS Smell and Taste Clinic over the past 35 years. Of these, 482 had information on both patient subjective chemosensory complaint, grouped as A: taste only (n=75), B: taste and smell (n=295), or C: smell only (n=112), and objective test results for both gustatory and olfactory function. Of patients reporting a taste only complaint, 24.0% (n=18) had abnormal gustatory function, whereas 50.7% (n=38) had abnormal olfactory function. For those reporting both taste and smell complaints 9.2% (n=27) had impaired gustatory function, while 90.5% (n=267) had impaired olfactory function. For those reporting a smell only complaint 6.3% (n=7) had abnormal gustatory function while 89.3% (n=100) had abnormal olfactory function. For all patients with a taste complaint (groups A and B) only 2.4% (n=9) had an abnormal taste test with normal smell. This study provides quantitative data from a large patient population supporting the hypothesis that patients who present with a taste or taste and smell complaint are more likely to have an underlying olfactory impairment than a gustatory impairment. These findings may prove useful to healthcare providers who evaluate patients presenting with a taste loss.

405 **Size Does Matter: Comparing Two Manual Methods Of Measuring Olfactory Bulb Volume**

Elbrich M. Postma[1,2], Lisette van Amerongen[1], Wilbert M. Boek[2], Kees de Graaf[1], Sanne Boesveldt[1]

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Measurements of olfactory bulb (OB) volume are used for clinical and scientific definitions of smell loss and as tool to predict potential regain of olfactory function. We set out this study to compare two manual methods of measuring OB volume. The study population consisted of 100 patients from the Smell and Taste Centre in Ede (NL). The OB was visualized with a coronal T2-weighted isotropic 2D TSE MRI-scan (28 slices of 1mm). As clinical measure we used results of manual metric measures (MMM) of OB volume by radiologists in IMPAX software, measuring width and height in the coronal plane and length in a reconstruction of the transverse plane. Research measures of OB volume were collected through planimetric manual contouring (PMC) in MIPAV software by measuring width and height of the OB in each slice on which the OB was visible. Volume was calculated by taking slice thickness into account. Sniffin’ Sticks were used to measure olfactory function. Patients were excluded if they were born without OB (n=10) or if it was not possible to measure OB volume (n=15). In total, OB volume was determined with both methods for 37 patients. Average OB volume differed significantly: 108.9±34.5mm^3 for MMM and 51.1±12.4mm^3 for PMC ($p<0.001$). However, a moderate positive correlation was found between the measures ($r=0.432$, $n=37$, $p=0.008$). No significant correlation for the measures with the Sniffin’ Sticks score (mean: 16.5±7.6; MMM: $p=0.338$; PMC: $p=0.795$) was found. Although the methods led to a significant difference in OB volume, there was a correlation between the measures. PMC seems to be more accurate than MMM, but takes more time. For research, PMC seems to be the most accurate measure. Further analysis is needed to show if MMM of OB volume might be sufficient for a clinical perspective.

406 **Associations Between Chronic Cigarette Smoking And Taste Function: Results From The 2013&Ndash;2014 National Health And Nutrition Examination Survey (Nhanes)**

Shristi Rawal[1], Howard J. Hoffman[2], John E. Hayes[3], Nadia K. Byrnes[3], Sarah-Grace Glennon[4], Valerie B.

Duffy[5]
[1]Rutgers University, Newark, NJ, United States, [2]National Institute on Deafness and Other Communication Disorders, Bethesda, MD, United States, [3]Pennsylvania State University, State College, PA, United States, [4]Yale University, New Haven, CT, United States, [5]University of Connecticut

We aimed to identify associations between cigarette-smoking history/dependence and taste function in a nationally-representative sample of US adults. In NHANES 2013-2014, 3556 adults 40+ years, reported tongue-tip and whole-mouth intensities of bitter (1mM quinine) and salt (1M NaCl) as well as cigarette-smoking status (current, former, never), history (pack years, PY) and dependence [time to first cigarette (TTFC) upon waking]. Linear regression models estimated associations between smoking and taste intensity, adjusting for age, gender, race/ethnicity, education and income-poverty ratio. Nearly half of the sample were former/current smokers. Tongue-tip quinine averaged just below moderate and NaCl between moderate and strong intensity. Chronic smokers (≥20 PY) tasted less tongue-tip bitterness than never or <20 PY smokers; differences were not significant after adjusting for demographic factors. Compared to never smokers, current smokers with high dependency (TTFC <30 minutes) and chronic smokers with high dependency (≥20 PY & TTFC <30 minutes) or heavy alcohol drinking (≥20 PY & 4+ drinks/day) rated significantly less bitter and salt intensities on the tongue-tip, even adjusting for demographic factors. Adjusted βs (95% CI) for quinine tongue-tip were -1.8 (-3.4, -0.1), -2.7 (-3.9, -1.4) and -2.8 (-4.7, -1.0), resp. Corresponding βs (95% CI) for 1 M NaCl tongue tip were -4.6 (-8.5, -0.7), -4.1 (-7.8, -0.4) and -3.5 (-7.3, 0.3), resp. Consistent associations were not seen with whole-mouth intensities. Conclusion: Chronic cigarette smoking with or without heavy drinking associated with lower taste and taste-irritant intensity on the tongue-tip, but not whole mouth. Smoking could alter taste directly via insults to sensory processes and indirectly via exposure to related pathologies.

408 **Anti-High Mobility Group Box 1 Antibody Suppresses Local Inflammatory Reaction And Ameliorates Olfactory Nerve Recovery Following Injury**

Masayoshi Kobayashi, Kengo Tamari, Mohammed O Al Salihi, Kohei Nishida, Kazuhiko Takeuchi
Mie University, Tsu, Japan

We previously reported that recovery in the olfactory system depends on severity of local injury and anti-inflammatory treatment with steroids, anti-interleukin-6 antibody and tumor necrosis factor-alpha is effective in improving recovery outcome after olfactory nerve transection. Recently, it is reported that proinflammatory cytokine, high mobility group box 1 (HMGB1), plays an important role in inflammatory reaction and anti-HMGB1 antibody suppresses inflammatory reaction. The present study was designed to investigate if anti-HMGB1 antibody is also useful for functional recovery in the olfactory system following injury. We made a model of severe injury by performing olfactory nerve transection using a rigid stainless steel blade in transgenic (OMP-tau-lacZ) mice. Anti-HMGB1 antibody was injected intraperitoneally just after the nerve transection. Histological assessment of recovery within the olfactory bulb was made at 5, 14, 42 and 100 days after injury. X-gal staining was used to label the degenerating and regenerating olfactory nerve fibers and immunohistochemical staining was used to detect the presence of reactive astrocytes and macrophages./microglia. PCR assays showed that the HMGB1 gene was significantly expressed in the olfactory bulb 12 hours after olfactory nerve transection (NTx). Anti-HMGB1 antibody-injected animals showed significant smaller areas of injury-associated tissue, less astrocytes and macrophages/microglia, and an increase in regenerating nerve fibers in a dose-dependent manner. These findings suggest that inhibition of HMGB1 could provide a new therapeutic strategy for the treatment of olfactory dysfunction following head injuries.

409 **Insulin'S Contribution To The Homeostatic Regeneration Of The Olfactory Epithelium After Injury In Adult Mice**

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Insulin is a metabolic hormone that regulates neuronal survival and maturation as well as glucose metabolism. Insulin receptors are broadly expressed in the olfactory epithelium (OE), but it is poorly understood whether insulin signaling affects ongoing incorporation of newly generated olfactory sensory neurons (OSNs) to maintain homeostasis in the olfactory epithelium (OE). We examined whether insulin affects the regeneration of new OSNs in adult mice after injury. Mice were administered Streptozotocin (STZ) to ablate pancreatic β cells, resulting in hypoinsulinemia. Methimazole, an olfactotoxicity-inducing drug, was also injected intraperitoneally to ablate OSNs in the STZ-mice. Up to 7 days post-injury, hardly any OSNs were observed in the OE and there was no difference in the numbers of recovering mature and apoptotic OSNs between the STZ- and control (saline-administered) mice. However, between days 7 and 28, control-mice had remarkably more mature and less apoptotic OSNs than STZ-treated mice. By day 28, control OE was restored to its pre-injury condition, while STZ-treated mice still had an only partially recovered OE. Odorant-induced electroolfactogram responses at day 28 following injury in STZ-mice were significantly smaller compared to control mice. Consistent with this structural and physiologically incomplete recovery of the OE, behavioral deficits were also observed in STZ-mice at days 28 following injury. But intranasal insulin administration during days 7 to 14 (unlike during days 0 – 6) post-injury increased the recovery of the OE in STZ-mice. These results indicate that newly generated OSNs have a high dependency on insulin signaling for their maturation following day 7 post-injury, and that insulin signaling strongly contributes to OE regeneration after injury.

410 **Multimodal And Species-Specific Hedgehog Signaling Regulation Of: Circumvallate Versus Fungiform Papilla, Taste Buds And Sensation In Rat And Mouse**

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The multimodal sensory systems of the oral papillae are regulated differently by Hedgehog (HH) signaling and with species-specific distinctions. In mice and rats we have shown that taste buds (TB) in the fungiform papillae (FP) and taste responses from the chorda tympani (CT) nerve are lost after 2 wk administration of the HH Pathway Inhibition (HPI) cancer drug sonidegib. In contrast, responses to tactile and cold stimuli are unaffected. We also reported that in mouse circumvallate papilla (CV), TB are not completely eliminated after HPI. Compared to anterior tongue, the CV taste system is: in a different lingual tissue; directly associated with von Ebner salivary glands; innervated by afferents from the glossopharyngeal (GL) nerve; and distinct in nerve response profiles to chemical stimuli. Using HPI we tested the proposition that HH signaling acts differently in CV/GL and FP/CT taste systems. We studied rat and mouse CV TB and GL nerve responses to touch, cold water and taste stimuli after HPI with sonidegib (LDE225 by oral gavage for 2-7 wk). In rat, CV TB and taste responses were essentially abolished after 2 wk. In mouse, however, CV TB were reduced to about 15% of control and GL taste responses were retained. Therefore, we show species-specific differences in HH regulation of the CV/GL taste system and the collective data indicate differences in HPI effects in FP/CT versus CV/GL systems. In rat and mouse GL responses to tactile and cold stimuli remained robust, although the innervation does not sustain TB. We currently are studying behavioral taste responses during HPI. Differences in HH signaling regulation highlight distinctions between FP and CV multimodal sensory systems and elucidate the basis of taste disorders in cancer patients who use HPI drugs.

411 **Nerves And Sonic Hedgehog Signaling Interactions In Fungiform Papilla Taste Organ Homeostasis**

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The fungiform papilla (FP) epithelial, taste bud (TB) and stromal cells are innervated by afferents from the chorda tympani (CT) and/or lingual (LN) nerves. The soma for CT (geniculate ganglion) and LN (trigeminal ganglion) nerves express Sonic Hedgehog (SHH), a major regulator of taste organ homeostasis and sensation. If HH signaling is inhibited or taste nerves are severed, TB degenerate but epithelial and stromal cells remain albeit altered in proliferation, differentiation and/or molecular expression. We tested the role of FP innervation in sustaining taste organ integrity and interactions with HH signaling cells by determining expression of HH signaling elements in FP after unilateral CT/LN nerve cut, removing a few mm segment to prevent regeneration, or contralateral nerve exposure, for 21 days. After nerve cut, Vimentin-positive stromal cells remained in the structurally altered FP core and these expressed HH signaling elements *Ptch1, Gli1, Gli2* (*lacZ* reporter alleles, stained for b-galactosidase activity). Further, a particular morphological interaction was seen between HH signaling stromal cells and uncut nerves, and in remaining stromal cells and nerves after cut. This distinctive morphology includes complicated and elaborate fiber contacts onto cells. We are studying the nature of these nerve/HH signaling stromal cell complexes. We previously reported that CT/LN nerves transport SHH ligand into the FP core and proposed that this SHH+ innervation sustains FP integrity via stromal cell as well as via TB-bearing and basal cell epithelial interactions. We suggest that nerve-derived SHH transported into the FP stromal core and to stromal cells is essential to maintaining FP integrity, as a TB residence and for the functional homeostasis in this multi-sensory taste organ.

412 **Role Of Gli Proteins In Horizontal Basal Cells During Regeneration Of The Olfactory Epithelium**

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The olfactory epithelium (OE) is comprised of several cell types, including olfactory sensory neurons (OSNs), which are replenished by two presumed stem cell populations: rapidly dividing globose basal cells (GBCs), and relatively quiescent horizontal basal cells (HBCs). HBCs and GBCs both contribute to OE regeneration; however, the signals that control this process are not well understood. Recent work demonstrated that HBCs contain primary cilia, an organelle that coordinates signals from multiple pathways. Notably, primary cilia are essential for proper vertebrate Hedgehog (HH) signal transduction, making the HH pathway an attractive candidate in the control of HBC function. GLI proteins are the transcriptional effectors of the HH pathway – GLI1 functions exclusively as a transcriptional activator and is also a target of HH signaling; GLI2 is the major transcriptional activator of the HH pathway; conversely, GLI3 acts largely as a transcriptional repressor. Our preliminary data using *lacZ* reporter mice suggest that *Gli2* is expressed in all HBCs, while *Gli3* is expressed a subset of HBCs. To assess possible GLI function in HBCs, we utilized doxycycline-inducible expression of a constitutively active form of GLI2 to stimulate the HH pathway specifically in HBCs (*K5-rtTA; tetO-GLI2DN*). Our data indicate that HBC-specific activation of GLI2 causes hyperproliferation of HBCs that are then unable to escape their HBC fate to differentiate and reconstitute the OE after methimazole-induced injury. This suggests a novel role for HH signaling in the olfactory epithelium and a novel contribution of GLI proteins to adult HBC function. Future studies of OE regeneration will investigate the roles of endogenous GLIs in HBC function, as well as in other OE cell types.

413 **Abundant Proliferating Cells Within Chicken Taste Buds Indicate A Potentially &Ldquo;Built-In&Rdquo; Progenitor System For Homeostasis**

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Like other epithelial cells, taste bud cells have a short life span and undergo continuous turnover. An active stem or progenitor cell niche is essential for taste bud cell renewal. In chickens, taste bud cells have a much shorter life span (~4 days) than those in rodents (~10 days) requiring a more rigorous stem or progenitor cell niche. To better understand precursor sources of taste buds in chickens, in the present study we analyzed the distribution of proliferating cells in different tissue compartments: taste buds, surrounding epithelium and underlying connective tissue. We found similarity and discrepancy between chickens and rodents pertaining to the distribution of proliferating cells in the gustatory tissue. Similar to rodents, chickens appeared to have proliferating cells in the immediate surrounding tissue compartments – the epithelium and underlying connective tissue. However, in contrast to rodents, chickens had abundant proliferating cells within taste buds. These proliferating cells, indicated by $BrdU^+$ cells, primarily localized to the basal region of taste buds and were largely unlabeled by molecular markers for chicken taste bud cells, suggesting their undifferentiated status. Our data indicate that chicken taste buds have “built-in” progenitors to meet the needs of maintaining their large size and rapid turnover.

414 **A Role For F-Actin In Olfactory Sensory Neuron Cilia Disassembly And Shortening**

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Olfactory sensory neuron (OSN) cilia are microtubule-based, actin exclusive organelles that are critical in transducing odorant signals. Loss or shortening of the OSN cilia, as seen in ciliopathy patients and animal models, exhibit impaired or loss of olfactory detection. Despite playing a significant role in olfactory function, little is known about the mechanisms involved in the biogenesis and maintenance of these structures. *In vitro* studies looking at primary cilia of other cell types have shown that ciliary disassembly occurs through an F-actin-dependent redistribution mechanism following GPCR agonist stimulation. To understand whether F-actin participates in OSN cilia disassembly in the pathological condition, we tested F-actin ciliary distribution in $Bbs1^{osnKO}$ and $Bbs4^{-/-}$ mouse models, where ciliary protein transport is disrupted. By ectopic expression of fluorescent-tagged proteins and live *en face* confocal imaging, we were able to observe OSN cilia directly. Our data showed that F-actin and Myosin VI (an actin-based molecular motor) were restricted to the OSN knob of wildtype mice. However, F-actin and Myosin VI redistributed into the OSN cilia of $Bbs1^{osnKO}$ and $Bbs4^{-/-}$ mice. Normal F-actin OSN ciliary distribution was restored in $Bbs4^{-/-}$ mice after *Bbs4* gene replacement. Interestingly, chronic odor hyper-stimulation of wildtype mice induced F-actin ciliary redistribution and disassembly (abscission) as well. Suggesting that overstimulation and abnormal ciliary transport can result in cilia disassembly through a possible mechanism involving receptor activation. Together, our data indicate that F-actin regulated machinery plays an important role in olfactory ciliary maintenance in the pathological condition, and may highlight alternative therapeutic targets for treating ciliary dysfunction.

416 **Pleasantness Ratings Of Odors In Children &Ndash; An International Multi-Center Approach**

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The hedonic value of odorants is well examined in adults showing that various parameters are influencing the individual rating of odorants such as socialization, experience and odor knowledge. The aim of this study was to examine the pleasantness of different odors in relation to odor identification ability and home country in children. Five hundred eleven children from 18 countries from five continents between an age of five and eight years underwent olfactory testing using a 17- item odor identification test and rated the pleasantness of each odorant on a five-point scale. A positive correlation between correct odor identification of an odor and the pleasantness could be displayed. For most odors a higher pleasantness has been found in participants who identified these odors correctly (chocolate, biscuit, flower, lemon, peach, strawberry; $p<0.05$). Children of all countries rated sweet and fruity odors (e.g. peach, chocolate) with a high pleasantness while odors like onion and fish were labeled as less pleasant. Nevertheless, children of different continents rated the pleasantness of all odors beside onion significantly different (onion $p= 0.075$, all other odorants $p<0.05$). The results of this study show that not only the correct identification but also the home country of the children influences the hedonic value of a certain odor.

417 **Crossmodal Correspondence Between Wine Labels And Wine Aroma**

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There is a high association between particular colors and shapes with certain odors, and there is strong evidence that packaging is an important component in driving consumers' response to beverages. The aim of the present study was to examine crossmodal associations between odor, color, and angularity in a complex wine matrix. Additionally, this study was designed to examine these associations in a way that would be applicable to how a consumer would naturally evaluate wine. Chardonnay wine was spiked with 5 odors commonly associated with chardonnay (buttery, citrus, floral, smoky, and vegetable) to create 5 unique wines. Fifty-two participants rated aroma and label pleasantness, and how well the wine aroma matched 8 realistic wine bottle labels with different colors and different levels of angularity. Label color, the aroma characteristic of the wine, and label pleasantness were all sound to influence how well a label matched the wine. No associations were found between odor and angularity. The vegetable-forward wine was found to match best with a green label. Smoky odor was better matched to the yellow and brown label than to the green or red. The floral odor was better matched to the yellow label than to the brown or red label. These results demonstrate that certain aromas, even in a complex matrix, are more associated with certain colors, but that hedonic liking might play a role. The results of this study further our understanding of cross-modal associations between olfactory and visual stimuli, and in particular between odors, colors, and angularity. Results can further be used by the wine industry to craft a more congruent label with the aroma, and likely improve overall liking.

418 **Are Changes In Cortisol Levels A Potential Biomarker For Changes In Olfactory Sensitivity?**

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It is known that stress reduces olfactory sensitivity in those with high state or trait anxiety (Takahashi, et al, 2015). In this study, cortisol levels were measured following an experimenter induced stress event in thirty six college students. The Wheeler UTC Olfactory threshold test (WUTC) was administered before and after the presentation of a stress event (Tewalt, 2015). Vanillin and isoamyl acetate were the odorants used in this administration sequence of the WUTC threshold test . A saliva sample was taken at the time of second administration of the olfactory threshold test. Differences in self reports of depression and resilience were correlated between differences in olfactory sensitivity. The use of cortisol as a biomarker for reactivity to stress is discussed.

419 **Effect Of Lavender And Peppermint Essential Oil Odors On Salivary Cortisol In Schoolchildren And College Students**

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Earlier we showed that exposure to peppermint (PO) or lavender (LO) odor selectively improved performance of schoolchildren in standard school tests which relied mostly on working memory. A number of studies showed that PO may also improve working memory in adults. The aim of current study: to evaluate the effect of peppermint and lavender oil (Sigma-Aldrich; ~ 0.13 mg/m^3) on saliva cortisol in children (10-11 years old) in comparison with college students (18-21 years old). Saliva cortisol was monitored using an ELISA technique. Individual saliva samples were taken every 15 minutes during control lesson (no odor, 45 min) and experimental lesson (PO/LO, 45 min). All experiments were performed at the same time of the day. Saliva cortisol was significantly lowered by PO in children of both sexes ($p<0.001$, $n=14$) regardless of the basal level of saliva cortisol. In adults we observed significant drop of cortisol only in female students ($p<0.01$, $n=10$) but not in male students ($p>0.05$, $n=10$); female students had significantly higher basal cortisol level than male students ($p<0.05$, $n=10$). In children with low basal saliva cortisol (<20 ng/ml) exposure to LO caused a significant elevation of the hormone ($p<0.05$, Fisher test), when in children with normal or elevated saliva cortisol (>20 ng/ml) we observed significant drop of the hormone ($n=8$, $p<0.05$, Wilcoxon test) in presence of LO. However, LO did not affect saliva cortisol neither in women ($n=10$, $p=0.09$), nor in men ($n=10$, $p=0.88$). Saliva cortisol is widely used as a biomarker of stress. It is known that elevated cortisol may have negative effect on memory retrieval both in adults and in children. Positive effect of essential oils on task performance in schoolchildren we explain by lowering of cortisol which facilitates memory retrieval.

420 **Free Fatty Acid Taste Perception Of The Domestic Cat (*Felis Catus*): Development Of A Cat Gpr120/ Ffar4 Recombinant Cell Line And Identification Of Taste-Active Compounds.**

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GPR120 (also called FFAR4) is a member of the rhodopsin family of G protein-coupled receptors (GPCRs) and is expressed in type II taste bud cells. It is implicated in the ability to taste free fatty acids, as its absence leads to reduced preference in mice to the free fatty acids oleic acid (C18:1) and linoleic acid (C18:2), as well as decreased neuronal response to oral free fatty acids (Cartoni et al., 2010; Galindo et al., 2012; Martin et al., 2011). The domestic cat (*Felis catus*) is an obligate carnivore and so naturally eats a meat-based diet, i.e. consisting mainly of protein and fat. Hence, we hypothesised that the cat has evolved to recognise and metabolise compounds from meat sources, including free fatty acids. However, the taste perception of free fatty acids for cats has not been studied in detail. Here we developed the first recombinant cell line expressing cat GPR120. We derived a consensus sequence for the short isoform, synthesized its full-length coding sequence and expressed it in a stable CHO cell line. The *in vitro* assay was optimised for High Throughput Screening (HTS)

and used to screen 121 compounds, including a range of free fatty acids and related compounds. 34 were identified as agonists, of which 24 had EC_{50} values <10 μM. None of the compounds showed any specific activity as a Positive Allosteric Modulator (PAM). Several long-chain free fatty acids were found to be agonists for the cat GPR120 receptor, including oleic acid and linoleic acid. The results of the behavioural tests are presented by Marshall et al. (see Abstract for further details). These results bring a new perspective on the taste and dietary preferences of the domestic cat. Cartoni et al.2010. J Neurosci, 30, 8376-82. Galindo et al.2012. Chem Senses, 37, 123-39. Martin et al.2011.PLoS One, 6, e24014.

421 **Impact Of Intensates&Reg; Flavor Levels On Flavor Perception And Flavor Lastingness**

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Intensates® flavors contain Sensates® ingredients which provide a 3rd dimension to the overall flavor experience. In addition to taste and aroma components of a flavor, the Sensates® ingredients deliver a trigeminal experience or chemesthetic effect (cool, warm, tingling). Individual Intensates® flavors affect saliva flow rate and flavor lastingness during chewing of chewing gum. This study explores the impact of a blend of Intensates® flavors in a soft chewable candy on salivation and flavor perception during and after chewing. Thirty-six participants chewed a sample and rated the flavor intensity in 3s intervals. After swallowing they continued rating the flavor intensity for 4min. A watermelon flavor and a mint flavor were augmented with three increasing levels of an Intensates® flavor blend. Lastingness after swallowing was measured as the time for the flavor intensity to drop below 25% of the maximum level perceived during chewing. Chew time was not affected by the presence of Intensates® flavors. Compared to the control, increasing levels of Intensates® flavors slightly increased flavor intensity during chewing. Flavor lastingness increased with increasing Intensates® flavor levels. The lastingness was longest in combination with watermelon flavor. Saliva flow was not affected by the level of Intensates® flavor blend. However, the lastingness after swallowing was longer for participants who had chewed for longer. Thus, the interaction between flavor perception and the chemesthetic effects of the Intensates® flavors increased the lastingness of the overall flavor after swallowing. Chewing behavior appeared to contribute to the high variation between participants, showing the need to assess flavor perception in the context of a product's texture.

422 **Electrophysiological Responses To Food And Feeding In The Nucleus Of The Solitary Tract In The Rat.**

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Previous work has shown that a subset of cells in the nucleus of the solitary tract (NTS) respond to odors as well as tastes, suggesting that the most effective stimuli for these cells may be complex naturalistic stimuli, i.e. food. Here, we test the idea that NTS responses to food-related odors may be apparent as a rat approaches a food that it is about to ingest. Subjects were Sprague Dawley rats that had a drivable microwire assembly implanted into the rostral NTS. Following recovery from surgery, rats were placed into an apparatus which contained seven wells filled with a selection of foods whose identities and positions were randomized daily. These stimuli included: dark chocolate (90% cacao), cheddar cheese, banana, Cheerios, milk chocolate chips, M&Ms, Granny Smith apples, lemon, and salted peanuts. A video camera linked to the recording apparatus (CinePlex, Plexon, Inc.) was used to record behavior in the experimental chamber. Each trial lasted 30 min where the rat was free to approach and consume any or all of the foods. Videos were scored offline to mark consummatory events. Analyses of three NTS multiunit responses showed bursts of neural activity that preceded and were predictive of subsequent consumption. These bursts were stimulus specific in each case. Stimulus-specific changes, either a long-lasting attenuation or excitation, in the level of neural activity were seen during the eating bout. Anticipatory responses in relation to eating may be evoked by food-related odors and/or may reflect instructions originating in higher-order structures. In all, results thus far suggest that NTS cells may be closely tied to appetitive as well as consummatory responses.

423 **Inhibition Of Ventral Tegmental Area Decreases Consumption Of Caloric And Non-Caloric Sweet Stimuli.**

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The ventral tegmental area (VTA) receives input from numerous brain areas, including from taste and feeding-related areas such as the parabrachial nucleus, lateral hypothalamus, and central nucleus of the amygdala (for review, see Rossi and Stuber, 2017). Dopamine is released in the nucleus accumbens (NAc) in response to both rewarding and aversive taste stimuli (Bassareo et al., 2002), and to oral sucrose through a PBN-dependent pathway (Hajnal and Norgren, 2005). Additionally, separate dopaminergic circuits involving either NAc or dorsal striatum have been shown to encode the hedonic and caloric properties, respectively, of sucrose (Tellez et al., 2016). However, the potential role of the VTA itself in relaying taste and viscerosensory information remains elusive. Using surgically implanted cannula, we microinjected the $GABA_A$ agonist, muscimol (10 g/L, 0.3 μL/mouse over 2 m), or vehicle into the midline VTA (spread was bilateral) of male and female C57BL/6J mice and measured licking to stimuli varying in taste valence and caloric content. Application of muscimol significantly decreased both licks and latency to lick of 3 mM sucralose, but not 0.1 mM QHCl or water, relative to earlier baseline measurements. These effects were not found in mice administered vehicle. When given a caloric sweetener (0.3 M sucrose), the suppressive effects of muscimol on licking were even more dramatic, including both licks and cumulative intake. In trials with sucrose adulterated with 0.3 or 3 mM quinine (to make

it less palatable), effects were more variable, although muscimol did not decrease licking of these solutions relative to prior baseline.

424 **Postingestive Influences On Ongoing Ingestive Behavior In Sucralose-Preferring And Avoiding Rats**

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Preference for sucralose is quite variable among individual rats. Using a series of 24-hr 2-bottle choice tests (0.0025-2.5 M sucralose versus dH_2O), we found that ~50% of our Sprague-Dawley rats prefer sucralose to dH_2O (preferrers, SPs), while the other half avoid certain concentrations of sucralose (avoiders, SAs) (n = 40), replicating the bimodal split found by others (e.g., Sclafani & Clare, 2004; Loney et al, 2011). The neurobiological bases of this phenotypic difference is yet unknown, though prior work has shown that SPs and SAs respond differentially to sweet and bitter taste stimuli (e.g., Loney et al, 2012; Torregrossa et al, 2015). Here, we assessed if SP/SA also display variance in their sensitivity to postingestive influences on ingestive behavior. Whilst food-deprived, SP and SA rats were given equimolar solutions (0.56, 1.1 M) of glucose (G) and fructose (F), sugars with similar taste properties, but different postoral consequences, in separate 30-min intake tests (order balanced). Lick pattern analyses revealed that SP and SA rats licked identically to G and F in the 1st minute, when intake is largely driven by taste, but soon thereafter, SA rats curbed licking for F, relative to G; SP rats licked more comparably for the two sugars across the session. Then, whilst water-deprived, rats were offered 0.12 M NaCl or a malaise-inducing LiCl solution to drink. Lick rates for NaCl and LiCl were equal in the 1st minute. By the 3rd minute, rats slowed LiCl ingestion; SAs exhibited significantly greater suppression of LiCl intake than SPs early on. No such phenotypic differences were seen for NaCl, at any point across the test. Thus, SA rats appear to be more responsive to at least two different types of postingestive feedback signals that guide ongoing ingestive behavior.

425 **Chemical Adducts Of Flavorants In E-Cigarette Liquid Solvents Act As Modulators Of Respiratory Irritant Receptors.**

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The use of E-cigarettes is rapidly increasing world-wide, especially among high school students and young adults. The major ingredients of the liquids used in E-cigarettes are nicotine, the solvents propylene glycol (PG) and vegetable glycerin (VG), and flavorants. Flavorants include aldehydes that may undergo chemical reactions with other e−liquid constituents under storage conditions or when heated in the e−cigarette device. The products of these reactions have not been systematically studied. We performed a chemical analysis by gas chromatography - flame ionization (GC-FID) of flavored E-cigarette liquids kept at room temperature conditions. In addition to the characterizing flavor aldehydes we identified several flavorant-solvent adducts in the e-liquids. These compounds were also detected in cold-trapped condensed e−cigarette vapors, and remained detectable in aqueous solution for several hours, suggesting that e−cigarette consumers receive significant exposures. Aldehydes cause respiratory irritation and pain through activation of Transient Receptor Potential (TRP) ion-channels such as TRPA1 and TRPV1 that are expressed in sensory neurons innervating the airways. It is unknown whether the detected flavorant-solvent adducts also activate these irritant pathways. Using calcium microfluorimetry in cultured HEK 293t cells transfected with cloned human TRPA1 or TRPV1, we observed that the flavorant-solvent adducts triggered robust activation of these TRP channels, some more potently than their parent flavor aldehyde. In conclusion, our data demonstrates that e-liquids, even under normal storage conditions, are chemically unstable. Constituents can react with each other and form compounds that engage known or unknown toxicological targets and require additional toxicological characterization.

426 **A Nasal Aerodynamics Perspective Of Retronasal Olfaction: Rodents Vs. Human**

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Odor perception can be achieved through ortho or retronasal routes, with the latter often considered less effective. As experiments on humans are difficult to conduct, many studies turn to animal models e.g. mice and rats. Thus, it is important to understand the differences between their nasal aerodynamics when it comes to olfaction. In this study, 3D computational models for a human and rat (Sprague Dawley) were used to investigate the impact of nasal anatomy on ortho vs. retronasal odorant transport to the olfactory receptor sites. The nasal pharynx region was modified for both human and rat models to make the human nasal structure more “similar” to that of rodent and vice versa. Absorption flux of 65 odorants to the olfactory zone was extracted from each model. For human, ortho and retronasal routes provided a similar level of odorant absorption, which changed similarly after modification - significant decrease of 61.81% for ortho and 62.30% for retro. For rat, the orthonasal route provided significantly higher odorant delivery than the retronasal route (medial: 188 times vs lateral: 21 times) and the anatomical modification had a differential impact: increase for the retro route (medial 1.62 times; lateral 2.99 times) vs decrease for the ortho route (medial 10.77%; lateral 85.11%). However, ortho still remained significantly higher than retro (medial: 105 times vs lateral: 1.2 times). There exist key differences between humans and rats when it comes to retro and orthonasal olfaction. While humans appear more reversible with odorant delivery, with both ortho and retronasal routes behaving similarly, rats seem to exhibit significant

differences between the two routes and are differentially impacted by nasal structural changes with significant medial and lateral variations.

427 **An Exploration Of Chemosensory Receptors In The Murine Nose**

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Airway diseases including chronic rhinosinusitis, rhinitis, and asthma are defined by chronic inflammation and dysregulated respiratory epithelial function. However, the mechanisms contributing to this inflammation are poorly understood. Specialized sensory cells called solitary chemosensory cells (SCCs) likely play a role as their activation has been directly linked to irritant-induced inflammation in mouse models. These cells are defined by their expression of Transient Receptor Potential Cation Channel Subfamily M Member 5 (TRPM5) and known chemoreceptors including bitter taste receptors and the canonical taste-signaling molecules α-gustducin and Phospholipase C Beta 2 (PLCβ2). However, whether expression of chemoreceptors is unique to SCCs is unclear as recent studies have identified ciliated respiratory epithelial cells as important chemosensors in the respiratory epithelium. In the present study, we identified chemoreceptors and signaling pathways unique to SCCs and ciliated epithelial cells of the murine respiratory epithelium. SCCs and ciliated cells were isolated from TRPM5-GFP and Forkhead Box J1 (FOXJ1)-eGFP mice, respectively. Using a combination of immunohistochemistry, flow cytometry, and single-cell PCR, we characterized the expression of chemoreceptors and canonical downstream signaling molecules. Canonical taste-signaling pathways were enriched in TRPM5-expressing SCCs as were specific bitter taste receptors. FOXJ1-eGFP-expressing ciliated cells lack components of the taste-signaling pathway and expressed far fewer putative chemoreceptors. This study gives insight to how inhaled irritants give rise to sinus inflammation and provides potential therapeutic targets for treatment of chronic respiratory inflammation. This work was funded by NIH 5K23DC014747-02 to VR.

428 **Automatic Feature Extraction From Human Respiratory Recordings Using Breathmetrics: A Respiratory Signal Processing Toolbox**

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Our ability to investigate olfaction and respiration is only as good as our ability to link biological events to features of respiratory waveforms. Human respiratory flow recordings are difficult to analyze because there are inherently noisy, non-stationary, non-sinusoidal, and imbued with a multitude of meaningful features that vary across individuals. With no tool for automatically extracting the full set of features hidden in raw respiratory recordings, researchers must build time-intensive, custom analysis protocols that often require hand-labeling each respiratory event in a recording. This methodology limits comparison across studies as well as the range and precision of possible insights that can be gained about the mechanisms underpinning olfaction and respiration. Here we present BreathMetrics: an open-source Matlab-based respiratory signal processing toolbox that automatically calculates the full set of features embedded in human airflow recordings (including sniff onsets), calculates statistical summaries of these features, and visualizes them. We show that BreathMetrics passes a rigorous validation process by evaluating BreathMetrics' feature estimation accuracy using several techniques on both recordings from human subjects and simulations. BreathMetrics' feature estimates were more accurate and revealed stronger odor-evoked theta power in electrophysiological recordings of human olfactory cortex compared to other techniques, these features resemble those that were hand-labeled, and feature estimations had 95% confidence intervals on the order of single milliseconds. We show that BreathMetrics accurately and thoroughly analyzes respiratory waveforms, allowing researchers to ask previously addressable questions about how respiration relates to body, brain, and behavior.

429 **Odorants&Rsquo; Metabolism In Human: A Critical Role In Odor Perception Revealed**

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To remain highly sensitive, the olfactory system needs the efficient clearance of odorants from the perireceptor environment which is catalyzed by Odorant Metabolizing Enzymes (OMEs) and avoids the saturation of the receptors and keeps them ready for new stimulations.
Our recent studies in animal models showed (i) that odorants are instantaneously metabolized in the olfactory mucosa giving volatile metabolites and (ii) that a competition between two odorants metabolized by the same OME can strikingly modify their perception. Here, we investigated these mechanisms in humans.
First, we set up a specific protocol to measure the olfactory metabolism using a Proton Transfer Reaction Mass Spectrometry method analyzing in real time the concentration of volatile compounds directly in the human nasal cavity. For various odorants, we showed an instantaneous production of their corresponding volatile metabolites in the perireceptor environment. We identified by gas chromatography (GC-MS) these metabolites, which exhibit odorous characteristics.
Second, we evaluated the impact of odorants' metabolism on the olfactory perception. We measured with an adequate psychophysical method, the modification of subjects (n=40) odor perception toward a target odorant in presence of its potential competitor odorant in terms of metabolism. We observed that the sensitivity for the target odorant was significantly enhanced probably due to its rapid accumulation in the perireceptor environment. These results indicate that odorants' metabolism catalyzed by OMEs in human nasal cavity, can significantly influence their relative bioavailability and thus modulate their detection and in fine critically contribute to the

olfactory perception. This peripheral mechanism is a new important step in the human olfactory system understanding.

430 **Cytokine Profile In Human Olfactory Cleft Mucus And Associated Changes In Olfactory Function**

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Multiple factors, including physical changes of the nasal mucosa and epithelium and exposure to air-borne environmental agents, appear to contribute to age-related olfactory loss. However, the molecular aspects of aging-associated olfactory loss in humans are not well understood. Although inflammation can be a significant underlying cause for olfactory impairment, whether aging increases the levels of inflammatory cytokines in the human olfactory mucosa and whether any inflammatory markers are associated with age-related olfactory loss remain unclear. Using a noninvasive method for collecting human olfactory mucus, we characterized and compared inflammatory cytokines, chemokines, and some growth factors, in the mucus collected from the olfactory cleft (OC) or the inferior turbinate/anterior part (AP) of the nose from 12 healthy, young (18-40 years old) and 12 elderly (60-85 years old) individuals. We also hoped to identify candidate molecular biomarkers associated with age-associated olfactory loss in humans. Olfactory thresholds were obtained for two odorants (PEA, n-butanol) and individual mucus samples were analyzed using multiplex assays for the levels of 30 cytokines. Results indicated elevated levels of certain inflammatory cytokines (IL-12, MCP-1) in mucus obtained from the OC of the elderly, relative to the AP. As well, high levels of some inflammatory factors (MCP-1, IL-8, IL-13 and VEGF) were significantly associated with reduced olfactory sensitivity, suggesting that inflammation may play a role in the olfactory decline associated with aging.

431 **Short-Term Neuronal Activity In The Basolateral Amygdala And Its Role In Taste Perception, Taste Learning And Gustatory Cortex Learning-Related Activity Changes.**

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Elecrophysiological studies have shown that gustatory cortex (GC) neurons process taste information in a fine temporal structure of sub-second epochs. In the ensemble level, the dynamics of these activity pattern were found to be highly correlated with changes in behavior across taste learning and extinction. Indirect evidence suggests that the basolateral amygdala (BLA) is driving these activity patterns in GC and is responsible to their change with learning. In this study we have directly tested whether short-term BLA activity is important for taste perception, taste learning and GC neuronal activity patterns. To that end we have optogenetically inhibited bilaterally the BLAs (BLA_{ox}) of rats for short periods during taste experience and tested its effect on current taste perception and on the acquisition of taste-malaise association learning (conditioned taste aversion [CTA]). We show that a short-term (~500ms) BLA_{ox} during any time between 500 to 3000 ms post taste delivery during the training day significantly attenuates CTA acquisition as tested a day later. This attenuation was confirmed not to be the outcome of either BLA damage or a state-dependency effect. Interestingly, additional experiments confirmed that BLA_{ox} has no effect on the perceptions of taste identity and hedonic value. Using extracellular recordings in the GC we directly show that short-term BLA_{ox} interrupts with learning-induced changes in GC palatability coding. Together, our results show that short-term BLA activity is essential for intact taste conditioning learning, and that this activity is important for learning-related changes in GC. We also show that this short-term BLA activity has no effect on taste perception. Additional experiments will test the specific pathways by which the BLA impact GC activity, and learning.

432 **(Don Tucker Award Finalist) Selective Attention Controls Olfaction**

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Critical animal behaviors, especially among rodents, are guided by odors in remarkably well-coordinated manners. While many extramodal sensory cues compete for cognitive resources in these ecological contexts, that rodents can engage in such odor-guided behaviors suggests that they selectively attend to odors. We developed a behavioral paradigm to reveal that rats are indeed capable of selectively attending to odors in the presence of competing extramodal stimuli and found that this selective attention facilitates accurate odor-guided decisions. Further, we uncovered that attention to odors adaptively sharpens their representation among neurons in a brain region considered integral for odor-driven behaviors. Thus, selective attention contributes to olfaction by enhancing the coding of odors in a manner analogous to that observed among other sensory systems.

433 **Taste And Place Coding In The Hippocampus**

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The hippocampus plays a key role in spatial learning and memory, and contains neurons known as place cells that respond to specific locations as animals explore their environment. However, little is known about how place cell maps encode meaningful stimuli, such as tastes, which is surprising, given that one of the most important purposes of having a mental map is to find food. To characterize how the hippocampus respond to tastes, we recorded from neurons in the CA1 hippocampal region of freely behaving rats as they randomly received four different taste solutions of varying palatability via intra-oral cannula. Our findings suggest that there are overlapping populations of hippocampal neurons that respond to tastes and places, and that taste experience in a new context can reorganize an animal's mental map. Furthermore, the population of taste-responsive hippocampal neurons was found to sequentially encode taste presence, identity, and palatability, similar to what has been observed in the gustatory cortex, but on a slower time scale. These findings are consistent with the idea that the hippocampus is not involved in basic taste processing, but rather, to associate contexts with tastes. Future work will be done to further separate the taste and place components of hippocampal responses, quantify the remapping of place fields after taste experience, and examine the reactivation of taste-responsive cells during sleep.

434 **Dual Functions Of Insect Wings: Balancing Aerodynamics And Olfaction**

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The ability to track odor plumes to its source (food, mate, etc.) is the key to the survival of many insects. During this odor-guided navigation, flapping wings have been speculated to actively draw odor to the antennae and enhance olfactory sensitivity. Utilizing an in-house computational fluid dynamics solver, we have quantified the odor plume structures of a fruit fly in forward flight motion and have confirmed that the flapping locomotion enhances the odor mass flux around its antennae (by ~2.8 times at its peak). The increased odor mass flux is the result of broader spatial sampling range in the vertical direction below the body, but not horizontally. This anisotropic spatial sampling range may have important implications in understanding the behavior and algorithm of plume tracking in insects. We further show that the trailing-edge portion of the fruit fly wing has poor aerodynamic performance but seems to be important for flicking the odor plume over its antennae. Intrigued by this observation, we virtually cut off the trailing-edge portion of the fruit fly wing; subsequent simulations showed that this altered wing has an improved aerodynamic lift coefficient (~18.0%) but with significantly reduced odor mass flux (~17.9%). Contrary to the common belief that the wing shapes of insects are optimized purely for aerodynamic performance, our results suggest that, because both aerodynamic and olfactory functions are indispensable during odor-guided navigation, the wing shape and size may be a balance between the two functions. Furthermore, we found that higher wing beat frequencies and wing reversal phase induced higher odor mass flux, while lower beat frequency and downstroke phase produced better lift coefficient - again, a balance between the two functions.

435 **Perturbation Of Amygdala-Cortical Projections Alters Temporal Coding In Gustatory Cortex**

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Gustatory cortex (GC) integrates taste-related information from multiple subcortical nuclei, including the basolateral amygdala (BLA). As a result of this convergence, GC single-unit taste responses convey a time series of information—first about taste identity (e.g., sweet, bitter; Epoch 1: ~0.2-0.7s post-delivery) and then taste palatability (Epoch 2: ~0.8-1.5s post-delivery). We have hypothesized that the dynamic nature of this coding specifically requires temporally-restricted inputs from BLA. Previous work (Piette et al., 2012) broadly confirmed the importance of BLA in cortical palatability coding; to more rigorously test our hypothesis, we examined whether taste-related GC firing could be altered by brief, targeted optogenetic perturbation limited to BLA->GC projections. We first infected BLA of adult female Long Evans rats with AAV-ArchT; four weeks later, we implanted 1) bilateral multi-electrode bundles with optical fibers ('optotrodes') in the GC and 2) intra-oral cannula (IOC) for taste delivery. With this preparation, we were able to specifically silence BLA->GC projections (sparing both BLA and GC somae) while presenting 0.1M NaCl, 0.3M Sucrose, 0.1M Citric Acid and 1mM Quinine. We found that optogenetic inhibition of BLA->GC projections had bidirectional effects on GC taste responses. Single unit responses were dramatically altered, but the effect was specifically restricted to the epoch of palatability-related firing; taste identity firing remains unaffected by the inactivation. This pattern of results is consistent with the hypothesis that relative to other inputs, BLA preferentially provides palatability information to GC. Future research will investigate the impact of this brief, targeted optogenetic inactivation on taste-guided behavior, such as conditioned taste aversion.

436 **Development Of An Experimental Design To Characterize The Functional Role(S) Of Cell-Type/Target-Specific Inputs To Brainstem Taste Nuclei.**

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We have known for decades that the gustatory region of the nucleus of the solitary tract (NST) and parabrachial nucleus (PBN) are densely innervated by forebrain structures like the central nucleus of the amygdala (CeA). Chemical or electrical stimulation of the CeA modulates responsiveness of NST and PBN neurons to sapid stimuli indicating active filtering of gustatory information. Yet, a long-standing problem in the field is the absence of tools to assess the extent to which such neuromodulation shapes the distinct functional roles of the NST and PBN in the control of taste-guided behaviors. In the study of circuit function, it is critical to not only target cell types but also their defined projections because subpopulations of neurons in a specific region can give

rise to behaviorally antagonistic pathways. The goal of the present research is to use existing optogenetic retrograde gene transfer techniques to develop a system for cell-type/target-specific modulation of taste circuits. The present results indicate that somatostatin (Sst) expressing neurons of CeA origin represent an ideal population to demonstrate the utility of such a system. Sst-CeA cells are a major source of input to gustatory NST and PBN compared to other forebrain areas and to cells that express corticotrophin-releasing hormone (Crh). In addition, the majority of Sst-CeA cells project to either the gustatory NST or PBN. Finally, Sst-CeA axon terminals in the PBN co-express GABA and optogenetic activation of these terminals produces IPSPs/IPSCs in PBN cells *in vitro* and inhibits taste responses *in vivo*.

437 **A Cortical Pathway Modulates Sensory Input Into The Olfactory Striatum**

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Sensory cortices process stimuli in manners essential for perception. The piriform 'primary' olfactory cortex (PCX) extends dense association fibers into the ventral striatum's olfactory tubercle (OT), yet the function of this cortico-striatal pathway is unknown. We optically stimulated channelrhodopsin-transduced PCX glutamatergic neurons or their association fibers while recording OT neural activity in mice performing an olfactory task. Activation of PCX neurons or their association fibers within the OT controlled the firing of some OT neurons and bidirectionally modulated odor coding dependent upon the neuron's intrinsic odor responsivity. Further, patch clamp recordings and retroviral tracing from D1 and D2 dopamine receptor-expressing OT spiny neurons revealed this input can be monosynaptic and that both cell types receive most of their input from a specific spatial zone localized within the ventro-caudal PCX. These results demonstrate that PCX odor information functionally accesses the direct and indirect pathways of the basal ganglia within the OT.

438 **Distribution Of Scc Markers And Tas2Rs In Different Locations Of Human Sinonasal Cavity**

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Bitter taste receptors (TAS2Rs) are expressed in the human sinonasal cavity, and may be relevant for the disease processes of allergic rhinitis and chronic rhinosinusitis. However, the location of solitary chemosensory cells (SCCs) and taste receptors in human sinus is unclear. The aim of this study is to characterize the distribution of SCCs and TAS2Rs in different locations of human sinonasal cavity. Human sinonasal biopsies were obtained from subjects with chronic rhinosinusitis (n=4-6) at four different anatomic sites. Quantitative RT-PCR was used to compare expression of several taste transcripts in different anatomic locations, including inferior turbinate, middle turbinate, septum and anterior ethmoid sinus. Relative mRNA expression of *TAS2R38, TAS2R47*, *TAS1R3*, *TRPM5, PLCβ2,* and *ARL13B* were examined. *TAS2R38, TAS2R47, TAS1R3, TRPM5, PLCβ2*, and *ARL13B* are all expressed in the inferior turbinate, middle turbinate, septum, and anterior ethmoid sinus. Overall, gene expression levels of *TAS2R38, TAS2R47, TAS1R3, TRPM5, PLCβ2,* and *ARL13B* were higher in the ethmoid sinus than all the other locations. In this region, however, the expression level of *ARL13B* is the highest, followed by *PLCβ2* and *TAS2R47*; the relative expression of *TRPM5, TAS2R3*, and *TAS2R38* were the lowest. These findings suggest that sinus has higher expression of SCC markers and taste receptors than the nasal cavity. Biopsies obtained from the anterior ethmoid region may serve as the best location to obtain tissue for study of human upper airway taste receptors and solitary chemosensory cells. This work was supported by a grant from NIH 5K23DC014747-02. Jingguo Chen gratefully acknowledges the financial support from Xi'an Jiaotong University Health Science Center.

440 **Fruity, Roasty, Rubber-Like Smelling Thiols Activate Distinct Receptor Combinations With Broadly Tuned Or2W1 As Common Target**

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Thiols are among the most potent aroma determinants, even if present in foods in trace amounts, due to their extremely low odor thresholds. The rubber-like smelling 2-phenylethanethiol is a key food odorant (KFO) in sesame seeds, 3-mercaptohexyl acetate with a fruity note determines the aroma of Sauvignon blanc wines or tropical fruits, and the sulfury, roasty 2-furfurylthiol is a maillard product and KFO, for example in coffee, heated meat, fish, and roasted nuts and seeds. Until now, few thiols could be assigned as ligands to human odorant receptors (ORs), mainly from family 2. Here we show that three thiol KFOs of different odor quality activate distinct receptor combinations out of all human ORs, and that these OR activity patterns overlap in broadly tuned OR2W1. Beyond the assignment of new cognate KFO/OR combinations, including broadly and narrowly tuned ORs, our results demonstrate that different odor qualities on a molecular level are represented as distinct receptor activity barcodes, adding to an understanding of the receptor coding of the biological relevant group of food-typical and aroma-determining odorants.

441 **Identifying The Constituents In The Ovarian Cancer Odor Signature**

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Ovarian cancer is difficult to detect due to the absence of distinct symptoms. To date, there are no reliable diagnostic tests for this type of cancer, and most patients are diagnosed in later stages of the disease, which reduces their treatment options and leads to poor prognosis. We hypothesized that alterations in cellular metabolism caused by the onset of cancer would create a distinguishable and unique odor signature and it was demonstrated by trained canines in our preliminary studies. We are attempting to isolate and identify the volatile organic compounds (VOCs) which constitute the ovarian odor signature, particularly those that signal the disease's earliest stages. Solid-Phase Microextraction-Gas Chromatography/Mass Spectrometry (SPME-GC/MS) techniques identify the VOC components from individual subjects' plasma sample and reveal a quantitative variation in VOCs between cancer and control samples. In order to determine if the VOCs seen in our analyses are those used by trained canines, we are employing Micro-Preparative Gas Chromatography (MP-GC) techniques to collect GC eluants containing the plasma-derived VOCs captured using SPME. The MP-GC technique employs a gradient-cooled glass tube connected to the GC outlet. This collected materials are presented back to the trained canines to judge their responses. Results to-date suggest that we are collecting some compounds of interest to the dogs. The ultimate goal of our research is to establish a vapor sensor device which offers a practical diagnostic system to diagnose the disease at an early stage. Knowing which VOCs are specific to the disease will help design more specific and sensitive sensors and help save lives.

442 **The Mechanisms Behind Odorant Receptor Gene Expression: Singular Or Multiple Choice?**

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What does it mean for an odorant receptor (OR) gene to be chosen? How does singular gene choice get established, when each of the 10 million olfactory sensory neurons (OSNs) in mice choose to express only 1 out of 2400 possible OR alleles? Studying gene choice is particularly difficult as each OR has a low but equal representation in the nasal epithelium where only 0.1% of OSNs express the same OR. To answer these questions, we employ our validated MouSensor technology that is known to dramatically increase the probability of one cloned OR gene to be expressed, using an identified 21-bp gene choice enhancer. We have developed transgenic mice, called MouSensors, for different OR coding sequences; crossing several MouSensors together enables us to study multiple OR high-probability choice events in the same transgenic mouse. We set out to look at how OR expression is affected when higher competition for choice is present, and whether we can uncover OR co-expression, through the synergistic effect of multiple 21bp-gene choice enhancers in the same background. In a Olfr16/Olfr151 double MouSensor, we find a population of OSNs co-expressing both Olfr16 (MOR23) and Olfr151 (M71) protein. The number of these co-expressing OSNs is sufficient for the axons to converge in the bulb and form a stable glomerulus with a unique Olfr16/Olfr151 identity. In order to verify if double choice events visualized at the protein level is reflected on the RNA level, we have analyzed the nuclei of co-expressing OSNs using RNA *in situ* hybridization. Our results demonstrate that stable OR co-expression is possible and offers a unique opportunity to characterize a novel OR identity and its odor profile *in vivo*. These findings will provide critical insight in the machinery regulating singular OR gene expression.

443 **Differential Modulation Of Olfactory Receptor Neurons In A *Drosophila* Olfactory Circuit**

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A considerable amount of information has been generated regarding the modulation of olfactory behavior by an animal's starved state. However, much less is known about the molecular and cellular basis underlying this modulation. Based on recent studies from our lab and others, we hypothesized that the *Drosophila* larva's starved state differentially modulates individual Olfactory Receptor Neuron (ORN) function and that this modulation is dependent on GABA signaling. We used two different behavioral assays to analyze the chemotaxis response of starved and fed larvae to a panel of seven odorants that specifically activate individual ORNs. Interestingly, the behavioral differences among starved and fed larvae varied when different ORNs were activated in the assays, suggesting that an animal's physiological state differentially modulates the functions of individual ORNs. GABA signaling was previously shown to impact ORN function in adult flies. Using immunohistochemistry we determined that $GABA_B$ receptors localized to terminals of larval ORNs. To study the role of $GABA_BR$ in starvation dependent modulation of behavior, we genetically altered its levels in individual ORNs. Reducing $GABA_BR$ in ORNs reduced the starvation dependent changes observed during larval chemotaxis. To systematically characterize the various molecular players involved, we quantified relative expression levels of different mRNAs in the brains of starved and fed larvae. Overall, our results suggest that starvation leads to increased GABA signaling in olfactory neurons and suggest a novel link between GABA and Insulin signaling pathways in the ORNs. Our results have the potential to explain how environmental signals are precisely translated into different behavioral outputs based on the animal's physiological state.

444 **A Search For Olfactory Receptor Antagonists Among The Constituents Of A Reconstituted Charred**

Wood Odor

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Several *in vitro* examples of olfactory receptor (OR) antagonism are known. Antagonists bind a receptor without activating it, thereby competing with agonists that would otherwise activate a cell expressing the receptor. Receptor level competition is one possible explanation of phenomena such as odor masking and mixture suppression. In this project we ask whether structurally similar odorants in a reconstituted natural odor mixture contribute to the mixture's olfactory code by OR-level interference. We used dissociated mouse olfactory sensory neurons (OSNs) and calcium imaging to study this question by searching for agonist-antagonist pairs within the major constituents of a charred wood odor mixture. The mixture consisted of six closely related phenols commonly found in charred wood: guaiacol, 4-methylguaiacol, 4-ethylguaiacol and 2-, 3- and 4-methylphenol. The odorants were first profiled individually. When applied at the same concentration (30 μM) each odorant activated between 0.48 – 0.83% of the 8,470 viable OSNs that were tested. The guaiacols activated a group of sensory neurons largely distinct from cells activated by the methylphenols, indicating that the guaiacol 2-methoxy group is a distinguishing pharmacologic feature between the two phenol subtypes studied. Two-component testing on 1,245 OSNs revealed only a single clear example of antagonism, where an OSN activated by 4-ethylguaiacol was competitively inhibited by guaiacol. Our results suggest that within this mixture of structurally similar odorants, which approximates the odor of charred wood, the olfactory code of activated neurons is almost entirely the additive result of activation by the mixture's individual components.

445 **Endogenous And Engineered Metal Nanoparticles Influence Responses Of The Olfactory Sensory Neurons To Odorant**

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Metal nanoparticles such as copper, gold and zinc have been isolated from human and animal blood. Of those, zinc nanoparticles (ZnNPs) have been shown to enhance responses of the olfactory sensory neurons to odorants. Characterization of these endogenous ZnNPs demonstrate a 1-2 nm size in a primarily-elemental metal state. Oxidation of laboratory engineered ZnNPs halted the physiological enhancement. At low concentrations, the endogenous and engineered ZnNPs enhanced amplitudes of electroolfactogram (EOG) or whole cell patch-clamp responses to odorants by about 3-fold. The presence of ZnNPs within the olfactory epithelium (OE) and respiratory epithelium (RE) has not been reported. This study examined the electrophysiological properties of endogenous nanoparticles obtained from the OE and RE compared to engineered ZnNPs on responses the olfactory sensory neuron to odorant. Endogenous nanoparticles were obtained by microsurgical collection, homogenization, and fine filtering. Engineered ZnNPs were prepared by underwater high-voltage discharge method. Particle size was determined by atomic force microscopy, crystallinity by transmission electron microscopy, and oxidation by X-ray photon spectroscopy. EOG performed on olfactory epithelium was evoked by an odorant mixture of ethyl butyrate, eugenol, and (+/–) carvone. Endogenous nanoparticles from OE and engineered ZnNPs showed comparable EOG enhancement followed by a reduced level of enhancement with RE nanoparticles. The presence of olfaction enhancing nanoparticles within the OE and RE suggests a functional similarity to ZnNPs and supports a physiological role in the initial events of olfaction at the receptor level.Further characterization of the filtrate is needed. .

446 **(Don Tucker Award Finalist) Humidity Response Depends On The Small Soluble Protein Obp59A In *Drosophila***

Jennifer S. Sun[1], Srinivas Gorur-Shandilya[1,2], Mahmut Demir[1], Nikki K. Larter[1,2], Sebastian Chahda[1], Zhe He[2], Hany Dweck[1], Douglas Rioux[1], Ankita Gumaste[2], Sonia Wang[1], Thierry Emonet[1,2,3], John R. Carlson[1,2]

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Odorant binding proteins (Obps) are remarkable in their number, diversity, and abundance. They are widely believed to deliver odors to olfactory receptors; however, some Obps are expressed outside the olfactory system and may bind ligands other than odorants. Obp59a is exceptional because of its high conservation among insects. We map *Obp59a* expression in fruit flies (*Drosophila*) and tsetse flies (*Glossina*), and find that it is highly localized in both species, expressed only around the second chamber of the sacculus, a multichambered opening on the antennal surface. We conduct double-labeling experiments with *Obp59a* and antennal ionotropic receptors (IRs), further revealing that *Obp59a* is expressed in the same sensilla as hygrosensitive IRs. Indeed, fruit flies with *Obp59a* deleted show a deficient humidity preference in four independent behavioral assays. Neuronal response to humidity is also diminished in deletion mutants. Composition of cuticular hydrocarbons used for waterproofing was altered in *Obp59a* mutants, which correlated with an observed altered desiccation resistance. The results implicate a new molecule in humidity response. A better understanding of this mechanism should allow us to better control insect pests and the diseases they can spread. Moreover, this study encourages a broader view of the functions performed by the large and diverse family of Obps.

447 **The Molecular And Cellular Basis Of Food Texture Sensation**

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Food texture, the physical property of food including hardness and viscosity, plays a critical role in regulating food preference. Although food texture has enormous effects on feeding behavior, the molecular and cellular identities of mechanosensory receptors responsible for food texture sensation were unknown. Akin to mammals, we found that the fruit fly, *Drosophila melanogaster* prefers food with a specific viscoelasticity. In Drosophila, the transmembrane channel-like (TMC) ortholog is required to discriminate food texture including hardness and viscosity. TMC defines a previously unknown class of multidendritic neurons (md-L) in the primary taste organ called the labellum. The md-L neurons extend elaborate dendritic arbors to innervate the base of taste hairs. Deflection of taste hairs leads to prominent action potentials in the md-L neuron. Remarkably, the md-L neurons exhibit direction selectivity in response to mechanical forces applied to taste hairs. Genetic ablation of *tmc* abolishes the mechanical responses in md-L neurons. In summary, we demonstrated that the single Drosophila transmembrane channel-like (TMC) is expressed in md-L neurons, where it is required for sensing food harness and viscosity. We propose that md-L neurons are long-sought-after mechanoreceptor cells through which food mechanics are perceived and encoded by a taste organ, and this sensation depends on TMC.

Friday, April 20, 2018

7:30 - 9:00 AM	Estero Foyer
Continental Breakfast	

8:00 - 10:30 AM	Estero Ballroom
Poster Session V	

D21 **In Home Sensory Testing: Assessing The Impact Of Genetics On Food Behaviour**

Nicholas Archer[1], Thibaut Buisson[2], Damian Frank[1], Taylor Pennie[3], Astrid Poelman[1], Konsta Duesing[4]
[1]CSIRO Agriculture and Food, Sydney, Australia, [2]AgroSup University, Dijon, France, [3]CSIRO Health and Biosecurity, Adeliade, Australia, [4]CSIRO Health and Biosecurity, Sydney, Australia

The effect of genetic variants in sensory genes on an individual's food preference or choice is currently unclear. The limiting factor in the validation of genetics with food behaviour is the poor match between small studies obtainable from sensory testing (10-100's) and genomic studies requiring 100-1000's of people. This highlights the need for novel solutions to rapidly collect sensory data from thousands of individuals. The primary objective was to determine if sensory testing in a home environment is a valid method to explore the influence of genetics on food behaviour. An in home sensory kit was developed, containing sensory tests (taste and aroma tests), dietary questionnaires (food preferences and dietary intake) and a DNA saliva collection tube, with all data collected using an online platform. The kit content was designed to meet the four following criteria: sound scientific quality, easy to complete, inexpensive, and easily transportable. A test-retest validation study of the kit confirmed that reliable data could be obtained for both sensory measures (taste and aroma tests) and dietary questionnaires in a home testing environment. Genetic testing for known gene by sensory interactions (n=40, 65% female, mean age=37) found the kit could identify known benchmark associations of PROP sensitivity with TAS2R38 variants (rs713598, rs1726866 and rs10246939) and β-ionone with ORA51 (rs6591536). Given the ability to collect reliable data and to detect benchmark sensory/gene interactions, sensory testing in a home environment is a method that can be used to assess the interaction between food preferences and genetics. Use of in home testing allows for fast and cost effective collection of samples enabling larger sample sizes to validate genetic/phenotypic markers with food behaviour.

D22 **Impact Of A High Fat High Sucrose Maternal Diet On The Progeny&Rsquo;S Olfactory System**

Laëtitia Merle, Vanessa Soubeyre, Sylvie Chaudy, Frédérique Datiche, Xavier Grosmaitre, David Jarriault
Centre des Sciences du Goût et de l'Alimentation - AgroSup Dijon - CNRS - INRA - Univ. Bourgogne Franche-Comté, Dijon, France

The influence of maternal diet on progeny's health has been thoroughly investigated regarding metabolic diseases, but the impact on sensory systems is still unexplored. Neurons of the olfactory system start to develop during the embryonic life and pursue their maturation after birth. Besides, these neurons are under metabolic influences, and it has recently been shown that adult mice exposed to an obesogenic or diabetogenic diet display reduced olfactory abilities. However, whether or not olfactory function is affected by the perinatal nutritional environment remains unknown. Here we investigated the effect of a high fat high sucrose (HFHS) maternal diet during pregnancy and lactation, on the olfactory system of the progeny in mice. In the three-week-old male offspring, maternal HFHS diet induced overweight and higher amount of gonadal fat, associated with hyperleptinemia. Olfactory function was assessed by investigating mice sniffing behavior. The progeny of HFHS diet fed dams showed reduced sniffing behavior in the presence of low doses of phenylethanol, compared to the progeny of standard diet fed dams. Furthermore, they exhibited increased time to retrieve a piece of breakfast cereals hidden beneath the bedding in a buried food test. Meanwhile, electroolfactogram recordings revealed no change in the sensitivity of olfactory mucosa. mRNA levels for elements of the olfactory transduction cascade were not affected either. Our results demonstrate that a HFHS maternal diet during gestation and lactation modulates olfactory perception in the offspring. This is not correlated to impaired odor detection by the olfactory epithelium. Our future studies will test the hypothesis that altered olfactory perception may originate from different modulation in olfactory processing by the central nervous system.

D23 **Correlation Between The Volume Of Olfactory Bulb And Olfactory Functions**

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Penn State College of Medicine, Hershey, PA, United States

Objective: Olfactory bulb (OB) is highly affected by the pathology of several neurodegenerative diseases that cause olfactory deficits, e.g. Parkinson's disease. At this time the relationships between olfactory functions and the structure and morphology of OB are not clear. In this preliminary study we investigated the correlation between OB volume and olfactory functions in the healthy subjects. Methods: Seven healthy subjects (aged 50-

63) participated in the study. Their olfactory functions were evaluated with the University of Pennsylvania Smell Identification Test (UPSIT), OLFACT smell threshold test, and the odor-related fMRI activation in the primary olfactory cortex (POC). The OB volume was measured using manual segmentation of each OB in the T_2-weighted images with a spatial resolution of 0.3 x 0.3 x 0.5 mm^3. Results: There was no significant volume difference between the left and right OB (left 56.1 ± 7.7 mm^3; right 55.2 ± 5.2 mm^3) in these subjects. The combined OB volume of the two sides significantly correlated with the UPSIT score. There was no significant correlation between the OB volume and the smell threshold. There were significant correlations between the combined volume of bilateral OBs and the odor-related fMRI signal in the POC, and between the volume of right OB and the odor-related fMRI signal in the right POC. Conclusions: Significant correlations between OB volume and olfactory functions were observed in this preliminary study of healthy subjects. Further research is warranted with more heathy subjects and subjects with olfactory deficits.

D24 **Coupling Of Spontaneous Intra-Ciliary Ca^{2+} Domain Dynamics And Ciliary Intraflagellar Transport In Olfactory Sensory Neurons.**

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Cilia are dynamic organelles that play important roles in cellular signaling across various cell types. Within the olfactory system, olfactory sensory neuron (OSN) cilia compartmentalize all the necessary machinery for odorant detection. The maintenance of this organelle is critical for the normal olfactory function, where shortening and/or loss of cilia due to disease results in olfactory loss. Ciliary maintenance is largely attributed to the intraflagellar transport (IFT) complex that traffic proteins in and out of the cilia. Recently, local changes in ciliary Ca^{2+} levels have been implicated in the facilitation of IFT protein trafficking in invertebrates. In the following study, we developed a strategy utilizing a lipid-anchored GCamp6f combined with live *en face* total internal reflection fluorescence (TIRF) imaging that would allow for the examination of intra-ciliary Ca^{2+} dynamics, and determination of the role of Ca^{2+} in the ciliary maintenance in intact OSNs. Utilizing this novel strategy, we observed robust spontaneous oscillating Ca^{2+} microdomains within the cilia. The frequency of these oscillations varies stochastically between neurons, but ciliary microdomains within the same OSN exhibited similar frequencies. Nevertheless, in all neurons oscillations were dependent on extracellular Ca^{2+}. Similarly, a decrease in external Ca^{2+} reduced ciliary anterograde and retrograde trafficking of IFT particles. Interestingly, oscillation frequency increased with odor perfusion and was followed by a uniform Ca^{2+} increase propagating from the cilia to the dendritic knob of the OSN. Together, these observations demonstrate the presence of spontaneous Ca^{+2} microdomains in OSN cilia, and suggest a role of Ca^{2+} dynamics in the homeostatic ciliary maintenance.

500 **Experience Dependent Axon Targeting In The Olfactory System.**

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Olfactory sensory neurons (OSNs) that express the same olfactory receptors (ORs) are scattered in the olfactory epithelium but their axons coalesce into a few bundles of axons that converge onto the glomeruli on the olfactory bulb. A single odorant binds to specific OR and activates a pattern of glomeruli. The mechanism wherein these OSN axons coalesce is still unclear. As a step toward understanding glomeruli map formation, we determined the effect of postnatal odor experience on OSN axon targeting of two related ORs, M71 and M72 using their cognate ligand, 2-hydroxyacetophenone. M71 and M72 differ in 11 amino acids and respond to an overlapping set of odorants. We obtained mice that has M71-GFP and M72-RFP knock in and exposed them to 1/1000 dilution of 2-hydroxyacetophone for 16 hours intervals daily from birth to day 21. Mice were sacrificed at day 21 and dissected to view their dorsal olfactory bulb under fluorescence microscope that highlighted M71 glomeruli with green signal and M72 glomeruli with red signal. M71 and M72 glomeruli were categorized as intermingling, adjacent, or separate based on their proximity on the olfactory bulb. The distance was analyzed according to minimum distances between each glomerulus, which was done by collecting the pixel coordinates of each object and determining the pair of coordinates between the two glomeruli with a minimum distance. We found that mice stimulated with 1/1000 2-hydroxyacetophone had M71 and M72 glomeruli to be intermingled more frequently and locate at closer distances in the olfactory bulb, suggesting that odor experience affects axons coalescence onto glomeruli in the olfactory bulb. Funding Acknowledgements: NIDCD DC012095 and Research Supplement to Promote Diversity in Health-Related Research

501 **Inflammation Induced By Lipopolysaccharide Intensifies Bitter Taste**

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Taste disorders, including taste loss and taste distortions, can have substantial impact on quality of life, food intake, and health. Despite recent advances in the identification of taste receptors and their downstream signaling molecules, the mechanisms of taste disorders, especially those of taste distortions, remain poorly understood. In this study, we investigated changes in bitter taste during inflammation, a condition associated with many

illnesses. We used a lipopolysaccharide (LPS)-induced systemic inflammation model, in which LPS was given to mice by intraperitoneal injection. Taste responses to bitter compounds were examined by gustatory nerve recording and behavioral testing. Gene expression analyses were conducted for bitter taste receptors, as well as inflammatory regulators. Our results showed that LPS-induced inflammation strongly intensified neural and behavioral responses to bitter tastants. The expression of NF-κb, a transcription factor controlling inflammation, was up-regulated by LPS, which was consistent with the induced expression of various inflammatory cytokines in taste buds. More importantly, the expression of the majority of mouse bitter receptors was increased by LPS. These results indicate that LPS-induced inflammation can escalate bitter taste in mice. Our study suggests that inflammation may contribute to heightened bitter taste, a form of taste distortion reported in some patients, such as cancer patients.

502 **Olfactory Networks And Dmn Behaviors During Odor Processing: A Sensitive Functional Marker For Cognitive Deficits And Dementia In Ad**

Prasanna Karunanayaka[1], Jiaming Lu[1,2], Bing Zhang[2], Bin Zhu[2], Paul J Eslinger[1,3], Qing X Yang[1,4]

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Functional imaging studies have suggested that memory, a process through which information is encoded, stored, and retrieved, is subserved by a distributed, large scale brain network encompassing the hippocampus, medial temporal lobe (MTL) and a set of cortical regions known as the default mode network (DMN). Anatomically, the DMN overlaps with and is functionally connected to olfactory structures in the medial temporal lobe (MTL). Previously, we showed that olfactory processing deactivates the DMN to a level that is comparable to the levels seen during attention and memory task performance (Karunanayaka et al., 2016). This finding indicated that the odor processing may draw significant cognitive resources and suggested a potential mechanism for the observed olfactory deficits in early AD. Presently, no study has characterized the specific relationships between primary olfactory networks (PONs) and DMN in AD, both of which show marked deficits. In this study, we investigated the dynamic relationship between the PONs and DMN in AD (N=12, mean age= 73.7 yrs), MCI (N=19, mean age= 72.8 yrs) and cognitive normal (CN, N=32, mean age= 69.5 yrs) subjects. Their smell function was measured using the UPSIT. Data revealed that the PONs as well as DMN activity are significantly reduced in MCI and AD compared to CN, and that the activations in PONs in MCI have reached levels that are comparable to AD. These results suggested that effective olfactory networks could be more sensitive and specific for detecting functional deficits of AD because, compared to standard cognitive tasks, olfactory tasks are less likely to be confounded by compensatory mechanisms. Thus, effective olfactory network analysis may provide a more sensitive marker for the early diagnosis of cognitive deficits and dementia.

503 **Abnormal Nasal Aerodynamics And Trigeminal Functions In Empty Nose Syndrome Patients**

Chengyu Li[1], Alexander A. Farag[1], Guillermo Maza[1], Sam McGhee[1], Michael A. Ciccone[1], Bhakthi Deshpande[1], Edmund A. Pribitkin[2], Bradley A. Otto[1], Kai Zhao[1]

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Abnormal nasal aerodynamics or trigeminal functions have been frequently implicated in the symptomology of empty nose syndrome (ENS), yet with limited evidence. In this study, CT based computational fluid dynamics (CFD) was applied to 27 ENS patients to simulate their nasal aerodynamics and compared with 42 healthy controls. Patients' symptoms were confirmed with ENS6Q, SNOT-22 and NOSE scores. Nasal trigeminal sensitivity was measured with menthol lateralization detection thresholds (LDT). Results: ENS patients had significantly lower (~25.7%) nasal resistance and higher (~2.8 times) cross-sectional areas compared to healthy controls (both $p<.001$). Despite inferior turbinate reductions, CFD analysis demonstrated that ENS patients had increased airflow concentrated in the middle meatus region (66.5±18.3%) compared to healthy controls (49.9±15.1%, $p<.0001$). Significantly less airflow (25.8±17.6%) and lower peak wall-shear-stress (WSS) (0.58±0.24 Pa) were found in the inferior meatus (vs. healthy: 36.5±15.9%; 1.18±0.81 Pa, both $p<.05$), with the latter significantly correlated with the symptom scores of ENS6Q ($r=-.398$, $p=.003$). Item-wise, complaints of "suffocation" and "nose feels too open" were also found to be significantly correlated with peak WSS around the inferior turbinate ($r=-.295$, $p=.031$; $r=-.388$, $p=.004$). These correlations were all negative, indicating that less air-mucosal stimulations resulted in worse symptom scores. ENS patients (n=12) also had impaired menthol LDT when compared to healthy controls ($p<.0001$). In conclusion, these results indicated that a combination of loss of neural sensitivity and poorer inferior air-mucosal stimulation may potentially lead to ENS symptomology.

504 **The Effect Of Olfactory Recovery On Cortical Thickness**

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Olfactory dysfunction (OD) occurs in nearly 20% of the population and is frequently caused by upper respiratory tracts infection (URTI). In post-URTI, over time recovery will benefit more than 50% of the patients. Olfactory training (OT) is a proven method to help patients recover partially their olfactory capacities. The link between

neuro-anatomical structures and olfaction has been shown multiple times, but the correlation between olfactory recovery and cortical thickness is still unclear. The hypotheses are that olfactory training will improve patients' olfactory scores and that this recovery will augment the grey matter thickness in olfactory regions. The objective of the present study was to quantify the impact of olfactory recovery due to OT on cortical thickness in patients suffering of post-URTI OD. 39 patients with post-URTI OD went through OT, which mainly consists of smelling four odorants twice a day for 12 weeks. Prior and post olfactory training, olfactory function was evaluated using the *Sniffin' Sticks test*. Neuro-anatomical data was acquired with a 3T scanner and analyzed via the *Surfstat* toolbox in Matlab. Patients exhibited a significant increase of their TDI score after OT ($p<0.001$). 56% had a clinically significant improvement of at least 6 TDI points. Patients got significantly better in threshold, discrimination and identification tests ($p<0.001$). This recovery of olfactory functions has no noticeable effects on cortical thickness. The severity of OD (anosmia VS hyposmia) at baseline did not have any impact either. OT proved itself, once again, to improve olfactory function in post-URTI patients. Although no correlation was found between recovery of olfaction and cortical thickness, more investigation is needed to comprehend the neurobiological underpinnings of OT.

505 **Electron Microscopy Analysis Of Happ-Induced Neurodegeneration In The Glomerular Network**

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Loss of smell is often an early indicator of Alzheimer's disease (AD), making the olfactory system an ideal model to study the effect of AD related proteins such as the Amyloid Precursor Protein (APP) on neuronal circuits. The plasticity and regeneration of the olfactory system provide a further benefit enabling studies of circuit recovery after APP induced degeneration. Although the cellular effects of APP are well documented, little is known about its effects on brain circuits at the ultrastructural level. To study such changes using glomerular circuitry we overexpressed humanized APP containing familial AD mutations (hAPP) in primary olfactory sensory neurons (OSNs) using a tetracycline-inducible (tTA) expression system. We then performed serial electron microscopy analysis on olfactory bulbs from both wild-type and hAPP expressing mice to compare glomerular organization. We found that by 6-weeks of age hAPP-expressing mice showed a decrease in glomerular connectivity and wide-spread changes of subcellular neurite structures including: a decrease in postsynaptic densities (PSDs) but an increase in synaptic vesicle density and apoptotic-like vacuole numbers. We then tested the glomerular circuits capacity for recovery using tTA control to turn off hAPP expression for an additional 3 weeks and found a partial restoration of both connectivity and subcellular structures, including an increase in PSDs. Interestingly, synaptic vesicle density remained elevated and we detected a decrease in mitochondria following recovery possibly linked to their regenerative state. Although these data are limited in scope they mark an important ultrastructural view of olfactory regions associated with AD and suggest that partial circuit recovery is possible following APP-induced neurodegeneration.

506 **Pain Intensity And Taste In Burning Mouth Syndrome (Bms) In Patients With And Without Geographic Tongue (Gt)**

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Burning mouth syndrome (BMS) is a common disorder, especially in post-menopausal females, many of whom demonstrate taste alterations in addition to oral burning dryness. Geographic tongue (GT) is considered a variant of normal affecting around 2% of the population, and is associated with neutrophil/lymphocyte infiltration and an increase in Langerhans cells in affected areas. Previous studies have shown that GT is a risk factor for BMS. In this study, we compared taste and pain intensity in fungiform (FP) and circumvallate (CV) areas, as well as smell, salivary flows, psychological factors, and reported burning intensity in patients without GT (BM) and with GT (BM/GT) to those patients with taste changes but no burning (TC). The goal of this study was to determine if BM (n=55), BM/GT (n= 17) and TC (n =11) represent different populations of patients.On spatial taste testing, at both FP and CV papillae, BM/GT compared to BMS and TC groups showed significantly more intense taste for salt, sour, and bitter and sweet (at FP only). For ethanol, pain response was significantly more intense for the BM/GT group compared to the BM and TC groups but only at the FP. A positive correlation was found between ethanol sensitivity and reported taste function at both the FP and CV. No significant differences were found between the three groups in demographic data, salivary flows, pH, smell identification, reported burning intensity and in depression, anxiety and sleep disturbances. This study suggests that BM patients have greater taste loss than BM/GT patients although clinically reported pain intensity is not significantly different. With more profound loss in the TC patients, pain no longer appears to be a factor, suggesting that there is a threshold for taste function that is required for sensory phantoms production.

507 **Olfactory Function In Patients With Sensorineural Hearing Loss**

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Objective:Olfactory disorders are common in subjects with neurodegenerative diseases. Congenital, hereditary or idiopathic sensorineural hearing disorders are considered to be isolated sensory diseases without any additional deficits. Aim of this study is to investigate whether other sensory functions such as olfaction are diminished as well. Methods: One hundred normosmic subjects participated (age range: 18 to 50 years). Fifty subjects (mean

age: 37.9y) had a normal symmetric normal hearing threshold (HT) of 6.0 dB PTA4 (pure tone average of the frequencies 500 Hz, 1, 2, 4 KHz) in contrast to 50 subjects (mean age: 39.6 y) with uni- or bilateral hearing loss (mean PTA4 right: 51.7 dB, 55.7 dB left). Olfactory function, HT and cognitive function were examined using pure tone audiometry, lateralized Sniffin´ Sticks test battery testing threshold (T), discrimination (D) and identification (I) and DemTect (dementia detection test, score range: 0-18). Results:Subjects with hearing loss exhibited decreased olfactory function compared to normacustics (composite TDI score right: 26.2 vs 30.8, $p<0.001$; left: 28.6 vs. 31.5, $p=0.005$). Moreover, hearing impaired subjects scored significantly worse in DemTect (14.9 vs 16.9, $p<0.001$). HT on the right side correlated significantly with odor discrimination tests results on both sides, HT on the left side with discrimination on the left side only. These correlations remained significant when controlling for DemTect test results. Conclusion: Subjects with sensorineural hearing loss show a significantly reduced olfactory function in general and exhibit a mild but significant cognitive impairment. Sensorineural hearing disorders should therefore no longer be considered as isolated sensory deficits but rather than as a part of a possibly more extensive disorder.

508 **Olfactory Loss After Dental Extraction Under General Anesthesia: Report Of A Case**

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BACKGROUND: Olfactory loss has been described in association with various aetiological factors, however, it is extremely uncommon after general anesthesia(GA). We report on a case of a young female suffering sudden anosmia after a dental extraction under GA. As such a phenomenon is not frequently reported, the incidence of anosmia related to anesthesia and surgery may be higher than expected. CASE PRESENTATION: a 16 y/o WM who underwent the extraction of maxilla unerupted supernumerary tooth under GA. At the first postoperative day, she complained of significant smell loss. The anesthetic consisted of sufentanil, remifentanil, Propofol and midazolam(i.v). The procedure lasted for about 1h. The patient had a PMH significant for mild asthma, she denied any loss of smell with her episodes of asthma in the past and also denied ER visits since childhood for asthma. Her medication before surgery included albuterol (PRN). The clinical evaluation using nasal endoscopy did not reveal any nasal pathology. The total TDI score (SS' test) was 14 (anosmia) (threshold 1/16, discrimination 6/16 and identification 7/16). Gustatory function is normal. The patient was treated with mecobalamin and ginaton, also followed an olfactory training using four odors (rose, mint, cloves, lemon) twice a day. 4 months later, SS' test showed significant improvement, with a TDI score of 32.5 (T 10.5/16, D 14/16, I 8/16). CONCLUSIONS: The case of this patient implicates the relationship between olfactory loss and general anesthetic drugs. But the exact roles of the anesthetic drugs used are still unknown. We need to be aware of this phenomenon and possibly pay more attention in the use of certain anesthetic drugs. Further study should focus on the mechanism of the phenomenon to improve the quality of patient care in the future.

509 **Neural Dynamics In The Developing Piriform Cortex**

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Cortical circuits mature gradually during early life. Previous work on sensory neocortex (NCx) has shown that development starts already before the sensory periphery has matured, and that this process relies on thalamo-cortical processing of internally-generated inputs. Olfactory cortex (piriform paleocortex, PCx) differs from NCx in many ways. However, NCx evolved from paleocortex, and the two must share underlying developmental mechanisms. Studying PCx development may therefore provide fundamental insight into cortical development in general. Here, we focus on the development of dynamic activity patterns PCx of rats from birth to adulthood, allowing a direct comparison with the dynamics previously observed in NCx of the same species. Animals were anesthetized with urethane and rigidly attached to a stereotaxic apparatus. Local field potential activity was recorded using acutely inserted electrodes. Odor stimuli were presented orthonasally at random intervals using an olfactometer. The results show that activity patterns in the developing PCx are highly similar to those observed during NCx development. Spontaneous activity is characterized by initially sparse delta waves that become more prevalent with age. Odor-evoked activity is characterized by alpha/beta spindles that gradually increase in frequency until they reach adult values. Differences with NCx include the absence of gamma oscillations and the fact that spontaneous oscillations remain after sensory-evoked dynamics have matured. Our findings suggest that cortical development is an evolutionarily conserved process that is at least partly independent of thalamus. We are currently investigating the dependence of this process on respiration, which may constitute the evolutionary origin of internally-generated activity patterns observed in NCx.

511 **Etv1 Is Necessary For Sweet, Umami, And Salty Taste Preferences**

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Individual taste cells in the oral epithelium contribute to evoke one taste quality. They are continuously replaced every few weeks by new ones derived from local epithelial stem cells. A POU homeodomain protein Skn-1a is necessary for the generation of sweet, umami, and bitter taste cells. Here we show that Skn-1a is also required for salty taste cells that express amiloride-sensitive epithelial sodium channel and reside in the taste buds of the palate and fungiform papillae. In addition, we report that an ETS domain transcription factor Etv1 (also known as Er81) is involved in the functional differentiation of sweet, umami, and salty taste cells. Etv1 is expressed in *Tas1r3*-expressing sweet and umami cells and *Scnn1a*-expressing amiloride-sensitive salty taste cells (i.e., Skn-1a-expressing cells except bitter taste cells). In taste buds of *Etv1* knockout mice, we observed the complete loss of *Tas1r1* expression, robustly decreased expression of *Tas1r2* and *Scnn1a*, and moderately decreased expression of *Tas1r3*, suggesting that Etv1 regulates the expression of taste receptor genes but is not involved in the generation of taste cells. Consistent with no or decreased expression of T1R genes and *Scnn1a*, *Etv1* knockout mice showed remarkably decreased gustatory nerve responses to sweet, umami, and amiloride-sensitive salty

tastes and impaired preferences to sweet, umami, and salty tastes. However, *Etv1*-deficient mice showed normal responses to bitter and sour tastes in the gustatory nerve recordings and behavior tests. These results demonstrate that Etv1 is necessary for the functional differentiation of the taste cells responsible for sweet, umami, and salty tastes.

512 **Genetic Deletion Of Sodium Salt Taste During Development Alters Gustatory Circuitry Within The Adult Mouse Nucleus Of The Solitary Tract**

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Neural activity plays a critical role in driving the development of many sensory circuits. By genetically manipulating specific taste transduction pathways, our lab has been able to examine how neural activity impacts the functional and structural development of gustatory circuits. Previous work showed that removal of sodium salt taste by functionally deleting the epithelial sodium channel (ENaC) within taste bud cells throughout development led to a dramatic reorganization of gustatory afferent terminal fields within the nucleus of the solitary tract (NST). At adulthood, the chorda tympani (CT), glossopharyngeal (IX), and greater superficial petrosal (GSP) nerve terminal fields were 1.5X-2X larger in ENaC knockout mice than in controls; suggesting that ENaC-mediated neural activity is necessary for proper development of NST circuitry. The present study was designed to further explore the effects of eliminating ENaC-mediated activity on NST circuitry. Retrograde tracers were used to visualize the dendritic fields of NST relay cells, the cells receiving input from gustatory afferent terminal fields, in ENaC KO mice and in littermate controls. Removal of ENaC-mediated neural activity resulted in dendrites that were up to 1.5X larger and more complex than in controls. Preliminary data also suggests that putative synaptic sites (sites of high colocalization between gustatory afferents and NST relay cell dendrites) also are affected by removal of ENaC-mediated neural activity. Therefore, removal of neural activity throughout development has significant effects on NST circuitry, which likely impacts physiological changes in how taste-related information in processed; influencing sensory coding of taste, and behavioral consequences related to feeding and motivated behaviors.

514 **Sox10-Expressing Cells Are Progenitors Of A Unique Population Of Differentiated Taste Bud Cells**

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In our recent studies using a mouse model, *SOX10-Cre*, to trace migrating neural crest lineages, labeled cells were found within mature taste buds (TBs) in adult mice. In the present study, we aimed to (1) define the time window when *SOX10-Cre*-labeled cells emerge in TBs, (2) characterize the properties of *SOX10-Cre*-labeled TB cells, and (3) explore the SOX10-expressing cell niches that contribute to TBs. The distribution of *SOX10-Cre*-labeled cells in neural crest and TBs was analyzed at different stages (E8.5, P1d, 1 wk, 2 wk, 4 wk, 8 wk, 16 wk) by crossing with a tdTomato (RFP) Cre reporter. We found that abundant *SOX10-Cre*-labeled cells were present in the connective tissue at all postnatal stages. At P1d and 1 wk, *SOX10-Cre*-labeled cells were absent within TBs. By 2 wk, *SOX10-Cre*-labeled cells were frequently observed in TBs. In mature TBs at 4 wk and in adult mice (8 wk and 16 wk), *SOX10-Cre* labeling was abundant and consistent among TBs in the three types of lingual taste papillae and soft palate, in which they co-localized with cell markers of Type I, II, and III TB cells. Intriguingly, *SOX10-Cre*-labeled cells within TBs were not co-labeled by keratin 8, a widely used marker for differentiated TB cells. Cre immunosignals were specifically distributed in migrating neural crest cells in E8.5 embryos, and quantitative RT-PCR analysis showed low Cre expression in tongue epithelium and connective tissue at 2 wk but negligible in adult tongue tissues of *SOX10-Cre* mice. Together, our data indicate that *SOX10*-expressing cells serve as precursors for TB maturation and homeostasis and contribute to a unique population of TB cells. Further studies are ongoing to define the *SOX10*-expressing cell population that contributes to TBs, likely neural crest or/and TB or/and TB-surrounding cells.

515 **Effect Of Olfactory Experience On Olfactory Bulb Glomeruli In Larval Chinook Salmon, *Oncorhynchus Tshawytscha***

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In anadromous Chinook salmon, olfactory learning, such as imprinting to natal waters occurs as early as larval stages. In this study, the effect of odorant imprinting on glomerular development of ciliated and microvillous olfactory sensory neuron projections was investigated by exposing early developmental stages to amino acid odorants or to phenylethyl alcohol (PEA), an odorant used in salmon imprinting studies, but not found endogenously in local municipal water. Microvillous olfactory sensory neurons (previously shown to respond to amino acid odorants) were labelled by calretinin immunocytochemistry. Starting at embryonic stages, lateral glomeruli lG_1, $lG_{3/4}$, lG_6 and dorsal lateral glomerular chain (dlG) were calretinin immunoreactive. At late larval and fingerling stages some medial anterior glomeruli (maG), ventromedial glomeruli (vmGs) and a ventroposterior glomerulus (vpG_1) were also calretinin immunoreactive. Of the calretinin immunoreactive glomeruli present from embryonic development, $lG_{3/4}$ decreased glomerular volume in early yolk-sac larvae during amino acid imprinting. G_{olf} immunoreactivity (labeling ciliated olfactory sensory neurons) was seen in medial and ventral glomerular regions, specifically in embryonic ventral medial glomeruli vmG_x, vmG_7 and the dlG and in additional dorsal glomeruli (dG), maG, smaller vmGs and vpG_2 starting in late yolk-sac larvae. In late yolk-sac larvae imprinted to PEA, the glomerular volume decreased for vmG_7. No difference was observed at other larval periods or for other lGs and vmGs. This study suggests that olfactory imprinting may affect the development of olfactory glomerular circuits. Different timing of development of various glomeruli may be important for understanding their role in salmon behaviour and the learning of olfactory cues.

516 **Termoral Effects Of Odorants On Mixture Perception**

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Odorants puffed at separate times in a Sniff Olfactometer (SO) yielded similar perceptions as odorants puffed in single puffs in a mixture but at specific concentration ratios. The psychophysical response for any latency up to 800ms was the same as the response for a particular concentration ratio. A unique linear relationship was observed between puff latency and concentration ratio for each particular pair of odorants. Because, these results were obtained with a small cohort of subjects (4) and odorants (3) we tested a larger group with different odorants. To further determine the temporal effects of odorant mixture perception we developed a reaction time test using the SO to study the effects of odorant chemistry on detection time in humans. The possibility that differences in odorant detection time is involved in mixture perception in mice was recently reported using neurobiological techniques and forced choice protocols similar to those used in SO experiments. These and similar experiments will be compared and discussed in this poster.

518 **Psychometric Functions In Olfaction**

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The method of constant stimuli has the benefit of producing a psychometric function and a threshold. The limited data on olfactory psychometric functions shows that both dogs and humans exhibit unusually-shaped functions – significant 'notches' exist in detection performance (Marshall & Moulton, 1981). Self-reported olfactory function is not well correlated with olfactory performance and less is known about trial-by-trial confidence in olfaction tasks. In two experiments, we had college students perform a 2-AFC task using "Snap & Sniff®" wands. On each trial two wands were presented in rapid succession, one containing amyl acetate at one of 10 predetermined concentrations and the other containing mineral oil. The participant's task was to indicate which one seemed stronger and to indicate their confidence. In Experiment 1, 42 undergraduates (21 females) completed one 30-minute session of 60 trials. In Experiment 2, 7 undergraduates (4 female) completed 10-20 sessions, depending on the stability of their performance. In Experiment 1 performance improved as a function of concentration, averaged data following a sigmoidal pattern. 'Notches' existed at low concentration in the average psychometric function of females for this odorant. There was no sex difference in overall performance. In Experiment 2 psychometric functions were consistent within, but somewhat variable between, participants and 'notches' were idiosyncratic but tended to emerge at low, sub-threshold concentrations in both sexes. In both experiments the relationship between confidence and performance was non-linear – confidence increased exponentially as performance improved. 'Notches', when present, were idiosyncratic, but tended to occur at low stimulus concentrations and likely depend on the stimulus characteristics.

519 **Discrimination Of Dog Palatant Solutions Using Human Olfactory Receptors Platform**

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A strong relationship has been observed between food choice and the sense of olfaction in dogs. In order to better understand the attractive compounds perceived by the dog, it is important to have an analysis method of palatant solutions, based on the olfaction physiology and mechanisms. An innovative study was conducted by Diana Pet Food and ChemCom to evaluate the interest of using olfactory receptors, as sensors, in the characterization and discrimination of dog palatant solutions. Four dog palatant solutions were assessed. First, palatability of these solutions, coated on dry dog kibbles, was evaluated by food preference tests, performed on dog panels. Second, discrimination tests on these solutions were performed on human panel. These solutions were finally analyzed on olfactory receptors platform composed of 135 deorphanized human olfactory receptors. The four solutions were discriminated by the dog and the human panels. Moreover, they were perceived with different levels of palatability by the dogs. On the olfactory receptors platform, a specific profile of activation was established for each palatant solution, leading to the product discrimination. In terms of discrimination, results obtained with the human olfactory receptors platform were comparable to those obtained by dog and human panels. The activation profile of human olfactory receptors of each solution was based on the nature and the activation level of each receptor, providing complementary information on the palatant solutions, presumably on the perceived volatile compounds present in a solution, and probably their impact on the palatability of the product. Based on these data, it would seem that the use of olfactory receptors as sensors could reveal certain molecules eventually implicated in the palatability of food products.

520 **Perception And Neural Representation Of Dichorhinic Odor Stimuli In Humans**

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Unlike most sensory modalities, olfactory connections from periphery to cortex are mostly ipsilateral. While

some cross-talk likely occurs across hemispheres, little is known about the extent of such connections in humans. Here we used psychophysics and functional neuroimaging to ask two questions about human olfaction: 1. Do ensemble patterns in olfactory regions reflect ipsilaterally- or contralaterally-delivered stimuli?, and 2. How does this inform the neural underpinnings of conscious perception of odors? 15 human subjects participated in an odor identification task. The odor stimulus was either monorhinic (same odor to both nostrils) or dichorhinic (different odor to each nostril). Following odor presentation, subjects were asked to select from one of four choices indicating what they smelled: odor A only, odor B only, both, or "other". When presented with dichorhinic stimuli, subjects responded with equal frequency that they smelled either odor A only or odor B only. By examining fMRI ensemble patterns in response to trials where subjects received a dichorhinic mixture but perceived only a single component of that mixture, we were able to ask if the non-perceived odor was still encoded in ipsilateral cortex and how far along the olfactory hierarchical pathway the subliminal odor representation was maintained. Preliminary analysis of data from 15 subjects suggests that subliminal odor representations persist to the level of piriform cortex but not orbitofrontal cortex. Interestingly, in orbitofrontal cortex, odor patterns appear to reflect the perceived odor only, even on the side of the brain ipsilateral to the non-perceived odor. While still preliminary, these data suggest that odors are primarily coded ipsilaterally, and that OFC may play a role in conscious perception of odor.

521 **Effects Of Background Odors On Olfactory Threshold Testing**

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Habituation is known to interfere with human olfactory abilities and particularly influences olfactory sensitivity. Most often habituation arises in response to background odors, often present in smell laboratories. As a result, measurements made in non-odorless space can be disrupted and unreliable. To examine the magnitude of habituation effects on olfactory sensitivity testing, we performed an experiment concerning the effects of different background odors on human olfactory sensitivity. Fifty-two females (M_{age}= 25.3 ± 3.1 years) and fifty-one males (M_{age}= 24.3 ± 3.7 years) had their olfactory threshold tested three times with Sniffin´ Sticks threshold test (Phenylethanol [PEA] or Linalool) with different background odor setups: (a) the same background odor as in the test, (b) with the other odor (e.g. PEA in the test and Linalool in the background) and (c) without background odor. Background odors were distributed on the experimenter's gloves. Order of the measurements was fully randomized. Results showed a strong habituation for both background PEA and Linalool (condition (a)). Presence of Linalool in the background decreased threshold for PEA to a greater extent than the opposite relation (condition (b)). Threshold scores were highest for the odorless background (condition (c)). We conclude that the threshold tests should be performed in odorless rooms. Additionally, results indicate that some background odors might influence the results to a greater extent than others.

522 **Rapid Characterization Of Taste Phenotypes In Human Subjects Using TāStation&Reg;**

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The TāStation® is a new taste measurement apparatus and methodology for high throughput operant taste discrimination with human subjects. Small volume (200 ul) samples of tastant solutions are randomly selected and robotically drawn from a 96-well plate, then presented to a subject who is trained using a game-like algorithm to distinguish among basic taste stimuli with high acuity and consistency. The 8x12 matrix of the 96-well plate is a practical format for arranging tastant solutions in concentration ranges with multiple replicates, and a subject can sample all 96 wells within a 40-minute test session. Thus robust concentration-response (CR) functions for any, and multiple, tastants can be generated quickly to yield precise EC50 values, quantitatively characterizing taste sensitivities for each individual subject. Aloin, a bitter substance isolated from *Aloe spp*, has been shown to be a specific agonist of the TAS2R43 (Current Biology, 17, 1403.) Eight concentrations of aloin and two other bitter tastants, quinine and the antihistamine drug diphenhydramine, were dispensed in triplicate into single 96-well plates and presented to subjects trained to use the TāStation® for bitter detection. Each subject repeated this test twice, with each test conducted on separate days. The resulting CR functions established at least two distinct "sensitive" phenotypes for aloin taste consistently associated with EC50s of approximately 3 uM and 15 uM, respectively, and a "non-sensitive" phenotype which failed to discriminate even the highest aloin concentrations (100 uM) from water. In contrast, EC50s for quinine ranged between approximately 50 and 200 uM among the subjects and did not co-vary with aloin phenotype. Diphenhydramine EC50s for all subjects were essentially equivalent at ~1 mM. The ability to rapidly generate CR functions with TāStation® in combination with receptor-selective tools such as aloin thus greatly facilitates quantitative determination of human taste phenotypes.

523 **Volatiles That Enhance Sweet Can Suppress Bitter**

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In a study of oranges designed to search for evidence of interactions between taste and retronasal olfactory perception of volatiles, 14 volatiles were associated with suppression of bitter taste. The objective of the present study was to determine whether those volatiles directly suppressed bitter or did so indirectly by enhancing sweet

which, in turn, suppressed bitter. Oranges were analyzed as follows. Sensory analyses used the Global Sensory Intensity Scale (GSIS) with which subjects rated the intensity of orange flavor as well as the intensities of salty, sweet, sour and bitter tastes on a scale from zero (no sensation) to 100 (most intense sensation of any kind ever perceived). Chemical analyses of volatiles as well as bitter compounds (limonin and nomilin) used standard methodologies. Multiple regression identified 14 volatiles as significantly associated with bitter suppression. These were: alpha-phellandrene, hexanoic acid, E-2-hexenal, Z-3-octenol, beta-sinensal, ethy acetate, ethyl butanoate, valencene, 2-methyl-propanol, alpha-ionone, 1-penten-3-ol, carvacrol, ethyl propanoate and nonanal. The 14 volatiles (V) were combined at the concentrations found in the oranges and added to 0.06 M sucrose (S) and 0.000024 M quinine hydrochloride (Q) as well as the mixture of both (SQ). Distributions of the sensory ratings were compared using chi square tests. SV was significantly sweeter than S (chi square=14.24, df=2, p=0.00081). QV was not significantly more bitter than Q. SQV was significantly less bitter than SQ (chi square=6.95, df=2, p=.031. Thus the 14 volatiles did not suppress bitter directly, but rather acted indirectly; the volatiles enhanced sweet and the enhanced sweet suppressed the bitter. Application: volatiles can intensify suppression of bitter without adding additional sugar.

524 **Wine Off-Flavor Determinants And Their Specific Activation Patterns Of Narrowly And Broadly Tuned Odorant Receptors**

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Wines are prone to contamination by a large variety of potent off-flavor-inducing compounds, which may influence consumer behaviour. 2,4,6-Trichloranisol, 1,1,6-Trimethyl-1,2-dihydronaphtalene, 1-Octen-3-ol, 1-Octen-3-one, representing muddy, musty, gasoline- or fungus-like odor qualities, are among the most frequently found off-flavors in wine. Until now, however, little is known about their odorant receptor targets. Here, we identified specific activation patterns for these wine off-flavor-inducing compounds, by screening them against an odorant receptor library in a cell-based cAMP-luminescence assay. We screened the best responding receptors against a library of 180 key food aroma compounds, and characterized the identified receptors to have narrowly or broadly tuned agonist profiles. Our results elucidate the coding of food aroma-relevant compounds on a molecular level, and ultimately may help to develop sensors for wine quality control measures.

525 **Suppression Of Bitter Taste By Microencapsulation Within Edible Strips.**

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Bitter taste is aversive to humans, and many oral medications exhibit a bitter taste. Bitter taste can be suppressed by the use of inhibitors, or by masking agents such as sucralose. Another approach is to encapsulate bitter compounds in order to slow their release. This delayed release permits the prior release of bitter masking agents. We have accomplished this goal by encapsulating bitter or sweet taste stimuli in erodible stearic acid microspheres, and embedding these 5 μmeter diameter microspheres in pullulan films that contain masking agents. Masking agents are released as films become hydrated by saliva, and before the erosion of microspheres. The simultaneous and delayed erosion of both bitter and sweet taste microspheres further masked bitter taste in subjects. Edible films that contained only control (blank) microspheres primarily exhibited a sweet taste quality with gLMS values in the moderate range. Films that included both quinine HCl (bitter taste) and control microspheres also showed gLMS scores in the moderate range. The ratio of sweet to bitter taste quality responses was nearly equal at all time points. The inclusion of both quinine and sucralose-containing microspheres within edible films increased sweet to bitter taste quality ratios, and further minimized the bitter taste of quinine. These films showed more favorable hedonic scores when compared to films without sucralose microspheres. These results indicate that masking compounds in the film base, along with sucralose-containing microspheres, decreases bitter taste intensities. This novel approach is useful for increasing the palatability of oral medications, and for enhancing the flavor of food. Supported by Temple U. Undergraduate Research Program, and DoD DURIP Award N0014-12-1-0777 from the Office of Naval Research.

526 **(Achems Undergrad Award Finalist) Comparison Of Light Therapy Vs. Peppermint Scent Administration On Mood: Synergistic Effects For The Treatment Of Depression And Seasonal Affective Disorder**

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Previous research indicates peppermint scent administration can facilitate a more positive mood and that light therapy can be effective in improving depression and depression-like symptoms. The present study was designed to assess the effectiveness of peppermint scent administration and light therapy, both individually and synergistically, in improving mood and depressive symptoms. Forty participants were exposed to each of four conditions: 1) light therapy, 2) peppermint scent administration, 3) a combination of light therapy and peppermint scent administration, and 4) a non-light, non-scent control condition. Each condition lasted for 30 minutes. After obtaining pre-experimental baselines and exposure to each condition, participants completed the Profile of Mood States (POMS) and Beck Depression Inventory. The combination of both light therapy and peppermint scent administration was associated with the lowest score for anger, confusion, depression, fatigue and tension on the POMS. Individually, the peppermint scent administration condition had the second lowest score in those categories, followed by the light therapy condition, followed by the control condition. The combination of light therapy and peppermint scent administration was associated with the lowest score on the Beck Depression Inventory, $F(4,148)=2.80$, $p=.03$. The highest vigor score was observed in the light therapy and peppermint scent administration condition, followed by the peppermint scent administration condition, followed by the light therapy condition, followed by the control condition, $F(3,117)=2.88$, $p=.04$. Such results are important as a potential non-pharmacological adjunct to therapeutic treatment of depression and seasonal affective disorder.

527 **Effects Of Jasmine Scent Administration On Decreasing The Stress Response In Cattle During Initial Processing**

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Past research indicates jasmine scent administration promotes relaxation and decreases stress. Cattle have an acute sense of smell, select their feed based on smell, and can detect scents miles away. The present study assessed the potential stress-relieving effects of jasmine scent administration on cattle undergoing initial processing, which involves weighing, an immunization injection, ear tagging and branding. 98 Bos Taurus Angus Steers were assigned to one of three groups: 1) no nasal strip, 2) unscented nasal strip, or 3) jasmine-scented nasal strip. Following processing, the cattle underwent an oral salivary swab to detect cortisol level and salivary pH, and were rated on their behavioral disposition. Salivary cortisol levels (low, medium, high) were compared in a Pearson Chi-Square analysis among the three conditions (no strip, unscented strip, jasmine scented strip) and no significant effect was found, X^2 (6) =8.72, p=.19). Salivary pH readings were compared among the three conditions and a significant main effect was found, F(2,84)=3.64, p=.03. Tukey post-hoc contrasts indicated the jasmine scented strip condition (M=7.53, SE=.21) resulted in a less acidic salivary pH in comparison to the no strip condition (M=6.78, SE=.19). Disposition scores were compared among the three conditions and a trend was found, F(2,85) = 2.41, p=.09. The jasmine scent condition (M=2.33, SE=.19) resulted in a lower (more positive) disposition scores in comparison to the no strip condition (M=2.88, SE=.17). Weights of the animals were re-assessed 6 months later, and those animals in the jasmine scent condition weighed on average 22 pounds heavier than the other two conditions. These findings suggest that the administration of jasmine scent can have significant effects on cattle industry production.

528 **Strategies For Successful Single-Neuron Sequencing From Gustatory Ganglia**

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Taste buds are innervated by neurons in geniculate, petrosal and vagal ganglia (which also include non-gustatory neurons). There have been few tools for identifying gustatory neurons and evaluating their diversity. To address this, we sequenced single geniculate ganglion neurons. We selected the Fluidigm C1 microfluidics system which captures individual neurons starting from only a few thousand cells, and because sequences cover full-length transcripts. We enzymatically dissociated geniculate ganglia with papain, collagenase, dispase (Malin, 2007), omitted centrifugation to avoid damaging neurons and removed large debris by gravity filtration through a 35μm cell sieve. Next, we removed axon fragments and glial cells by gently swirling the suspension, removing and replacing buffer several times. Cell viability, determined by Propidium Iodide exclusion was >95% for neurons, much higher than obtained with trypsin digestion. RT-qPCR for GFAP showed that the purified neuron preparation was $\geq 10^5$-fold depleted of glia. The buffer was adjusted to a density equal to that of neurons to optimize neuronal buoyancy. We ran two independent captures in C1 chips for large cells (17-25 μm) and microscopically assessed captured neurons. After pre-amplification in the C1, all samples were evaluated for yield and full-length of cDNA, and representation of low abundance transcripts. cDNAs from 96 neurons that passed these quality control steps were converted to barcoded libraries and subjected to RNA-sequencing ($\geq 10^6$ mapped reads per cell). We detected ≥13,000 genes in every cell, and the profiles of cells from two independent captures were similar. Hierarchical Clustering Analysis and Principal Component Analysis sorted the 96 geniculate ganglion cells into two groups, one of which is gustatory neurons.

529 **Three Classes Of Gustatory Neurons In The Geniculate Ganglion**

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The geniculate ganglion contains gustatory neurons innervating taste buds and somatosensory neurons innervating the skin of the outer ear. To assess the diversity of gustatory neurons, we performed single cell RNA-sequencing of 96 neurons from the mouse geniculate ganglion. Unsupervised Hierarchical Clustering Analysis (HCA) and Principal Component Analysis (PCAs) showed 2 distinct groups corresponding to 59 gustatory and 37 somatosensory neurons. A second iteration of HCA and PCA then revealed that the 59 gustatory neurons could be further classified into 3 distinct clusters of 33 (T1), 6 (T2), and 20 (T3) neurons. These clusters express separate sets of transcription factors (e.g. *Foxg1*, *Mafb*, and *Prox2*, for T1, T2, T3, respectively), suggesting distinct neuronal identities. To assess whether the clusters represent innervation of different taste fields (anterior tongue or palate), we anterograde-labeled chorda tympani (CT) and greater superficial petrosal (GSP) taste nerves with fluorescent (TRITC, FITC) dextrans. We immunostained sections of anterograde-labeled ganglia for markers of the three gustatory clusters. T1 and T3 neurons were found in both CT and GSP (for T1, 56% of 147 neurons were in CT; for T3, 45% of 96 neurons were in CT). In contrast, all 39 T2 neurons were detected only among the CT-labeled neurons. That is, T2 neurons innervate only the anterior tongue. Neurons of clusters T1 and T3 can each be further divided into 3 smaller sub-clusters. We are validating immunohistochemical markers

for each sub-cluster. Our goal is to use the cluster and sub-cluster selective markers to dissect the functional heterogeneity among gustatory neurons and address questions regarding target interactions and neural connectivity from taste buds to brain.

530 **Difference In Low Frequency Phase-Locking Between Piriform Cortex And Orbitofrontal Cortex In Cue Matched Versus Cue Non-Matched Olfactory Decision-Making**

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Perceptual decision-making lays the foundation of almost all higher order cognitive functions. The predictive coding theory posits that the human brain makes moment-by-moment predictions about sensory input from the environment. Accordingly, perceptual decision-making is achieved by comparing the incoming sensory information to the expected internal template, a dynamic process involving communication between sensory cortices and higher order regions. Indeed, previous human fMRI studies have shown that the orbitofrontal cortex (OFC) holds the predicted sensory template. However, the sluggish nature of the fMRI signal does not allow direct recording of local field potential (LFP) oscillations, leaving the temporal signatures of this process unexplored. In this study, we used intracranial EEG (iEEG) to record LFP oscillations directly from human OFC and piriform cortex (PC) during a cued perceptual decision-making task. In an event-related design, each trial began with an auditory cue ('rose'/'mint') indicating which odor to look for. After a short delay, an odor was presented and the subject's task was to decide if the odor matched the cue (yes = match/no = non-match). According to predictive coding theory, a stronger error signal is sent from PC to OFC in response to non-matching trials compared to matching trials. Therefore, we hypothesized that stronger connectivity between OFC and PC would be observed in the non-match condition compared to the match condition during decision-making, indicating stronger cross-regional communication. Initial analyses testing phase-locking-value supported this hypothesis in the low frequency range (delta and theta band). Follow-up analyses will examine the potential directionality of the information flow.

531 **Chlorhexidine Effects On Anterior Tongue Salt Taste**

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Chlorhexidine gluconate [0.12%] changes human Na^+ salty taste to tasteless with sweet tastes unaltered (1). We focused on the mostly affected chorda tympani receptive field to determine whether NaCl concentration or the taste of a salt influenced the effect of chlorhexidine on the anterior tongue. A concentration series of 'salty' NaCl and 'sweet' sucrose [0 M, 0.1 M, 0.3 M, 1.0 M] plus single concentrations of various salts with distinct tastes: $CaCl_2$ [0.2 M], $MgSO_4$ [0.3 M], Na_2SO_4 [0.5 M], NaBenzoate [0.5 M], NaCitrate [0.5 M], NH_4Cl [0.5 M], and KCl [0.5 M] were tested with Q-tips at 5 locations (2). Neither tongue locus nor NaCl concentration affected identification of the perceived taste qualities. NaCl was mostly "salty" after water and was "tasteless" twice as frequently ($p < 0.004$) after chlorhexidine. Non-ionic sucrose taste was equally identified as "sweet" with or without the chlorhexidine rinse. NaBenzoate, tasting more "sweet" than "bitter" ($p < 0.04$) after water, was more frequently identified as "bitter" compared to "sweet" ($p < 0.002$) after chlorhexidine. The 92% sweet identification of total sweet and bitter identifications after water rinse fell to just 12% after chlorhexidine. Our other results demonstrate differential effects of chlorhexidine on Na^+ salty tastes compared to divalent bitter salt-tastes. Eg, Na_2SO_4 was called salty fewer times after chlorhexidine ($p < 0.04$), but $CaCl_2$ was equally bitter after either rinse. Our experiments suggest non-salty anionic tastes of Na^+-salts are affected by chlorhexidine. Specifically, mostly sweet NaBenzoate became predominantly bitter after chlorhexidine. Thus, chlorhexidine can affect anionic sweet in addition to cationic salty human taste perception (3). References: (1) Frank et al, 2001; (2) Grover & Frank, 2008; (3) Gent et al, 2002.

532 **&Rdquo;Taste&Rdquo; And Temperature: A Study Of Capsaicin, Menthol, And Mustard Oil**

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Orofacial sensations such as touch, temperature, and pain are detected by peripheral terminals of trigeminal ganglion neurons. We previously reported *in vivo* confocal Ca^{2+} imaging in mice that express GCaMP in sensory neurons. Specifically, we reported that trigeminal ganglion cells were activated by stimulating the oral mucosa with natural compounds—capsaicin, mustard oil, and menthol—at concentrations found in pungent foods and cooling spices. We have confirmed and extended those studies to investigate whether there are significant interactions between thermal- and agent-evoked responses. We found that trigeminal ganglion cells sensitive to oral cooling ($<30^o$-32^o) far outnumbered those responding to warm (32^o-45^o). Moreover, ~¼ of cool-responding cells were also activated upon the termination of a warm stimulus (i.e. "off" response). Brief (10 sec) oral lavage with 100μM capsaicin, 3mM menthol, or 10mM allyl isothiocyanate (AITC, mustard oil) activated separate but overlapping populations of neurons. The effects of capsaicin were much slower and more prolonged than AITC or menthol. All 3 agents modified thermal responses of trigeminal ganglion neurons to some extent: capsaicin sensitized neurons that responded to warm and nociceptive hot ($>45^o$) stimuli, as did AITC, albeit to a lesser extent. Menthol depressed responses of cool-sensitive neurons. These data may provide a better understanding of our sense of oral thermosensitivity and how it is changed by foods and spices, for example that the oral cavity is more sensitive to cool than warm temperatures, that spicy foods appear "hot" and even painful, and that certain spices produce rather long-lasting effects.

533 **Subpopulations Of Chemoresponsive Neurons In Gustatory Cortex Represent Different Properties Of Flavors**

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The gustatory cortex (GC) is integral for the multisensory integration of taste and smell. Congruent taste-odor mixtures (associations based on experience) are necessary for the perception of flavor. Perceptually incongruent taste-odor mixtures (a taste and odor from two different flavors) perturb responses to chemosensory stimuli. Our previous findings (Samuelsen and Fontanini, 2017) suggest that bimodal neurons in GC (those neurons that respond to tastes and odors) represent the affective properties of both odors and tastes. To test this hypothesis, rats were given experience with two different flavors: a pleasant taste-odor pair (sucrose-isoamyl acetate) and an unpleasant pair (citric acid-benzaldehyde). Then odor preferences were confirmed with a two-bottle brief access task. After experience with flavors, we recorded single-unit neural activity in GC of behaving rats during the intraoral delivery of taste, odor, and congruent and incongruent flavor stimuli. Our preliminary results suggest that subpopulations of chemoresponsive neurons in GC differently encode the sensory and affective properties of flavors. Neurons in GC that are selective to tastes, but not odors, respond similarly to flavors with the same taste component, regardless of taste-odor congruence. Whereas those neurons in GC that respond to odors, but are not selective to tastes, represent congruent flavors, regardless of the taste and odor components. Bimodal neurons in GC, those selective for tastes and responsive to odors, represent the affective value of odors after experience with flavors. These data suggest that GC is a pivotal node in processing the sensory and affective properties of olfactory and gustatory signals after flavor experience.

534 **Molecular And Physiological Correlates Of Peripheral Olfactory Modulation**

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Olfaction in fruit flies plays a key role in locating mates, food sources and identifying suitable substrates for laying eggs. An Asian fruit fly, *Drosophila suzukii,* offers an exciting model system to study olfactory plasticity during an adult's life wherein a gravid female seeks out fresh fruits to lay eggs. Both males and females of this fly are otherwise saprophytic, as are most other members of drosophilids; however females encounter a very different olfactory landscape as they seek out appropriate substrate to lay eggs. A chemical-analytical analysis of odor profiles constituting saprophytic and fresh-fruit landscapes revealed significant qualitative and quantitative variations in the odorants. Additionally olfactory physiological measurements will be presented demonstrating the accompanying peripheral modulations in the antennal detection of gravid and non-gravid females. Finally, a detailed analysis of olfactory transcriptome demonstrated a significant modulation of critical olfactory receptors at the gravid or non-gravid stage. A comprehensive review of peripheral olfaction and its modulation will be presented based on our extensive chemo-analytical, physiological and molecular analyses.

535 **Human Apolipoprotein E Genotype Differentially Affects Olfactory Behavior And Sensory Physiology In Mice**

Brett S East[1,2], Gloria Fleming[1], Kathy Peng[4,9], Jonas K Olofsson[1,2,3], Efrat Levy[4,5,6,7], Paul M Mathews[4,6], Donald A Wilson[1,2,7,8]

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Apolipoprotein E (ApoE) is an important lipid carrier in both the periphery and the brain. The ApoE e4 allele (ApoE4) is the single most important genetic risk-factor for Alzheimer's disease (AD) while the e2 allele (ApoE2) is associated with a lower risk of AD-related neurodegeneration compared to the most common variant, e3 (ApoE3). ApoE genotype affects a variety of neural circuits; however, the olfactory system appears to provide early biomarkers of ApoE genotype effects. Here, we directly compared olfactory behavior and olfactory system physiology across all three ApoE genotypes in 6-month- and 12-month-old mice with targeted replacement for the human ApoE2, ApoE3, or ApoE4 genes. Odor investigation and habituation were assessed, along with, olfactory bulb and piriform cortical local field potential activity. The results demonstrate that while initial odor investigation was unaffected by ApoE genotype, odor habituation was impaired in E4 relative to E2 mice, with E3 mice intermediate in function. There was also significant deterioration of odor habituation from 6 to 12 months of age regardless of the ApoE genotype. Olfactory system excitability and odor responsiveness were similarly determined by ApoE genotype, with an ApoE4 > ApoE3 > ApoE2 excitability ranking. The hyper-excitability of ApoE4 mice may contribute to the impairment of odor habituation memory, while the hypo-excitability of ApoE2 mice may contribute to its protective effects. Given that these ApoE mice do not have AD pathology, our results demonstrate the potential process by which ApoE affects the olfactory system at early stages, prior to the development of AD.

536 **Human Olfactory Bulb Analysis In Relation To Age And Epithelial Neuronal Content**

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Objectives/Hypothesis: Recognizing abnormalities in the olfactory bulb (OB) can provide insight into etiologies for smell loss. Our current knowledge of OB morphology is mostly based on rodents while the relatively sparse papers on human OB have shown dramatic differences between the species. Age-related smell loss appears to be correlated with diminished ORNs. Although changes in human OB histology with age are not well documented, it would be expected considering it is the end target of OSNs. A more extensive immunohistochemical analysis of olfactory autopsy tissue including both the OE and OB in relation to age would enrich our understanding of the normal and abnormal condition and may provide insight into the pathophysiology of age-related smell loss.
Methodology: A bank of 52 human olfactory tissue autopsy specimens including OE and OBs were obtained with ages ranging from embryonic to 96 years. Sections of this material were processed for immunohistochemical analysis using known markers for OSNs as well as OB specific neurons and glomerular synapses. Qualitative changes in glomerular structure and periglomerular neurons as well as quantitative changes in OB size and structures were analyzed with respect to age and OE neuron composition.
Results: Human adult OBs reveal a less organized morphology compared to mice. Our preliminary assessment suggests some changes in OE and OB morphology appear to occur with advancing age. Developing human OB appears more organized in glomerular structure reflective of rodent histology.
Conclusion: As with OE, human OBs appear to undergo changes with time. Further analysis of human olfactory tissue, including both peripheral and central components, is crucial for establishing the normal condition and recognizing abnormalities associated with olfactory loss.

539 **Defining The Functions Of Olfactory Bulb Processing Via Comparison Of Input And Output.**

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Humans and other animals can recognize an odorant as the same over a range of odorant concentration. It remains unclear whether the olfactory bulb, the brain structure that mediates the first stage of olfactory information processing participates in generating this perceptual concentration invariance. Olfactory bulb glomeruli are regions of neuropil that contain input and output processes; olfactory receptor neuron nerve terminals (input) and mitral/tufted cell apical dendrites (output). Differences between the input and output of a brain region define the function(s) carried out by that region. We compared the activity signals from the input and output across a range of odorant concentrations, and to repeated odor stimulation. The output maps maintained a relatively stable representation of odor identity over the tested concentration range, even though the input maps and signals changed markedly. Repeated odor stimulation of the same concentration resulted in a decline in the output maps, while the input remained relatively stable. These results suggest that the mammalian olfactory bulb may participate in the perceptions of concentration invariance of odor quality and sensory adaptation. Our imaging methods should also be useful for determining the input/output transformation in other regions of the mammalian brain.

540 ***Ir76B* Acts As An Inhibitor Of Sensory Responses In *Drosophila* Specific Chemosensory Neurons**

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Drosophila melanogaster ionotropic receptors (*IR*s), which share sequence similarities to mammalian ionotropic glutamate receptors (*iGluR*s), are generally thought to confer sensory responses by acting as a ligand-gated cation channel. *IR76b*, a broadly-expressed *IR* in both gustatory and olfactory systems, has been proposed to be a detector of several biologically meaningful chemicals. Here, we identify an unexpected function of *IR76b* such that it acts to *dampen* as opposed to promote sensory responses in specific chemosensory neurons. First, our behavioral analysis showed that *IR76b* mutants exhibited a robust taste-driven attraction towards acetic acid (AA) at the concentrations that generally too low to induce a clear behavioral response from wild-types. Second, our calcium-imaging analysis showed that labellar sweet-sensing neurons can sense AA and that loss of *IR76b* caused their AA-induced neuronal responses to increase significantly. Importantly, the increased behavioral and neuronal sensitivities to AA of *IR76b* mutants were restored to WT levels when *IR76b* was specifically re-introduced to the sweet neurons. Third, *IR76b* mutants' hypersensitivity is not restricted to sensing AA: these mutants exhibited enhanced responses to sugars as well as citric acid in their sweet neurons. Finally, we proposed that the dampening effect of *IR76b* plays an important role in allowing animals to distinguish egg-laying substrates whose chemosensory quality is more complex: whereas *IR76b* mutants can readily distinguish a plain substrate from an AA-containing substrate for egg-laying, they failed to tell apart a sweet substrate from an AA-containing sweet substrate. Together, this study reports a novel behavioral and cellular role for *IR* in chemosensation.

541 **Differences In Regional Taste Sensitivity**

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Previous studies have shown that there are differences in taste sensitivity between different regions of the tongue. Notably, the perceived intensities of bitterness and umami are stronger on the posterior than the anterior region of the tongue. However, results on regional sensitivity for sweet taste are inconclusive. Furthermore, studies in our lab have suggested that humans can taste glucose oligomers (MOS) independently of sweet taste, but the regional differences in taste sensitivity for MOS have not yet been investigated. Therefore, this study investigated regional differences in taste sensitivity on the anterior and posterior regions of the tongue for four target stimuli: 56 mM Sucrose, 0.10 mM Quinine, 320 mM Monopotassium Glutamate (MPG), and 224 mM MOS. Deionized water was also included as a tasteless control. The MOS sample was made using 5mM acarbose, an α-glucosidase inhibitor, to prevent oral hydrolysis by α–amylase. Each stimulus was applied to one of four target areas (left and right sides of the anterior and posterior regions) on the tongue using a cotton swab. Importantly, subjects were instructed not to touch any part of the mouth until they rated the intensity of the stimulus on the gLMS. This "passive" tasting mode minimized the spread of stimuli to other regions of the tongue. Results showed no noticeable differences in regional sensitivity for the control. In contrast, sucrose and MOS stimuli were perceived as more intense on the anterior than posterior region of the tongue. Surprisingly, quinine and MPG did not appear to differ in perceived intensity between regions. We reasoned that this may be due to passive tasting. Currently, data are being collected with the same procedure, but using "active" tasting which mimics natural food tasting.

542 **Microfluidics-On-A-Tongue Imaging Chamber For Functional Screening Of Taste Cells *In Vivo***

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Taste sensation is initiated by taste cells on the tongue, which translate ingested chemicals into cellular-level activity. Current understanding on this cellular encoding process has relied on studies using *ex vivo* model systems, which cannot fully recapitulate natural cellular microenvironment *in vivo*. To resolve this methodological limitation, we develop a novel microfluidics-on-a-tongue imaging chamber which integrates a microscopic imaging window for the taste cells and a multichannel microfluidic interface for controlled delivery of various tastants. We also introduce a dual-color ratiometric calcium imaging, which provides microscopic stability of taste cells even under time-varying fluidic stimuli. Using the devised methodology, we demonstrate real-time calcium imaging of fungiform taste cells *in vivo* in response to the five basic tastes, which provides a comprehensive cellular-level taste map. By screening over 100 taste cells, we reveal that ~70% of taste cells are single-tuned but the remaining ~30% are mostly tuned to dual taste qualities with several distinct modes of crosstalk. Notably, we found a strong crosstalk between the two favored tastes: sweet and umami. Consistently, single mRNA imaging show that a significant portion of the fungiform taste cells indeed expresses the both sweet and umami receptors. By opening new opportunities to observe functional activity of taste cells in natural living milieu, our novel tool will contribute to deepening our understanding on the taste coding logic.

543 **T1R2-Independent Sweet Taste Pathways In Chickens**

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Kyushu University, Fukuoka, Japan

Although there were some articles about sweet taste systems in chickens, precise analysis about sweet taste of chickens has not been reported. Because *T1r2* gene is lost in chickens, chickens don't have the major sweet taste receptor, T1r2/T1r3 heterodimer. However, there is also evidence of T1r-independent sweet taste in mammals such as glucose transporters (GLUTs), a sodium-glucose cotransporter (SGLT1), and two components of the ATP-gated K^+ (K_{ATP}) metabolic sensor. Thus, in this study, we focused on these T1r2-independent sweet taste molecules in chickens. In addition, we investigated whether chickens sense sugars and noncaloric sweeteners. Rhode Island Red strain 0-2 week-old chicks were used. Firstly, we examined the expression of glucose transporters (*GLUT2*, *GLUT8*, *GLUT9*, and *SGLT1*), the components of K_{ATP} channel (*SURs*, *Kir6.1*, and *Kir6.2*), *T1r3*, and *TRPM5* in the chicken palate, where taste buds are rich, and other organs by RT-PCR. In one-bowl drinking tests, after water deprivation for 23.5 hours, the chicks were given water (control) or sweet solutions for 30 min. In palate, *GLUTs* except *GLUT2*, *SGLT1*, K_{ATP} channel subunits, *T1r3*, and *TRPM5* were expressed. In behavioral tests, chicks slightly preferred glucose, galactose, sucrose, and maltose but chicks disliked high dose sucrose and fructose. Chicks did not show preferences for noncaloric sweeteners and sugar alcohol such as acesulfame K, aspartame, saccharin, sucralose, and sorbitol. Interestingly, the preference for galactose was inhibited by phlorizin, an inhibitor of SGLT1. These results suggest that chicks sense sweet taste slightly *via* T1r2-independent pathways in oral tissues.

544 **Characterization Of *Koku* Taste In Egg Yolk Type Mayonnaise And The Influence On The Cells Expressing Calcium-Sensing Receptor**

Chisa Nishimura[1], Takuya Yanagisawa[1], Daisuke Moriya[1], Yiseul Kim[2], Mee-Ra Rhyu[2]
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An egg yolk type mayonnaise (MayoY) that contains more than 15% of egg yolk is popular in Japan and has been generally recognized to be rich in *koku* taste. We have previously examined if calcium-sensing receptor (CaSR) is associated with *koku* taste of MayoY in taste cells and have shown the water-soluble extract of MayoY selectively enhances intracellular Ca^{2+} influx in cells expressing CaSR. Herein, we evaluated the effectiveness of mayonnaise models by egg yolk content in cells expressing CaSR by Ca^{2+}-flux signaling assay and performed to understand how the molecular weight distribution of active components contributes to *koku* taste. We investigated the effects of three mayonnaise models containing egg yolk 6% and egg white 7% (Y6W7), egg

yolk 6% (Y6), and egg yolk 15% (Y15) on CaSR-expressing cells. Of the three models, Y15 selectively activated CaSR and the activities were effectively inhibited by the CaSR antagonist, NPS 2143. We next performed stepwise ultrafiltration with MayoY into MY10, MY10-3, and MY3-01, containing materials of molecular weights >10000 Da, 10000-3000 Da, and 3000-100 Da, respectively. MY3-01 showed the strongest *koku* taste in trained panelist. Changes in intracellular Ca^{2+} levels to the MY10, MY10-3, and MY3-01 were monitored in hCaSR-expressing cells. As expected, MY3-01 induced increment of the intracellular Ca^{2+} influx in a dose-dependent manner and this increment was selectively blocked by NPS-2143. These results indicate that the molecules of molecular weight 3000-100 Da contribute to the *koku* taste of MayoY that at least partly activates calcium-sensing receptor in taste cells.

545 **(Don Tucker Award Finalist) The Salty Taste Of Chloride**

Jennifer K. Roebber[1], Stephen D. Roper[1,2], Nirupa Chaudhari[1,2]

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One component of salt (NaCl) taste is inhibited by the diuretic amiloride and this pathway is believed to detect Na^+ through ENaC channels. However, the mechanisms behind amiloride-insensitive salt taste detection are unknown. To study NaCl responses in taste bud cells, we performed Ca^{2+} imaging in a fungiform lingual slice preparation that allowed us to visualize the responses of individual taste bud cells while maintaining them in a semi-native environment. NaCl and other salts were applied focally and restricted to the apical taste pore, mimicking the *in vivo* stimulus. We imaged responses from excitable taste bud cells (type II and III) by using transgenic mice that express the Ca^{2+} indicator GCaMP3 specifically in these cells. Ca^{2+} transients were limited to the apical region of select cells. NaCl responses were concentration-dependent, and mapped onto known properties of salt taste. We recorded NaCl-evoked responses in the presence and absence of 100μM amiloride. NaCl-evoked responses were *insensitive* to amiloride ($p=0.66$, paired t-test). Next, we tested the ionic specificity of salt-evoked responses. Surprisingly, modifying the cation by stimulating with either KCl or choline chloride produced responses in the same cells as NaCl (n=5-9 cells, 3 mice). In contrast, substituting the anion eliminated responses. That is, NaCl-sensitive cells were unresponsive to sodium gluconate (n= 7 cells, 2 mice). These data suggest that *chloride* drives salt responses and is both necessary and sufficient elicit responses in NaCl-responsive cells. Together, these findings suggest that Cl^- transduction may underlie the amiloride insensitive component of salt taste. Thus, Na^+ and Cl^- components are separately detected to define the overall salty taste of NaCl.

546 **Decoding The Bad Taste Of Drugs**

Amanda Soohoo[1], Yi Wang[1,2], Peihua Jiang[1]

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The World Health Organization recommends artemisinin, praziquantel and piperaquine as essential medicines for treatments of malaria, schistosomiasis and pneumonia, respectively, in the developing world. Non-compliance in children is prevalent because of their strong unpleasant taste and accompanying nausea. The commonly used approach to mitigate noxious taste is to add sweeteners and flavors to medications in an attempt to mask their bitterness or other objectionable off-tastes with competing flavors. However, this approach has had limited efficacy in pediatric populations. To effectively block bitterness elicited by such compounds, we set out to identify specific TAS2R bitter receptors that are activated by each of the three target drugs. We have expressed all the 25 human bitter receptors individually in heterologous cells and identified receptors that respond to these drugs. Our results show that praziquantel activates multiple bitter receptors, whereas artemisinin and piperaquine activate a limited set of receptors. Our next step is to screen for receptor-specific antagonists to block the receptor activity in response to each of these three drugs by high-throughput screening. Similar approaches can be applied to other intensely bitter-tasting drugs.

9:00 - 10:30 AM	Estero Foyer
Coffee Break	

10:30 - 12:30 PM	Calusa FGH
ORAL CARBOHYDRATE SENSING: BEYOND SWEET TASTE	

Chair(s): Juyun Lim

10:30 **Oral Carbohydrate Sensing: Beyond Sweet Taste**
Juyun Lim
Oregon State University, Corvallis, OR, United States

Carbohydrates are the most abundant and diverse class of organic compounds found in nature. Even considering only those readily utilized and metabolized in the human body, those available carbohydrates encompass a wide range of molecules commonly classified as sugars and complex carbohydrates. Accordingly, humans utilize both classes as sources of energy. Thus, oral detection of both types of carbohydrates would be highly beneficial. Historically, research has focused almost exclusively on the perception and mechanisms underlying the detection of sugars and alternative sweeteners based on the T1R2/T1R3 sweet receptor. The goal of this symposium is to share state-of-the-art knowledge about possible additional gustatory pathways involved in carbohydrate sensing.

10:40 **Functional Aspects Of Carbohydrate Sensing In Humans**
Nicholas Grant
The University of Auckland

The presence of glucose polymers in the mouth activates a signalling mechanism capable of immediately improving physical performance. Remarkably, human strength and endurance can be enhanced when carbohydrate solutions are rinsed in the mouth (and expectorated) during exercise. This novel form of nutrient signalling involves an oral transduction pathway that is activated independently of sweet taste and post-oral factors.Our research uses neuroimaging and non-invasive brain stimulation techniques to study the neural basis of this phenomenon. The mechanisms involved are poorly understood, but we have demonstrated that oral carbohydrate sensing can facilitate corticomotor output to both fresh and fatigued muscle. Oral sensing primes task-specific regions of cerebral cortex and increases activity within networks known to drive emotional and behavioural response to rewarding food stimuli. These findings suggest that oral chemoreceptors encode food qualities that are distinct from taste within a homeostatic system involved in the identification of forthcoming energy.This presentation will summarise the performance effects and neural mechanisms of carbohydrate sensing during physical activity, describing how carbohydrate sensing can be exploited to enhance human performance.

11:10 **Multiple Pathways Mediate Caloric Sugar Taste Signaling**
Sunil Sukumaran
Monell Chemical Senses Center

The heterodimer formed by the G-protein coupled receptor subunits T1R2 and T1R3 is the primary sweet taste receptor in mammals, capable of detecting the full range of sweet tastants, including caloric sugars, artificial sweeteners and sweet proteins. In spite of this, evidence exists for T1r-independent sweet taste signaling mechanisms. Indeed, *Tas1r3* knock out mice retain diminished but significant behavioral and taste nerve responses to caloric sugars, but not to artificial sweeteners. In metabolic-sensing tissues such as the intestine, pancreas and hypothalamus, caloric sugars are sensed by pathways that involve the sequential action of alpha glucosidases, glucose transporters and the ATP-sensitive potassium K+ channel (KATP). We hypothesized that these pathways may also be active in taste cells. In agreement with this hypothesis, cell type-specific expression of the alpha-glucosidases sucrase-isomaltase (SI) and maltase-glucoamylase (MGAM), sodium-glucose co-transporters (SGLTs), several facilitative glucose transporters (GLUTs) and subunits of the KATP channel was detected in T1R3-expressing taste cells in mice and humans. Functional studies in mice showed that pharmacological inhibitors of alpha-glucosidases partially abrogate taste nerve responses to disaccharides such as sucrose and maltose without affecting responses to monosaccharides, non-caloric sweeteners and non-sweet tastants that activate umami, bitter and sour taste signaling pathways. We could also detect KATP mediated potassium currents in mouse fungiform taste cells. Pharmacological inhibitors of the KATP channel partially inhibited sweet taste signaling in cultured human taste cells. Our studies indicate that sweet taste signaling involves multiple pathways and raise the possibility of developing novel non-caloric sweeteners targeting components of the alternate sweet taste signaling pathways.

11:30 **Oral Stimulation With Glucose Elicits Insulin Release By Activating A T1R-Independent Taste Signaling Pathway**
John Glendinning
Barnard College, Columbia University

Humans and rodents are attracted to the taste of sugars. This attraction is mediated by a taste signaling pathway that includes the G protein-coupled heterodimeric sweet taste receptor, T1R2+T1R3. Indeed, genetic or pharmacological inactivation of the T1R2+T1R3 signaling pathway severely attenuates taste-mediated ingestive responses to simple sugars. These observations have led many investigators to infer that inactivation of T1R2+T1R3 signaling renders mammals “taste blind” to sugars. However, there is growing evidence for the

existence of a T1R-independent signaling pathway for sugars. Stimulation of this signaling pathway produces metabolic effects (e.g., insulin release from pancreatic beta cells), but no apparent behavioral effects in mice. This taste-mediated metabolic response—called cephalic-phase insulin release (CPIR)—dramatically improves glucose tolerance. The magnitude of the CPIR increases with glucose concentration. While other glucose-containing carbohydrates (e.g., sucrose, maltose and Polycose) also elicit CPIR, their ability to do so is blocked by the presence of an alpha-glucosidase inhibitor (acarbose). This latter observation indicates that sucrose, maltose and Polycose do not directly elicit CPIR; instead it is the glucose liberated from these carbohydrates by salivary amylases and disaccharidases in taste cells that does so. To identify the components of the T1R-independent signaling pathway, we examined the necessity of several transduction proteins (Calhm1, P2X2+P2X3, SGLT1 and Sur1) to CPIR. Among these proteins, only Sur1 was necessary for CPIR. Given that Sur1 is a subunit of the ATP-sensitive K+ channel K(ATP) and that this channel functions as a part of a glucose-sensing pathway in pancreatic beta-cells, we asked whether the K(ATP) channel serves an analogous role in taste cells. We discovered that oral stimulation with drugs known to increase (glyburide) or decrease (diazoxide) K(ATP) signaling produced corresponding changes in glucose-stimulated CPIR. We propose that the K(ATP) channel is part of a novel signaling pathway in taste cells that helps animals determine the concentration of glucose or glucose-containing carbohydrates in food and generate a CPIR of appropriate magnitude.

Oral Complex Carbohydrate Sensing In Humans

12:00 Juyun Lim
Oregon State University

Human diets in many cultures are based on starch-based carbohydrates (i.e., complex carbohydrates). However, research on human taste responses to carbohydrates has focused almost exclusively on simple carbohydrates (i.e., sugars). This is perhaps due to the long standing assumption that sugars are the only class of carbohydrates that humans can taste. In contrast, there has been mounting evidence indicating that rodents and even some nonhuman primates are attracted to the taste of oligo- and polysaccharides that are derived from starch. Recently, we found the evidence that humans can taste starch hydrolysis products (i.e., maltooligosaccharides) and that such detection is independent of the sweet taste receptor, hT1R2/hT1R3. These results support the presence of a separate taste perception mechanism for maltooligosaccharides. In this presentation, I'll discuss the role of salivary α-amylase in oral digestion of starch and illustrate perceptual evidence of gustatory detection of starch hydrolysis products. I'll also discuss sensory perception and possible transduction mechanisms of starch hydrolysis products. Overall, this presentation will highlight open questions about sensory mechanisms underlying oral complex carbohydrate sensing.

10:30 - 12:30 PM	Calusa ABC

EVOLUTIONARY ASPECTS OF CHEMICAL SIGNALING IN MICE

Chair(s): Yoram Ben-Shaul and Marc Spehr

10:30 **Introduction**

10:40 **Diversity Of Major Urinary Proteins In Wild House Mice**

Michael Sheehan
Department of Neurobiology and Behavior, Cornell University

Urinary territory marks play an outsized role in house mouse social behavior influencing both male-male competition, female mate choice and even patterns of cooperative nesting. Wild mice produce distinctive blends of major urinary protein (MUPs) isoforms, which provide information on the individual identity of the owner. In order to provide information on individuality, diversity and variation must be maintained in composition of MUP blends within populations. This talk will first review some recent literature on the processing maintaining diversity in the MUPs of wild house mice as well as present new data documenting the range of diversity in wild mouse urinary proteins. Findings reveal two patterns: (1) Many but not all amino acid variants present among MUP isoforms are relatively conserved across individual, populations and species samples. (2) Novel MUPs frequently arise through combinatorial shuffling of common mutations rather than new amino acid variants. These processes are likely shaped, in part, by the dynamics of gene family evolution but may also reflect selective constraints on the properties of MUPs as signaling ligands.

11:10 **Neuronal Responses To Wild And To Inbred Urine Signals**

Rohini Bansal
Hebrew University of Jerusalem

Many animals, including mice, depend on chemosensory cues for social communication. Most research on chemical signaling in mice uses inbred strains, which have undergone numerous generations of breeding. These may dramatically alter both their sensory abilities, and the signals that they emit. The common use of classical inbred laboratory strains may thus provide only a limited, and perhaps even biased view of chemosensory signals and their processing.While our broader goal is to assess the cumulative effects of laboratory breeding on both signal transmission and signal detection, here we focused on the ability of urinary secretions to convey ethologically relevant information. Specifically, we asked how laboratory inbreeding has affected the magnitude and variability of responses evoked by the urinary secretions in different inbred subjects.To this end, we measured and compared neuronal responses to urinary secretions from inbred (BalbC, C57), wild derived, and from offspring of real wild mice. We used extracellular electrodes to monitor responses in the accessory olfactory bulb (AOB) of male mice from the BalbC and C57 strains.Our preliminary analyses show that compared to secretions from inbred lab strains, wild mouse urine evoked stronger responses in both BalbC and C57 subjects. However, secretions from wild derived mice elicited somewhat different response patterns in each of the subject strains. For example, C57 subjects showed stronger responses towards inbred, as compared to wild derived female secretions, while wild male urine elicited stronger responses than inbred strain male secretions. In addition, we observed differences in the response patterns of the different inbred subject strains to the various secretions.Altogether, our results show a complex pattern of responses that depend on the extent of inbreeding associated with the stimulus donor, its sex, and even the subject strain. We speculate that these observations reflect evolutionary pressures acting on mice in the lab environment, in terms of both the secreted signals and their detection.

11:30 **Evolution Of The Olfactory Genome And Its Consequences For The Social Behavior Of Wild Mice**

Jean-Marc Lassance[1,2]

[1]Department of Molecular and Cellular Biology, Department of Organismic and Evolutionary Biology, Harvard University, [2]Howard Hughes Medical Institute

Social behaviors are an essential component of animal's life, yet the mechanisms underlying their evolution remain largely unknown, especially in mammals. The transition from promiscuity to monogamy represents an exciting opportunity to deepen our understanding of social behavior as it comprises multiple facets such as pair bonding, biparental care, and female-female aggression. Wild mice -specifically the deer mouse *Peromyscus maniculatus* and its sister species the oldfield mouse *P. polionotus*- have become a model for linking genes to behavior. As with most mammals, *P. maniculatus* is highly promiscuous, whereas P. polionotus provides a rare example of both social and genetic monogamy. To further integrate behavioral and genomic information, we generated high quality reference genomes for these two species and combine comparative-genomic analyses with RNA sequencing to identify the DNA changes that contribute to behavioral evolution. Here, we focus on variation in the olfactory system, as changes affecting the sense of smell are known to lead marked modifications of mammalian behavior. First, genome-wide scans show that a significant portion of Fst outlier regions contain chemosensory genes, consistent with olfaction being an important driver of behavioral divergence. Second, our phylogenetic reconstructions of olfactory receptor genes indicate that several receptor clades show *Peromyscus*-specific expansion or contraction, revealing the extremely dynamic evolutionary history of these gene families and deviation from a random birth-death model. Finally, these mice show a high degree of differential transcriptome regulation in the olfactory sensory organs. By contrast, the olfactory transcriptomes differ only minimally between males and females in both species, suggesting that the pronounced sexual dimorphism

observed in olfactory-mediated behaviors - including parental behavior - is not driven by alteration at the periphery but rather has its origin in divergence at higher processing centers. Taken together, this study provides insights into the evolution of the mammalian olfactory system, and differences in the olfactory repertoires likely mediate the divergent social behaviors of these two species of deer mice.

12:00 **Urinary Lipocalins As Chemical Signaling And Toxic Waste Disposal Systems And Their Differences Between Inbred And Wild Mice**

Pavel Stopka
Department of Zoology, Faculty of Science, Charles University, Prague

Mammalian olfaction depends on the detection of chemical signals with chemosensory neurons in the main olfactory epithelia (MOE) of the nose, and/or in the accessory olfactory epithelia (AOE) of the vomeronasal organ (VNO). Many of these signals are secreted with urine as volatile organic compounds (VOCs) that are presumably transported with major urinary proteins (MUPs). Previously, most mass spectrometry studies depended on gel-based techniques that provided only a partial view on the protein content. Thus we employed the label-free LC-MS/MS techniques in combination with GC-MS/MS to provide a broader perspective on the urinary proteome and the ligands that have the potential to stimulate specific responses in the mouse receivers. We also compared these profiles with the two strains of the laboratory mice BALB/c and C57BL/6J. We are providing new evidence that MUPs represent a fraction of the urine proteomes of up to ~85%, however, some of these proteins belong to different lipocalin sub-families. We are also showing that the variation in protein abundance is limited in inbred mouse lines. Potential causes of higher variation in the abundance of up-to 300 urinary proteins in wild mice are discussed in the light of interactions of the host with symbiotic bacteria.

12:30 - 1:30 PM	Lunch On Own
Lunch On Own	

1:30 - 3:30 PM	Calusa FGH
CHOLINERGIC MODULATION OF OLFACTORY FUNCTION IN HEALTH AND DISEASE	

Chair(s): Richard Doty and Donald Wilson

1:30 **Introduction**

Functional Cholinergic Modulation Of Olfactory Bulb And Cortex Processes

1:40 Christiane Linster
Cornell University

Cholinergic inputs to the olfactory system provide important modulatory function for olfactory guided behaviors. This presentation will review behavioral and electrophysiological evidence of cholinergic modulation of olfactory learning. We will propose a model of feedback control of cholinergic inputs to the olfactory system through which the olfactory cortex switches between learning and recall of information based on recognition of an odor.

Biophysical Models Of Cholinergic Neuromodulation In Olfactory Bulb

2:10 Guoshi Li
University of North Carolina at Chapel Hill, Chapel Hill, NC, United States

The olfactory bulb (OB) receives massive cholinergic inputs from the basal forebrain and represents an ideal system to study cholinergic functions and its potential deregulation in neurodegenerative disorders. To provide a mechanistic understanding of cholinergic modulation of OB functions, we have developed biophysically realistic, multiscale dynamical models of the OB that specifically address three important questions: (1) What are the individual and combined effects of nicotinic and muscarinic acetylcholine (ACh) receptors in odor representations? (2) How does ACh dynamically interact with norepinephrine (NE) to regulate OB functions? and (3) What is the dynamical region for stable cholinergic modulation of OB circuits? First, with a two-layer biophysical model of cholinergic modulation, we showed that the effects of nicotinic and muscarinic receptors are both distinct and complementary to each other. While nicotinic receptors sharpen the mitral cell (MC) chemoreceptive field, muscarinic receptors enhance MC spike synchronization with gamma power. Thus, co-activation of these two types of receptors would synergically decorrelate similar odor representations leading to improved odor discrimination. Next, using a microcircuit model of mitral-granule cell interaction, we showed that ACh is important for MC spike synchronization and odor discrimination, whereas NE is particularly important for the modulation of neuronal signal-to-noise ratio and potentially the regulation of cholinergic function. Lastly, by employing a biophysical spatial model of OB, we illustrated that OB gamma oscillation arises from an inhibition-coupled oscillator framework which permits stable ensemble coding to cholinergic modulation. These findings support the notion that ACh is a critical regulator of multiple OB functions.

Cholinergic Modulation Of Olfactory Cortical Connectivity And Odor Perception

2:30 Donald A. Wilson[1,2]

[1]Department of Child & Adolescent Psychiatry, NYU School of Medicine, New York, NY, United States, [2]Emotional Brain Institute, Nathan Kline Institute for Psychiatric Research, Orangeburg, NY, United States

The piriform cortex (PCX) processes olfactory bulb output in the context of activity from a wide variety of intra- and inter-cortical inputs. These cortical connections are critical for linking distributed ensembles of PCX neurons responding to specific odor-evoked input, as well as provide information about expectation, recent history and multisensory context. Importantly the efficacy of intra- and inter-cortical synaptic connections is hypothesized to be state- and behavior-dependent. For example, Hasselmo and colleagues demonstrated that intra- and inter-cortical synapses in PCX Layer IIb are modulated by acetylcholine, via cholinergic pre-synaptic depression. This modulation also affects plasticity in these synapses – a critical factor in PCX synthesis of molecular features into odor objects. However, odor memory and perception can also be shaped by sleep-dependent memory consolidation. In this talk I will describe the important role of ACh in odor perception and memory, with an emphasis on PCX odor coding and plasticity during acquisition, consolidation and expression of olfactory experience. Data will be reviewed demonstrating the importance of ACh within the PCX for PCX single-unit odor coding, and for odor perceptual learning. We will also describe data showing the importance of ACh for state-dependent shifts in PCX network connectivity. Together, the results suggest a highly dynamic role for ACh in PCX sensory physiology and connectivity, helping shape odor perception and memory.

Putative Involvement Of Acetylcholine In Modulation Of Olfactory Function Among A Wide Range Of Neurological Disorders

3:00 Richard Doty
University of Pennsylvania

There is a spectrum of smell dysfunction among neurodegenerative diseases ranging from severe loss, as seen in Alzheimer's and Parkinson's, to relatively little loss, as seen in progressive supranuclear palsy. Given the ubiquitous but varying degrees of olfactory disturbances among such diseases, it is conceivable that differential damage to a common neuropathological substrate explains the relative differences in the olfactory deficits. Such damage may occur prior to or coincident with the onset of the classic neuropathology of a number of disorders, such as abnormal brain deposits of tau- or beta-amyloid. In this presentation I will point out that the amount of damage to forebrain cholinergic circuits, as well as other measures of cholinergic function, appears to be correlated with quantitative smell test scores across a wide range of neurological disorders.

1:30 - 3:30 PM	Calusa ABC

PERIPHERAL MODIFICATION OF THE CHEMICAL SIGNAL

Chair(s): Ann-Marie Torregrossa

Peripheral Modification Of The Chemical Signal

1:30 Ann-Marie Torregrossa
University at Buffalo

Perception of chemical signals is plastic and can change with an individual's metabolic state or previous experience with a stimulus. This symposium will explore ways in which the physiology of an organism can alter the stimulus in the periphery, perhaps even prior to interaction with its candidate receptor. Talks will include data on salivary protein interactions with taste stimuli as well as the biotransformation of odorants.

The Role Of Oral Fluids And Films In The Sense Of Taste

1:40 Martine Morzel
INRA- Centre des Sciences du Gout et de l'Alimentation

Taste buds constantly bathe in saliva, or more precisely in the oral fluid (termed whole saliva) made of secreted saliva, plasma exudate, shedding cells and microorganisms. Furthermore during eating, whole saliva is mixed with the food containing tastants. The various documented actions of saliva will be reviewed: protection of the integrity and functionality of the anatomical taste structures, dissolution and transport of taste molecules or binding between salivary components and tastants, with different consequences on taste perception. Subsequently, our own research performed on human subjects will be presented. Such studies aimed to establish links between taste acceptance (in infants) or taste sensitivity (in adults) and saliva composition using non-targeted "omics" analytical methods. Overall, it is suggested that proteolysis within the oral cavity might be determinant, as evidenced by the differentially represented salivary cystatins (inhibitors of cysteine proteases) or protein fragments between groups of different sensitivity. We further suggest that this proteolysis might impact the structured biological layer on oral soft surfaces (the mucosal pellicle) formed through bioadhesion mechanisms. A cell-based model, suitable to study the interaction between the mucosal pellicle and flavour compounds, was therefore developed. Its application to the characterization of tannins-salivary proteins interactions will be presented. In parallel, our non-targeted studies also pointed at the possible involvement of the oral microbiota in the taste function. A preliminary study on this topic will be presented. Generic taste sensitivity was linked to some microbiologically-related variables in saliva and in the film lining the tongue, confirming the interest of further pursuing this line of research.

Salivary Proteins Decrease Orosensory Sensitivity To Quinine

2:10 Ann-Marie Torregrossa
University at Buffalo

Most taste stimuli are dissolved in saliva before reaching their receptor targets. Uncovering how changes in this diverse and complex solution alters taste will increase our understanding of the taste system and how an animal may modulate the taste signal in the periphery. Exposure to dietary tannic acid (TA, 3%) and quinine (0.375%) upregulate partially overlapping sets of salivary proteins (SPs,) and our work suggests that these SPs then increase acceptability of the bitter diet. To clarify the mechanism of increased acceptance we isolated the orosensory effects of these SPs in three tests. We recorded the licking responses to super threshold levels of quinine with and without SPs upregulated in brief-access taste tests. We also assessed changes in sensitivity to quinine (threshold) in a two response operant task with and without SPs induced, and recorded from the chorda tympani nerve while stimuli were delivered in the presence and absence of SPs. Rats with SPs show an increased acceptance of quinine in brief-access licking tests and have higher detection thresholds compared to control conditions. Likewise, when SPs are delivered with the stimulus it results in a decreased nerve response to quinine compared to the control condition. Taken together, these results suggest that SPs increase palatability by reducing orosensory sensitivity to quinine.

Function Of Nasal Odorant Metabolism In Mammalian Olfaction

2:30 Jean-Marie Heydel
Dijon University for Health Sciences

Thanks to the combination of biochemical, chemical and physiological approaches, the knowledge about peripheral odorant recognition by olfactory receptors has known a constant increase in vertebrates. Nevertheless, we know that peripheral events only considering odorant interaction with olfactory receptors may not predict or fit the corresponding physiological or psychophysical recording. Perireceptor (PR) events might be more seriously considered to get a comprehensive picture of the peripheral olfactory processing. The role of PR enzymes has been often dedicated to the smooth functioning and maintenance of the cellular integrity in the peripheral olfactory process rather than to the regulation of the olfactory signal. However, the characteristics shared by olfactory receptors and Odorant Metabolizing Enzymes (OMEs) strongly support complementary functions: preferential expression in the olfactory epithelium, cellular co-localization, large number of isoforms, cross-reactivity toward odorants or genetic variability. Furthermore, we currently know that OMEs are involved in the clearance of odorants from the PR environment and that their inhibition leads to changes in odor intensity and quality. It has been also observed that the competition between two odorants toward the same OME can lead to the accumulation of one odorant, hence to the reinforcement of its olfactory signal, perception or associated behavior. In addition, the recent development of technics for systematic analysis of odorant metabolism has

confirmed the high velocity of OMEs activity (millisecond range), instantaneously producing odorant volatile metabolites able to activate olfactory receptors. Such progresses clarify and support PR OMEs contribution in the equation governing the peripheral olfactory process.

Xenobiotic Metabolizing Enzymes And Olfaction In Insects

3:00 Martine Maibeche
Sorbonne University - Institute of Ecology and Environmental Sciences of Paris Paris (iEES Paris)

Xenobiotic Metabolizing Enzymes: role in insect olfaction Chertemps T., Steiner C., Durand N., Bozzolan F., M., Maïbèche M.Sorbonne Université, Institute of Ecology and Environmental Sciences of Paris, F-75005, Paris, FranceInvestigation of insect olfactory system has allowed a better understanding of how animals detect, encode, and process odorant stimuli, making it a major model in neuroscience. Insects smell with their antennae, which are covered with sensory hairs called sensilla. These sensilla house sensory neurons whose dendrites bath into the sensillar lymph which has similar properties than the olfactory mucus in vertebrate nose. Detection of odorant molecules includes their transport through the lymph, their interaction with the olfactory receptors embedded in the dendritic membrane and their inactivation. Pioneer studies suggested that Odorant-Degrading Enzymes (ODEs) quickly metabolize odorants into inactive chemical forms, *i.e.* which cannot elicit receptor response, preventing overstimulation. However, their function remains elusive and few ODEs have been identified and functionally characterized yet.A high diversity of xenobiotic metabolizing enzymes belonging to different multigene families, such as carboxylesterases (CCEs) or cytochromes P450 were identified in antennae. Some of them could play a role of ODEs. Using transcriptomic approaches, we have established the repertoire of antennal detoxification enzymes in several insect species, including pest moths and the fruit fly. Their expression patterns and structural diversity were analysed to select ODE candidates. Several antennal enriched CCEs were produced as recombinant enzymes and were able to differentially hydrolyse volatile acetate odorants. By combining molecular genetics, electrophysiological and behavioural analyses, we have shown that two CCEs might be involved in the physiological dynamics of fly's response to common food odors, suggesting them as potential ODEs, thus as essential actors in the temporal dynamic of odorant perception.

3:15 - 3:45 PM	Calusa Foyer
Coffee Break	

3:30 - 5:00 PM	Blue Heron
JOURNAL CLUB: FROM THE CHROMATOGRAPHIC THEORY TO ODOR PERCEPTION: SPATIOTEMPORAL PATTERNING IN OLFACTION	

From the Chromatographic Theory to Odor Perception: Spatiotemporal Patterning in Olfaction Highlighting Contributions to the Chemosensory Sciences of Maxwell M. Mozell Founder of AChemS The Chromatographic Theory: What is it? Where did it come from? How is it used now?

	Brief Introduction To The Journal Club
3:30	Charlotte Mistretta
	Informal Introduction To The Mozell Laboratory
3:35	Richard M. Costanzo Commonwealth University
	The Classic Paper: Maxwell Mark Mozell, The Chromatographic Theory: Evidence For A
3:45	**Chromatographic Model Of Olfaction, Journal Of General Physiology 56:46-63, 1970.** Thomas Eiting Postdoctoral Fellow with Matt Wachowiak, University of Utah
	To The Present: Recent Work Drawing On Spatiotemporal Patterning And The Chromatographic Theory
4:00	Justus V. Verhagen The John B. Pierce Foundation Laboratory
	Overview: The Chromatographic Theory And Relevance To The Field
4:15	Donald A. Wilson NYU Langone Medical Center
	Reminiscences And Comments: The Mozell Laboratory And Comments From The Audience
4:30	Dave Hill, Claire Murphy, Steve St. John, Robert Bradley, Rich Costanzo

7:00 - 9:00 PM	Calusa ABC

Award Lectures

Chair(s): Minghong Ma

7:00 **Achems Young Investigator Award: Predicting Human Olfactory Perception From Molecular Structure**

Joel D. Mainland[1,2]

[1]Monell Chemical Senses Center, Philadelphia PA, USA, [2]University of Pennsylvania, Philadelphia, PA

A fundamental problem in neuroscience is mapping the physical properties of a stimulus to perceptual characteristics. In vision, wavelength translates into color; in audition, frequency translates into pitch. By contrast, the mapping from chemical structure to olfactory percept is poorly understood. Recent progress in the field has begun to address this hole in the field, and here we will review several emerging models. First, we developed a model that can distinguish odorous from odorless molecules based on their physicochemical properties with 72% accuracy (AUC = 0.82) in external validation. Second, we participated in the DREAM Olfaction Prediction Challenge, which predicted the intensity (r = 0.78, p <10-228), pleasantness (r = 0.71, p <10-8), and quality (r = 0.55, p

7:30 **Barry Jacobs Memorial Award: Neural Plasticity Of Flavor Processing And Food Preferences**

Sanne Boesveldt
Associate Professor Sensory Science and Eating Behavior, Division of Human Nutrition, Wageningen University, Wageningen, the Netherlands

Food and flavor perception is a multisensory experience, including the sense of smell and taste, but also texture, visual and even auditory input. These sensory inputs are sent to the brain where they may evoke separate responses and are integrated to form a unique combined flavor percept. However, the neural signature of flavor representation may change and is dependent on individual flavor preferences, internal (metabolic state) or other factors (experience, sensory dysfunction). I will present some of our recent work that sheds light on multisensory food perception in the context of interpersonal differences that may help to understand vulnerability for deviant food intake behavior. I will also discuss how plasticity in the neural networks underlying food and flavor perception may be adaptive for the regulation of food intake.

8:00 **Ajinomoto Award For Young Investigators: The Organization Of Neural Circuits For Thirst And Satiety**

Yuki Oka
California Institute of Technology

Appetite and satiety are two key components that regulate goal-oriented ingestive behaviors. Despite recent technological advances, the mechanisms by which the brain regulates these aspects are still not fully understood. There are two key steps for appetite regulation; central motivation and peripheral sensation. How the brain integrates these two independent signals to drive appropriate behavior is an unsolved problem in neuroscience, resolution of which could have significant implications for treatment of appetite-related disorders. We study thirst as a simple platform to understand appetite and homeostasis. Using genetics, circuit manipulation/imaging, and tracing techniques, we have identified genetically-defined cell types in the brain and on the tongue that regulate body fluid homeostasis. In my talk, I will present our recent study on the circuit organization for thirst and drinking-induced satiety. I will discuss the mechanism of how brain thirst neurons integrate internal information on water balance as well as real-time drinking behavior.

8:30 **Max Mozell Award: Chemosensory Perception In The Fly**

John Carlson
Dept. Molecular, Cellular and Developmental Biology, Yale University

Although tiny, the fruit fly Drosophila has remarkably sophisticated chemosensory systems that allow it to detect an immense diversity of chemical compounds. With a limited number of neurons, the fly translates chemosensory input into a rich variety of behavioral outputs. The molecular, cellular and circuit mechanisms underlying its chemosensory perception have been investigated with a variety of approaches. Large families of receptors underlie the detection and coding of odorants, tastants and pheromones. The molecular basis of odor coding has been explored using an in vivo expression system, the "empty neuron system". Analysis of the Or (Odor receptor) repertoire of the fly with this system has revealed that several properties of ORN response are dictated by the receptor it expresses. These studies further showed that odorant receptors vary widely in their breadth of tuning, and that odorants vary widely in the number of receptors they activate. The cellular basis of both odor and taste coding has been explored by systematic electrophysiological analysis of the olfactory and taste organs. By combining molecular and cellular maps of the chemosensory systems, an integrated view of chemosensory coding in the fly has been obtained. Recently the circuit basis of several behaviors has been explored by optogenetics. Understanding of chemosensory perception in the fly has provided insight into the mechanisms by which insect disease vectors and agricultural pests locate their human and plant hosts, which in turn suggests new means of preventing disease and protecting the world’s food supply. This work was supported by grants from the NIDCD.

9:00 - 12:00 AM	Mangroves & Belvedere Room
AChemS 40th Birthday Dance Bash	

Kick off your shoes and come celebrate 40 years of fragrant and tasty AChemS research and camaraderie on Friday night April 20th at the Mangroves lounge! The dance party will begin at 9:00pm following the AChemS Award Lectures and will continue until midnight. Appetizers and non-alcoholic beverages will be provided, alcoholic alternatives are available 20 feet away at the Mangroves bar! Dance music provided by: DJ with Class