6th Annual Meeting of

DIGITAL OLFACTION SOCIETY

第6回デジタルオルファクション国際会議

December 3 - 4, 2018 - Tokyo, Japan

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Digital Olfaction Society

December 3-4, 2018

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Welcome to Tokyo DOS Annual Meeting 2018

After the success of the three DOS World Congresses (Berlin, 2013 and Tokyo, 2014-2016) and the two congresses on Olfaction & Issues (Paris, 2010 and Milano, 2016), the scientific committee decided to organize its annual meeting to cover the two topics.

This meeting will be divided in two days:

- *Olfaction & Issues 2018: Science, Applications & Strategies - December 3, 2018*
- *Digital Olfaction 2018: Recent Advances & Perspectives- December 4, 2018*

Olfaction & Issues 2018: Science, Applications & Strategies – December 3, 2018

The first part of the meeting is dedicated to **Olfaction & Issues in 2018.** The aim of this first part is to present the latest advances and applications of olfaction in health and sciences, life style and marketing.

The manipulation of olfaction can introduce substantial advantages in health, design and marketing if we integrate odors in appropriate and ingenious ways. The design and marketing of odors is not only associated with perfumes, but also with other items that are typically odorless, such as buildings and places. It is possible to create odors that induce memorable emotions in users. We can accomplish this if we govern and simulate the entire process of production, perception, and evolution of olfactory communication and messages, which must be consolidated with the other sensory receptors.

Olfaction & Issues 2018 will highlight different strategic topics:

- Olfaction 2018: recent scientific advances & perspectives - the sense of smell in health
- Olfaction & marketing: towards a personalized emotional perspective

Digital Olfaction 2018: Recent Advances & Perspectives – December 4, 2018

In the second day, the scientific committee will allocate time to discuss about **the digital olfaction**, and the oral talks will be combined to demonstrations of olfactory displays. People will take part to those demos and will enjoy mysterious experience to have digital olfaction in the daily life.

We will discuss:

- The advances of digital olfaction Research & Development
- The practical applications of digital olfaction

The Digital Olfaction Society Meeting 2018 also will highlight:

- The interdisciplinary sciences related to Olfaction and Digital olfaction.
- The way in which we can transfer the concrete breakthroughs of Research & Development towards industrial applications concerned by digital olfaction.
- How to design and extend the applications of digital smell technologies to everyday life?
- Digital Olfaction and Artificial Intelligence: in this discussion, we will highlight how artificial intelligence will push the digital olfaction into and new level.
- The impact of these applications on our life and lifestyle

We would like to thank all speakers and chairpersons for their contributions:

- **Djamchid Assadi**, Groupe ESC Dijon-Bourgogne, France
- **Marina Carulli**, Politecnico di Milano, Italy
- **Peter de Cupere**, PXL – MAD School of Arts in Hasselt, Belgium
- **Andreas Keller**, Rockefeller University, USA
- **Agata Maria Kokociñska-Kusiak**, Polish Academy of Sciences, Poland
- **Maria Larsson**, Stockholm University, Sweden
- **Thierry Livache**, CSO of Aryballe Technologies, France
- **Jesús Lozano Rogado**, University of Extremadura, Spain
- **Johan Lundström**, Department of Clinical Neuroscience, Karolinska Institute, Sweden
- **Kohji Mitsubayashi**, Tokyo Medical and Dental University, Japan
- **Simon Niedenthal**, Malmö University, Sweden
- **Jonas Olofsson**, Stockholm University, Sweden
- **Dmitry Rinberg,** NYU Neuroscience Institute, USA
- **Tristram Wyatt**, University of Oxford, United Kingdom

We wish you an interesting and great conference here in Tokyo.

Prof. Marvin Edeas
Founder of the Digital Olfaction Society
Université Paris Descartes, France

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6th Annual Meeting of

Digital Olfaction Society

Abstracts for Oral Presentation

Day 1 – December 3, 2018

TARGETING OLFACTORY RECEPTORS BY DIGITAL AGONISTS, AROMAS OR SCENTS: MYTH OR REALITY?

EDEAS, Marvin

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The olfactory receptor (OR) is the first protein that recognizes odorants in the olfactory signal pathway and it is present in over 1,000 genes. Olfactory receptors are G protein-coupled receptors which serve important sensory functions beyond their role as odorant detectors in the olfactory epithelium. Olfactory receptors detect volatile chemicals that lead to the initial perception of smell in the brain.

Most ORs are extensively expressed in the nasal olfactory epithelium where they perform the appropriate physiological functions that fit their location. However, recent whole-genome sequencing shows that ORs have been found **outside of the olfactory system**, suggesting that ORs may play an important role in the ectopic expression of non-chemosensory tissues.

As the outermost barrier of the body, the **skin** is exposed to multiple environmental factors, including temperature, humidity, mechanical stress, and chemical stimuli such as odorants. Keratinocytes, the major cell type of the epidermal layer, express a variety of different sensory receptors that enable them to react to various environmental stimuli and process information in the skin. Recently, the identification of a novel type of chemoreceptors in human keratinocytes, the olfactory receptors OR2AT4, and identified Sandalore, a synthetic sandalwood odorant, as an agonist of this receptor. Sandalore induces strong Ca(2+) signals in cultured human keratinocytes, which are mediated by OR2AT4, as demonstrated by receptor knockdown experiments using RNA interference. The activation of OR2AT4 induces a cAMP-dependent pathway and phosphorylation of extracellular signal-regulated kinases (Erk1/2) and p38 mitogen-activated protein kinases (p38 MAPK).

Moreover, the long-term stimulation of keratinocytes with Sandalore positively affected cell proliferation and migration, and regeneration of keratinocyte monolayers in an in vitro wound scratch assay. OR 2AT4 is involved in human keratinocyte re-epithelialization during wound-healing processes.
The **Gut Microbiota** and Olfactory Receptors are one of the intriguing phenomenons. How Gut microbiota communicate with the brain, skin, kidney, liver...? How they activate OR? What kind of agonist? This is one of questions which will be discussed.

The Digital Olfaction science needs the understanding of how to activate and modulate these multi-locations ORs. Why our nose is everywhere? Can a Digital aroma activate skin OR? A multi-disciplinary collaboration is urgently needed between experts of olfactory receptors and the digital science.
Finally, a strategic question is how digital olfaction world will establish **non-verbal communication** between us (our Olfactory Receptors) and the artificial systems (robots, connected devices…)?

THE STRUCTURE OF OLFACTORY APPEARANCES

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The temporal and spatial aspects of olfactory perception are impoverished compared to the perception of space and time through vision or audition. Furthermore, the perceptual qualities (smells) that are arranged in space and time seem to resist being organized in an orderly system according to similarity in the same way tones and colors are.

The structure of olfactory appearances therefore cannot be described using the framework developed in other modalities. Developing a framework that reflects actual olfactory experience rather than the semantic representation of the experience will be a crucial step in enabling the reproduction of natural olfactory scenes.

SMELL LOSS: A MARKER OF COGNITIVE DECLINE, DEMENTIA AND MORTALITY

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This presentation addresses how impairments in olfactory function are related to ill-health outcomes in aging. Based on unique population-based data from the Swedish Betula Prospective Cohort Study and the Swedish National Study of Aging and Care, we find that olfactory dysfunction is closely related to processes of memory decline, dementia pathology, and mortality. Overall, the findings indicate that olfactory impairment is a valid marker of a declining brain health in old age.

CAN MICE DETECT ODOUR OF NEOPLASM BEFORE CLINICAL SYMPTOMS?

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Recently the ability of animals to distinguish odours of humans suffering from some diseases as cancer, tuberculosis, as well as alerting episodes of hypoglycaemia in diabetes type I or seizure was increasingly reported. Animals are also able to discriminate sick and healthy conspecifics probably on the base of odour. In the last decade the possibilities of using sense of smell of trained and untrained animals have been studied. The most widely studied species are dogs that were used in detection research like: lung cancer (Amundsen et al. 2014), breast cancer (McCulloch M., Jezierski T., et al. 2006), melanoma, (Pickel, Manucy, et al. 2004), colorectal cancer (Sonoda, Kohnoe, et al. 2011), bladder cancer (Willis, Church, et. al. 2004), hypoglycemia (Hardin, Anderson, Cattet, 2015), seizure (Strong, Brown, Walker, 1999). There is also known that another species are able to distinguish odour of healthy and unhealthy individuals like rats in detection of tuberculosis (Edwards, Ellis, Watkins et. al. 2017, Ellis, Mulder, Valverde et.al 2017) or mice, which can distinguish by odour: parasite infections (Kavaliers et al. 2003; Ehman and Scott 2002), influenza (Penn et al. 1996), mouse mammary tumor virus (Yamazaki et al. 2002) and inflammatory processes (Arakawa et al. 2010). Pathological processes involve production of either new volatile organic compounds (VOCs), that were not present in healthy individuals, or changes in the proportion of particular VOCs. Trained mice have been shown capable to distinguish urinary odours from conspecifics with and without experimentally induced lung cancer tumors (Matsumura et al. 2010), however, until now we did not know at what moment the smell appears.

In this research I have proved that mice are able to train to distinguish neoplasm and healthy samples by odour and I found the moment of odours appears. I will present my groundbreaking research that led to the discovery of cancer biomarkers.

A NON-INVASIVE MEASURE OF OLFACTORY BULB FUNCTION IN HUMANS

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Chemosensory neuroscience has the ability to acquire relatively non-invasive recordings from all main stages of human olfactory processing but one, the olfactory bulb (OB). This current lack of recording techniques poses a serious problem for the advancement of our understanding of how the human olfactory system works in health and disease. In this talk, I will outline a new method that enables the measurement of functional processing within the human OB on a millisecond time-scale. By means of active electrode EEG with subsequent wavelet-based post-processing, in a total of 6 individual experiments, we can demonstrate a clear response from the OB that, by exclusion and source analyses, we can demonstrate originate from the OB. Moreover, we can demonstrate that the signal is absence in other-wise healthy patients born without OB.

Finally, I will present data suggesting that the human olfactory bulb is processing both intensity and pleasantness but at different time intervals and in a centrifugal feedback loop with other cerebral areas.

A NON-INVASIVE MEASURE OF OLFACTORY BULB FUNCTION IN HUMANS

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Humans and other animals have the ability recognize olfactory stimuli as the same across a range of concentrations, as well as the ability to segment novel olfactory stimuli from those embedded in the environmental background. However, it remains unclear where in the brain processing related to these kinds of perceptions is occurring. Recent work has suggested that the olfactory bulb, the brain structure that mediates the first stage of olfactory information processing is involved in generating perceptual concentration invariance. Here we asked whether the bulb also contributes to olfactory adaptation. 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 to repeated odor stimulation, which resulted in a decline in the output maps, while the input maps remained relatively stable.

These **results** suggest that the mammalian olfactory bulb may also participate in the perception of sensory adaptation. Our imaging methods should also be useful for determining the input/output transformation in other regions of the mammalian brain.

THE OLFACTORY SYSTEM IN GENESIS OF ALZHEIMER'S DISEASE

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Introduction: Alzheimer's disease (AD) is characterized by cognitive impairment and neurodegeneration in the cortical and subcortical areas related with olfactory system in aging people. Clinical data confirm the olfactory disturbances in AD patients. In the eighties an idea about possible role of the olfactory system in AD genesis was suggested.

Material & Methods: We focused on experimental verification of this hypothesis.

Results: We have shown that the consequences of olfactory bulbs (OB) ablation reproduce the main characteristic features of AD in behavior, biochemistry, electrophysiology, neuronal morphology, and immunology. Amyloid plaques absent in brain of mice and rats was a significant obstacle. However, OB removal induces the plaques in guinea-pigs expressing Aβ analogous to a human one.

Conclusion: Therefore, OB plays the important role in AD genesis, and bulbectomized animals are useful model of this pathology. Recently, we have shown positive effect of YB-1 protein in olfactory bulbectomized and transgenic 5XFAD mice.

This work is supported by RSF № 141400879

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EXPLORATION INTO OLFACTION AND EXPERIENTIAL STRATEGY: STATE OF ART

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From five human senses, smell and taste are still absent in a substantial manner in the virtual reality world. While visual (numbers, words, and images), audition (sounds) and tactile senses are widespread in virtual reality; the sense of smell remains largely absent. Absence of sense of smell also causes absence of taste (and flavor) because the former has a significant impact on the formation of the latter.

Without smell that has a much higher emotional valence than do numbers and words, human experiences are always defective and even confusing in the cyberspace. For example, an Internet user continues to smell olfactory signs of the computer lab, while s/he is virtually in a forest.

The absence of pertinent odor reduces the reality of virtual experience and consequently impedes the deployment of the experiential marketing in the borderless market of the Internet. The olfactory sensation can enhance the sensational experience of virtual reality, increase the stickiness of the website, and consequently lead to deployment of capable online experiential marketing strategies. In addition, smell can get attention through emotions on the Internet where abundant and increasing data and information have made attention a scare resource. In an age where sound and touch have already been mined, scent is the next logical next step in digital experience. It has the potential to tap into very strong emotions.

The research on hands aims to explore the past and current olfactory experiences in the different disciplines. The objective is to provide insights on the development of digital olfactory technologies and the impacts they might have on the deployment of experiential marketing strategies.

In this perspective, the paper respects following structure: First, we briefly present an olfactory sense system. Second, we review the literature on the impact of scents on human experiential attitudes. Third, we study the cases of digital olfactory technologies since the initial experiences up to now in order to pinpoint the factors of failure and success. Forth, we explore the potential of the existent olfactory digital technologies and the relative prototypes on the online experimental marketing strategies. Two methods command the development of this research. We adopt the research method of case study for the analysis of the digital olfactory technologies, and the method of strategic review for the analysis of experiential marketing online and offline.

SEXING UP HUMAN PHEROMONES: HOW A CORPORATION CREATED A "SCIENTIFIC" MYTH

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Pheromones, evolved chemical signals used between members of the same species, have been found throughout the animal kingdom (1). Identifying a pheromone relies on demonstration of an odour-mediated behavioural or physiological response, identification and synthesis of the bioactive molecule(s), followed by bioassay confirmation of activity (2). As humans are mammals, it is possible, perhaps even probable, that we 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 story of molecules claimed to be 'putative human pheromones' provides a classic example of bad science carried out by good scientists (3), making it an excellent example of the 'reproducibility crisis' in psychology (4). Ways to create better, more reliable science are being mapped by psychology researchers in particular, with an emphasis on enhancing reproducibility and using approaches from open science (e.g. 5).

Conclusion: Could olfactory researchers of every kind benefit from these ideas?

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ENANCING USER INTERACTION WITH OLFACTORY EXPERIENCES

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Human beings explore and interact with the external world through the perception that they get by touching, looking at, listening to, tasting and smelling it.
Even if this exploration is essential to identify opportunities and dangers, today it is also used to investigate, understand and enjoy objects that surround us and to use them to manage our life, have fun, increase our knowledge, relax, etc.

To date, interaction is based primarily on sight – through images, videos, texts and symbols -, on hearing - through audio information, voice commands, and on touch - through elements to touch, rotate, push, handle to write and draw, etc. Very little interaction, however, is based on smell, a sense considered very difficult to manage and to use for creating more pleasant and effective experiences.

Yet, olfactory experiences, if appropriately designed and implemented, can make the interaction between users and objects more engaging and effective on sub-conscious levels and long-term memory.

This work presents several examples of olfactory experiences integrated in applications for cultural and learning purposes, and for entertainment and wellness, and effectively used to enhance the user interaction and experience.

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THE LANGUAGE OF SMELL: CONNECTING LINGUISTIC AND PSYCHOPHYSICAL PROPERTIES OF ODORS

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Olfactory research and commercial applications rely on accurate verbal descriptions of odor quality. However, the relationship between olfaction and language is tenous, and little is known about how odors are described in natural language. We analyzed 100 million websites (English language) to quantify olfactory word associations, and we developed a 2D semantic space where these words are placed according to their degree of ”odor association” and ”odor specificity”. This 2D odor-semantic space was then validated via large psychophysical datasets.

Our **results** show that our 2D space captures important properties of odor words, properties that should be considered whenever odor qualities are assessed verbally.

THE POWER OF SCENTS – SCENT IN CONTEXT

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Smell is a powerful sense that offers many possibilities. By combining odors with another sensory organ, an interaction is created to give both senses a greater impact. The context of an odor or image can also change by cross-over with a different sense. In his lecture he explains how the use of scents can create awareness.

How smells are perceived and how they have impact on the spectators and media. He let the spectator experience the smell of Air Pollution that was used for his work Smoke Flowers in which he has managed to conjure real flowers to regurgitate the fumes of industrial pollution. Furthermore, he discuss other examples of the use of smell to raise public awareness of environmental situations.

PERSONAL SCENT FOR A HEALTH AND PRODUCTIVITY MANAGEMENT

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Introduction: We demonstrate user-trials of Sony's AROMASTIC in some specific situations to see how a personal scent effects for work-performance, stress-management, and conditioning.

Results: The second-scale and personally localized scent helped people to get focus on their task (1). It also accelerated junior high school students to solve calculation. From user trials, we also had preliminary results where it supports people to reduce a daily number of smoking.

Conclusion: These case studies suggest that the personal scent has a substantial opportunity as one of a solution to support a health and productivity in points of costs for time, space, and performance.

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SMELLS OF A MODERN WORLD: HOW TO IDENTIFY AND CHARACTERIZE ODORANTS IN CONTEMPORARY MATERIALS

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Introduction: Humans in our modern world are exposed to a multitude of odorous compounds. Many of these arise from consumer products, such as plastic toys, glues or building materials. However, these odorants have hitherto been rarely investigated and little is known about such substances. In view of this, we analyzed and identified the odorants in adhesives, diverse children's toys, and several types of wood.

Material & Methods: Odor-active compounds in the samples were investigated using one and two dimensional gas chromatography-olfactometry (GC-O). This analytical approach makes use of the human nose as a sensitive and selective detector for the targeted elucidation of odorants, combined with an analytical detector.

Results: A wide variety of odorants was successfully identified in the samples, such as diverse alkylated derivatives of naphthalene and phenol, as well as residual solvents in the toys, several acrylates in adhesives or different terpenes in the wood samples.[1-4]

Conclusion: Modern chemo-analytical tools have been shown to be effective in elucidating odorants in contemporary materials. Knowledge of the causative substances and their smell properties deepens our understanding of the underlying principles of smell perception, thereby providing a basis for future applications of data analytics in conjunction with machine-learning tools.

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SCENTS AND MEMORY IN VIRTUAL REALITY

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The present aim was to investigate the effects of authentic and synthetic odors to memory in virtual reality (VR).

Participants (N=30) navigated through a VR environment and interacted with 12 virtual objects. Interaction was varied by scent authenticity (i.e., authentic or synthetic), congruency of scent and the VR object (i.e., congruent, incongruent, and no scent), and interaction style (i.e., participants could look or look and touch objects). There were two authentic scents (lemon and jasmine) and two synthetic scents (cis jasmone + benzyl acetate to imitate jasmine and limonene to imitate lemon).

The scents were routed to the nose using a mask connected to our gas based scent synthesizer. After navigation, the participants listed the objects they remembered. Interaction with each object was rated using scales of pleasantness and arousal.

The results showed that objects with congruent scents were remembered significantly better than objects with incongruent or no scents. Scent authenticity and interaction type had no effect on recall or ratings. Interaction was significantly more pleasant when scents were congruent with objects than when they were incongruent.

The findings give evidence that congruent synthetic odors can function as well as authentic ones in VR.

HUMAN RESPONSE TO SENSORY EFFECTS ON 360° VR CONTENT

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The purpose of this study is to investigate the effect of the scent and wind effects on the 360° VR (Virtual Reality) video content that affect the satisfaction, sense of presence, and immersion of the experimental participants. We implement a sensory effect creation system that provides users with sensory effects by recognizing the objects they see in the 360° VR video. Each participant experiences scent and wind effects in the 360° VR environment and responds to pre-prepared questionnaires. The experiment participants are divided into three groups (i.e., group w/ scent only, group w/ wind only, group w/ scent+wind), and the satisfaction, the sense of presence, and the immersion degree are measured. As a result of ANOVA, there is a considerable difference among experimental groups in degree of the satisfaction, immersion and sense of presence. In addition, analysis of the difference through post-test (Scheffe) shows that providing multiple sensory effects on 360° VR content affects better on immersion, satisfaction, and sense of presence than providing a single sensory effect. In the single effect presentation, it is found that providing a scent effect affects better on immersion, satisfaction, and sense of presence than providing a wind effect.

This work (Grants No. 1425114682) was supported by Business for Startup growth and technological development (TIPS Program) funded Korea Ministry of SMEs and Startups in 2017.

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Annual Meeting of

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Abstracts for Oral Presentation

Day 2 – December 4, 2018

MINIATURIZED ELECTRONIC NOSE SYSTEMS FOR DIGITAL OLFACTION: PRESENT AND FUTURE APPLICATIONS

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Electronic nose systems are devices that transform scents or odours into a digital signal. They consists basically of a sensor array, which generates an electrical signal from the concentration of different chemical compounds, an electronic instrumentation system to measure that signal and a signal processing system for data interpretation. In recent years, there have been great advances in the main components of an electronic nose system that have allowed a reduction in the size, consumption and cost of these devices, which could contribute to extend the use of this devices for digital olfaction.

This study addresses the development of two miniaturized (60x60mm) wireless sensing module (electronic nose) for digital olfaction. The proposed prototypes has several sensors (humidity, ambient temperature and gas). The core of the system is based on a high performance microcontrollers. The obtained data values were transmitted to the Smartphone through a Bluetooth communication module and a home-developed Android app. The discrimination capability of the modules have been tested with different scents and results show high success rates in classification stage.

This work will analyze the applications in which this systems are being used now and future applications of interest.

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BIO-ELECTRONIC NOSE: A MOUSE NOSE AS AN ULTRA SENSITVE AND VERSATILE CHEMICAL DETECTOR

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One of the best chemical detectors in the world are the ones which are results of millions of years of biological evolution. Despite of a significant effort dedicated to developing artificial detectors for volatile organic components, an animal nose outperforms majority of these detectors by versatility, speed, and often detectability of specific volatile chemicals. That manifests in using trained animals for chemical detection in homeland security, defense, healthcare, agriculture, and other fields of human activities. Here we propose an alternative approach to capitalize on the superior capability of mammalian olfaction. We engineer a new bio-electronic nose based on a brain-machine interface designed to capture the neuronal signals from an early olfactory system of an awake mouse and use machine learning techniques to form a sensitive and selective chemical detector. We chronically implanted a grid electrode array on the surface of the mouse olfactory bulb and systematically recorded responses to a large battery of odorants and mixtures in a wide range of concentrations. The detection sensitivity of our bio-electronic nose is comparable to the sensitivity of a trained animal used as a benchmark. We tested the detection accuracy under variable background masking conditions. We also introduce novel genetic engineering approach designed to improve the sensitivity of our bio-electronic nose for specific targets. Our bio-electronic nose outperforms current detection methods and unlocks a wide spectrum of civil, medical and environmental applications.

SNIFF-CAM FOR REAL-TIME IMAGING OF VOLATILE CHEMICALS

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Introduction: In the fields of medical and healthcare, human volatiles are non-invasive biomarkers of some diseases and physical conditions. In this study, a novel gas-imaging system (Sniffcam) for gaseous ethanol (EtOH) and acetaldehyde (AcH) and physiological applications for ethanol imaging in breath and skin gas after drinking.

Materiel & Methods: The Sniff-cam employed a UV-LED sheet, a camera and an enzyme mesh with NADH dependent alcohol dehydrogenase (ADH). The oxidation/reduction reaction catalyzed by ADH is controllable with pH of buffer solution. NADH that was used in the oxidation/reduction reaction as a co-enzyme shows auto-fluorescence at 490 nm by UV irradiation at 340 nm.

Results: The imaging of the distribution of EtOH (or AcH) was possible by measuring the increase (or decrease) of fluorescence intensity of NADH on the ADH mesh. The sniff-cam showed not only wide dynamic range against to EtOH or AcH but also the high selectivity. The sniff-cam was also succeeded to image the concentration distribution of EtOH and AcH transpired from skin surface.

Conclusions: The sniff-cam for imaging distribution of gaseous EtOH and AcH was developed, and it was successfully applied to visualize both volatiles in breath and skin gas after drinking.

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OWIDGETS: A DEVICE-INDEPENDENT TOOLKIT FOR OLFACTORY EXPERIENCE DESIGN

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Introduction: While other modalities like vision, hearing, and touch are supported with interaction techniques, design tools, and widgets, such a support does not exist for the sense of smell. Several delivery devices have been developed [e.g., 1] but they are linked to single applications or proprietary software. These devices and software solutions do not allow for replicable olfactory experience design. Hence, the interaction design community is missing out on many opportunities to improve interactions through olfactory stimulation [2].

Material & Methods: Here we present OWidgets, a toolkit to enable olfactory experience (OX) design. We propose a device-independent software solution which enables the creation and replication of OXs [3]. We identified a set of olfactory design features and discuss how these features were exploited in the design of three user studies including VR and desktop implementations.

Results: We present details on the functionalities of the toolkit and preliminary results from the user studies that demonstrate the positive effect of olfactory stimuli on user's performance.

Conclusion: We discuss the relevance of OWidgets and the opportunities emerging through a device-independent toolkit for olfactory experience design. We highlight remaining challenges and future directions to extend and integrate the toolkit into the wider audio-visual ecosystem.

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NEOSE INSTRUMENT: IMAGING AN ODOR

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Beyond the classical lock/key-recognition-based approach in used in the bio-analytical field, an electronic tongue or nose device (eT/eN) is an assembly of non-specific sensors. The information given by each sensor is complementary and the combination of all sensors' results generates a unique fingerprint. Following a long story around the imaging of biological interactions of biomolecules by Surface Plasmon Resonance, we extended this approach to the non-specific interactions' studies in liquid phase (optical E-tongue) using a combinatorial approach of bioreceptors. The signals resulting from the interactions of analytes on this surface can be seen as 3D continuous dynamic images or movies. The recent extension of this approach to the VOCs analysis in gas phase has led to the construction of a new optical-nose generation. The binding of VOC on the array of bio-inspired materials will give rise to a local change of reflectivity of the surface that can be recorded in real time by a ccd camera. This dynamic and biomimetic approach can analyze a sample at room temperature without complex concentration/desorption process and remains fully compatible with unstable volatile molecules. Moreover, since this approach relies on an imaging process, the number of biosensors used in parallel can be easily extended from one hundred, currently used, to few hundreds if necessary. This flexible and straightforward approach allowed a down-scalling of the device and a new miniaturized portable and generic opto-nose *Neose* was recently launched. Finally, complex data obtained from odors are analyzed as simple images via a specific database. The translation of a smell into an image could be seen as a first step to open up the merging of the olfactory and visual senses…

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SMELL–ENABLED VR GAMES FOR OLFACTORY TRAINING

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Digital games have been used as experiment stimuli within psychology research since the mid 1970s (Washburn 2003). The rationale for employing games has traditionally focused upon the benefits accruing from the complexity of the world that can be represented to the subject, positive effects upon the subject, and the benefits of digital games as a research platform. First, the current capabilities of game engines allow for the rendering of rich and nuanced worlds that present tasks to the subject in an environment of high ecological validity. Moreover, it is believed that games are an engaging, motivating, challenging and familiar cultural form that may be more enjoyable for subjects than standard psychology texts. And, finally, digital games serve the needs of researchers to control experimental variables, present repeated and consistent stimuli to subjects, log and archive test data, and build common platforms for comparison of results (Washburn 2003, Camillo-Gamez et al 2011, Järvelä et al 2012). Historically, the repetitive aesthetic of digital gamplay has lent itself to studies of instruction and training. From 1983-´86, the custom-designed game Space Fortress was used to investigate the role of practice in skill acquisition (Donchin 1995). "Some of the earliest research uses of computer games were as tools for teaching or training, and these applications have remained popular across the decades" (Washburn 2003, p. 190).

Expanding the use of digital games as experiment stimulus to the area of olfactory training calls for the creation of an immersive research platform that includes a digital olfaction system and scent output through an olfactory display. One recent study questions the value of 2D gamelike features in psychology research (Hawkins et al. 2013), but there is evidence that gameplay in rich and immersive environments enhances cognitive benefit when compared to simpler "gamified" applications (Shute et al. 2015). Consequently we have chosen to develop our olfactory training games for the HTC Vive VR system, and we have also developed a handheld olfactory display that outputs scent from the Vive controller (we presented the initial design at the 2016 DOS congress). Developing games for this platform begins with identifying olfactory targets for training, and designing suitable game mechanics and challenges. Olfactory targets can include any smelling behaviour that can be trained, and that allows for performance tracking and comparison. We will conclude with lessons learned in our current experiment with scent and spatial memory in a VR environment.

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EXPLORATION OF BIOLOGICAL OLFACTORY MECHANISM USING RANDOMLY MIXED RECEPTOR SIGNALS DECODED BY RESERVOIR COMPUTING

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Introduction: To explore the mechanism behind the olfactory neural system discriminating numerous mixed odorant molecules encoded by relatively fewer olfactory receptors (ORs) [1], we investigated the learning and discrimination process of randomly mixed receptor signals decoded by reservoir computing (RC), a class of extended neural networks [2]. We achieved quantitative discrimination of mixed odorant molecules even in the case of learning only individual concentrations.

Material & Methods: Mixed odorant molecules were encoded as optical images of two randomly mixed kinds of insect cells expressing different insect ORs along with Ca^{2+} indicator fluorescence protein [3]. Output weights of an RC network were optimized for the individual concentrations and used to discriminate the mixed concentrations.

Results: Even when the number of signals from randomly mixed cells was increased to virtually mimic a "generalist" receptor profile, a relatively high discrimination accuracy was preserved with an optimized RC network compared to a linear regression.

Conclusion: RC can act as a part of the biological olfactory neural system to decode the signals of generalist ORs that efficiently encode numerous mixed odorant molecules.

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NEURAL NETWORK WITHIN AN OLFACTORY SENSORY UNIT FOR NESTMATE AND NON-NESTMATE DISCRIMINATION OF ANT: THE ULTRASTRUCTURES AND MATHEMATICAL SIMULATION FOR OLFACTORY IMFORMATION MODIFICATION

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Introduction: Ants are known to use a colony-specific blend of cuticular hydrocarbons (CHCs) as a pheromone to discriminate between nestmates and non-nestmates and the CHCs were sensed in the basiconic type of sensillum (S. basiconica), which possesses >100 olfactory receptor neurons (ORNs).

Materiel & Methods: To investigate the functional design of this type of sensillum, we observed its ultrastructure, using a serial block-face scanning electron microscope, and reconstructed a 3D model of the sensillum. As physiological experiments were difficult to be conducted, we attempted mathematical simulation for elucidating functional property of this olfactory system.

Results: Our study revealed that the dendritic processes of ORNs in S. basiconica had characteristic beaded-structures. At the “beads,” the cell membranes of the dendritic processes were closely adjacent, forming functional interactions via GJs. These data suggest that the ORNs form an electrical network via GJs between dendritic processes. With the aid of simulation of a mathematical model, we further examined the putative function of this novel neural network.

Conclusion: This is the first report of inter-neuronal network within an olfactory sensory sensillum, and our mathematical simulation suggested that its functional property seemed to play a role in flexible modification of olfactory information processing.

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CHALLENGES IN THE APPLICATION OF MACHINE LEARNING METHODS TO THE PREDICTION OF ODOR AND HOW TO ADDRESS THEM

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Introduction: Although Machine Learning methods have huge impact in various fields, it is still not possible to predict odor satisfactorily.[1] A key to successfully apply these methods is sufficiently good data. These algorithms have specific requirements on the data they are trained with, such as the quantity, the noise it is afflicted with and a reliable annotation.[2] Odor-quality datasets lack most of these requirements, as they are typically small and their annotation is noisy in such way that they are highly subjective and disparate, as well as they contain unspecific descriptors.

Material & Methods: To provide a high-quality data basis for Machine Learning approaches, a unique set of objective and possibly chemical descriptors for odor classification is being defined. Subsequently a few hundred odor qualities are being collected in an expert panel trained on the previously defined set of descriptors.

Results: To create a valuable database connecting molecular structure and odor quality we systematically reevaluated the sensory properties of several hundred selected target compounds and subsequently minimize distracting noise.

Conclusion: In order to apply modern machine learning methods towards odor predictions, we create a suitable data base for training classifiers.

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ODOR SENSING AND CLASSIFICATION BY USING MACHINE LEARNING

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Introduction: The smell information has played an important role for our lives as being one of five senses. Human beings have done the culture or action by using those senses. In the course of evolution, those five senses have had different progresses. In this paper, we have used an array of the MOGSs to measure the smells. Furthermore, using learning vector quantization, we classify the smells into three typical smells of human body and show the results in visible form using a smart phone. We have named the hardware configuration as Kunkun (which means sniff-sniff in Japanese) Body.

Methods: The sensors are metal oxide semiconductor gas type and the method used for classification is machine learning. After applying the coffee company names and kinds of coffee, we apply real chemicals with four inputs and three outputs competitive neural network.

Results: In order to apply for classifying typical three smells of human body, we developed hardware using smartphones with Bluetooth. The training data are 2,100 persons who were selected ten levels for Sweaty, Middle-age, and Well-aged smells. Thus, each category consists of 700 persons and each class 70 persons, who were selected by specially trained perfumers. After training the network, total number of output layers are 30 has been settled. The total system has been named Kunkun Body and it has been sold in the market.

Conclusion: Kunkun Body is produced in the style of open innovation and the production capital was used Cloud Funding system. Therefore, we could get much knowledge about the style, color, weights, etc.

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STABILITY OF THE VORTEX RING TRAJECTORY BY THE SHAPE OF THE APERTURE FOR GENERATING SCENT FIELDS

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Scent projector is a system for presenting a scent locally to a user by conveying a scent using vortex rings [1]. By letting two vortex rings collide and collapse, it is possible to make scented spots appear in free space. In order to improve the success rate of the collision, it is necessary to stabilize the vortex ring trajectory. AIREAL [2] uses a vortex ring as a tactile display, and an optimum aperture of air cannon was examined.

However, the required characteristics are different between when a vortex ring is used as a tactile display and when it is used as an olfactory display. Therefore, we created various apertures (Figure 1) and examined the optimal aperture for stability of the vortex ring trajectory. We setup an experimental environment to measure the trajectory of vortex ring (Figure 2). Vortex rings were expelled multiple times using each aperture, and the standard deviation of the vortex ring position was measured (Figure 3). As a result, it was revealed that the stability of the vortex ring trajectory can be improved by using an aperture that extrudes curvedly forward from the body.

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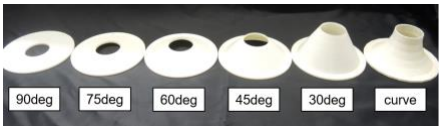

Figure 1. Aperture of air cannon

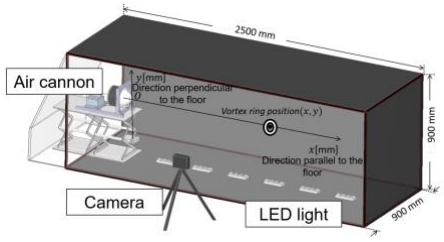

Figure 2. Environment measuring vortex ring *[1]*

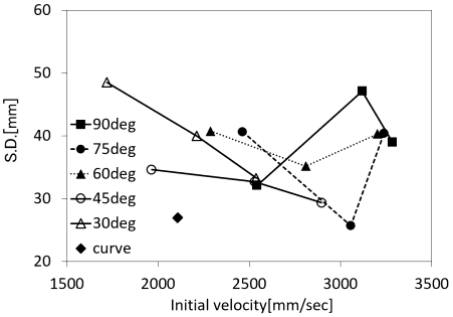

Figure 3. Standard deviation in the direction perpendicular to the floor surface

ONLINE SCENT CLASSIFICATION USING MEASUREMENTS FROM AN ION-MOBILITY SPECTROMETRY-BASED ELECTRONIC NOSE

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Transferring scents from one location to another requires the scent to be measured and classified. For measurements we used the ChemPro100i, an ion-mobility spectrometry-based electronic nose (eNose). For classification an approach based on K nearest neighbors (KNN) classifier was used. One problem with the eNose measurement is that it suffers from a transient measurement phase when first placing the odorous object in front of it. Once stabilized, the temporal responses are still volatile, meaning that they fluctuate around the stable state. Furthermore, environmental factors (temperature, humidity, etc.) affect the movement of molecules and hence the measurements with the eNose. Our tests showed that by measuring 30s of ambient air before measuring the scent the impact of environmental factors could be mitigated. Furthermore, by using sequences of measurements, rather than single measurements, from the eNose for scent classification we improved the accuracy of the KNN classifier and used measurements already from the transient phase for classification. The proposed KNN-based classifier also provides information on the trustworthiness of the provided label for the analyzed scent.

DIGITAL OLFACTION WITH GRAPHENE

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Ethene is a highly diffusive and relatively unreactive gas that induces aging responses in plants in concentrations as low as parts per billion. Monitoring concentrations of ethene is critically important for transport and storage of food crops, necessitating the development of a new generation of ultrasensitive detectors. In this talk I will show that by functionalizing graphene with copper complexes biologically relevant concentrations of ethene and of the spoilage marker ethanol can be detected. Importantly, in addition these sensors provide us with important insights into the interactions between molecules, a key concept in chemistry. Chemically induced dipole fluctuations in molecules as they undergo a chemical reaction are harvested in an elegant way through subtle field effects in graphene. By exploiting changes in the dipole moments of molecules that occur upon a chemical reaction we are able to track the reaction and provide mechanistic insight that was, until now, out of reach. To conclude I will discuss the important requirements and unconventional device designs to multiplex the development of graphene as a selective sensor, towards digital olfaction and biomimetic nose sensors.

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Annual Meeting of

Digital Olfaction Society

Abstracts for Demonstrations & Displays

Day 2 – December 4, 2018

TECHNOLOGY FOR SCENT CLASSIFICATION AND PRODUCTION

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We propose a demo that showcases classification and production of scents. In the scent classification part, we measure scents with ChemPro100i, an ion-mobility spectrometry-based electronic nose (eNose). The measurements are then used to label the scent using a classifier based on the K nearest neighbors (KNN) approach. The classification results are shown in real time on a display. The scent classification technology could be used, for example, in quality control in the food industry. In the scent production part, we will present an olfactory display prototype that is used for adding scents to objects seen in virtual reality (VR). Through a VR headset, the user sees an environment with two types of objects; a lemon and jasmine vase. When the user picks up one of the objects, a scent congruent with the object is routed to the nose using a mask connected to the olfactory display. It is possible to use authentic scents originating from a headspace or synthetic scents based on vaporized liquid odorants. This scent production technology could be used, for instance, in experimental research to study whether users perceive synthetic scents similarly to authentic scents in VR.

TRANSMITTING AROMAS BY USING A MINIATURIZED ELECTRONIC-NOSE AND AN OLFACTORY DISPLAY

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This demonstration will be the first attempt to transmit aromas from one place to another by the Perception and Intelligent Systems Research Groups of the University of Extremadura. It will consist on a simple test for transmitting 4 aromas of different beverages. The system developed for this purpose can capture odors, turn them into digital data so as to transmit them to a smartphone via Bluetooth, identify the aroma, sending to the olfactory display in order to be restored. This system consist on a miniaturized electronic nose, a smartphone, a wifi router and an olfactory display.

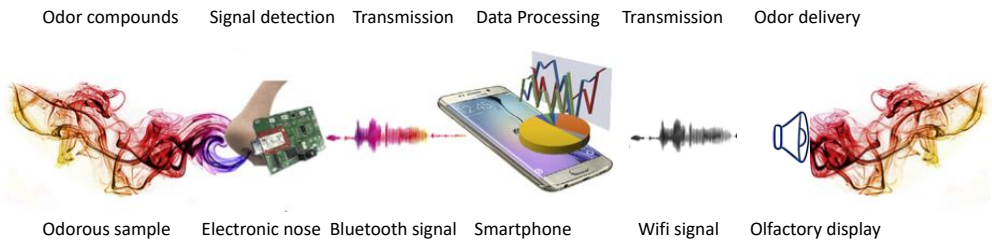

Figure 1. Scheme of the system for transmitting aromas.

The electronic nose used for detecting aromas is connected with a smartphone through Bluetooth connection [1, 2]. The control of the system is based on a PIC18F46K80 microcontroller. It includes four miniaturized MOX sensors and an integrated sensor of temperature and humidity with the appropriate conditioning circuits. The communications with the smartphone are made with a Low Energy Bluetooth Transmitter. An Android app is made to connect the electronic nose with the olfactory display and to control the experiment. The olfactory display is based on a wifi receiver with remote activation of digital outputs and a fluidic system based on electrovalves and pumps that will restore the 4 aromas in the destination.

This simple test opens the door to future more complex transmissions in which more scents and aromas could be detected and transmitted in different applications, by using more sophisticated e-noses and olfactory displays.

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PRESENTATION OF SONY NEW PRODUCT "AROMASTIC"

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We demonstrate our personal scenting product "AROMASTIC" with various kinds of cartridges. AROMASTIC is a product that stimulates olfactory system and unleash human senses just like forbidden fruits.

The personal and momentary diffusion provided by AROMASTIC enables a free use of scents even in public environments such classrooms and offices for people with different conditions and in various situations.

Annual Meeting of

Digital Olfaction Society

Abstracts for Poster Presentation

by alphabetical order

SNIFF OLFACTOMETERY: ELEMENTAL AND CONFIGURAL PERCEPTIONS

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Odorant mixture perception is either elemental, i.e. the resulting behavior is a conditioned response to a component of a mixture, or configural, i.e. the resulting behavior is a conditioned response to a pattern of components in the mixture.

Experimentally, the use of elemental or configural odor decoding is controlled by the nature of the conditioning steps in the experiment. In a more natural setting humans, as well as lobsters, use decoding methods determined by events in their ecological history1. The response of humans to complex mixtures is driven by a small number of key odorants (3 to 7) while many other odorants, well above their thresholds, are often ignored2-3. Determining what odorants are essential for configural odor perception is important to how mixtures are decoded. The most potent odorants in commercial almond milk were analyzed by GCO-SPME and tested in a SO that delivers 15 ml headspace puffs with a 70 m sec stimulus duration and psychophysical software. GCO-SPME found hexanal (grass), 1-octene-3-ol (mushroom), and 2,3,5-trimethylpyrazine or 2-acetyl-1- pyrroline (nuts) to be key odorants for the configural perception of almond milk41.

It appears that among the most potent odorants those with the most divergent odor quality are key.

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MICROBIAL VOC FINGERPRINTS: RAPID DETECTION OF ANTIMICROBIAL RESISTANCE IN PATHOGENIC BACTERIA

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The US Centers for Disease Control and Prevention (CDC) estimates that at minimum, 2 million people in the United States are infected with antimicrobial resistant (AMR) bacteria, resulting in 23,000 deaths each year. With no projected decrease in the number of deaths and the ever-growing threat of multi-drug resistant bacteria, the development of a rapid and accurate diagnostic test is crucial, not only to reduce the burden on the public healthcare system, but to save countless lives.

Microbial volatile organic compounds (mVOCs) are a structurally diverse group of microbial-derived metabolites, generally related by their volatility at ambient temperature. There is great diagnostic potential for mVOCs, as numerous studies have identified unique mVOC- fingerprints indicative of specific bacterial pathogens. In addition, specialized headspace sampling methods, such as solid-phase microextraction (hSPME), coupled to gas chromatography, have enhanced the isolation, preconcentration, and analysis of mVOCs from biological specimens. Herein, we describe the development and assessment of our newly developed and patented metabolomics method known as “simultaneous multifiber headspace solid-phase microextraction (simulti-hSPME),” for the rapid and minimally invasive preparation of mVOC fingerprints. This method is evaluated against antimicrobial susceptible and resistant strains of *Yersinia pestis* and *Francisella tularensis*.

TOWARDS VISUALISING HOUSEHOLD AIR POLLUTION: CHEMO-RESPONSIVE SENSORS FOR VOLATILE ORGANIC COMPOUNDS

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Introduction: The World Health Organisation estimate that 3.8 million deaths are attributed to household air pollution annually[1]. Concentrations of volatile organic compounds (VOCs) are consistently higher indoors than outdoors and can have seriously harmful health effects[2]. Measurement of individual exposure to airborne is an integral part of human health risk assessment, but urgently requires development of appropriate tools to assist evidence-based public health and environmental measures. The development of colourimetric sensor arrays to measure VOCs in indoor air is presented herein.

Materials & Methods: A range of chemo-responsive dyes incorporated in porous matrices of organically modified siloxanes and plasticizers were deposited on solid supports. Imaging of sensors yielded RGB colour values that were used to evaluate response to a selection of VOCs.

Results: Sensor colour change upon exposure was quantified to generate calibration data and determine linear ranges of the array. Examination of sensor colour space revealed multidimensional fingerprints unique to different VOCs.

Conclusion: This method shows promise towards visualizing the presence of VOC air pollutants indoors using a low-cost portable approach. The sensor array is currently being applied to fingerprinting VOC emissions associated with common household activites. Future work will target algorithm development for recognition of household air pollution events that can impact human health.

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SPECIFIC INTRANASAL AND CENTRAL TRIGEMINAL ELECTROPHYSIOLOGICAL RESPONSES IN PARKINSON'S DISEASE

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Introduction: Olfactory dysfunction is a frequent early non-motor symptom of Parkinson's disease (PD). Olfactory dysfunction related to PD may be different from other olfactory disorders, especially with regards to its influence on trigeminal perception: trigeminal sensitivity is unimpaired in PD patients as opposed to patients with non-Parkinsonian olfactory dysfunction (NPOD). However, the underlying mechanisms remain unknown.

Materiel & Methods: We investigated the trigeminal pathway measuring peripheral and central electrophysiological recordings in response to a specific trigeminal stimulus in 21 PD patients and compare them to 23 NPOD patients and 25 controls.

Results: On peripheral levels PD patients showed faster responses than NPOD patients. On a central level, PD patients showed larger early components response compared to NPOD patients. A discriminant analysis revealed a model that could accurately predict group membership for 80% of participants based on the negative-mucosa-potential latency, olfactory threshold, and olfactory discrimination test.

Conclusion: These results provide novel insights on the pattern of trigeminal activation in PD patients on peripheral, central and behavioral levels which will help to differentiate PD-related olfactory loss from other forms of olfactory dysfunction. This appears to be a crucial step towards establishing early screening batteries for PD including smell tests.

COLORIMETRIC SENSING OF VOLATILE ACIDS FROM THE BODY

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Introduction: Hundreds of volatile organic compounds (VOCs) are emitted from the human body. VOC emissions can reflect internal metabolic processes, where infection or metabolic disorders can alter the normal VOC profile[1]. Many VOCs emitted from the body are carboxylic acids. Patients suffering from severe respiratory failure present increased levels of volatile acids in their blood[2]. Determination of volatile acid levels present in the body typically rely on invasive methods[3]. VOCs in blood may be released via the skin[4], offering the possibility for non-invasive monitoring of volatile acids.

Material & Methods: The development and characterization of a colorimetric sensor array will be presented. The sensor array is comprised of pH-responsive dyes immobilized in a porous sol-gel matrix on a flexible substrate. This functionalized substrate is worn on the body at different locations for periods of time and its colorimetric response to skin volatiles monitored.

Results: The results show that the concentrations of volatile acids being emitted from the body are location-dependent. This is likely due to a diversity of gland distributions and microbiota at different locations on the body[4].

Conclusion: Development of non-invasive technologies for detection of VOC biomarkers are attracting significant interest for disease diagnosis and management. This research represents an initial wearable colorimetric sensor prototype for skin volatile monitoring.

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OVEREXPRESSION HUMAN DOPAMINE RECEPTOR USING BACTERIAL EXPRESSION SYSTEM FOR CONSTRUCTION DOPAMINE DETECTION SENSOR

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In the brain and central nervous system, dopamine plays a crucial role as a neurotransmitter for interneuronal communication. Therefore, dopamine detection is essential for medical diagnosis. Herein, we present a novel human dopamine receptor (hDRD1)-conjugated multidimensional conducting polymer nanofiber (NF) membrane for the selective and sensitive detection of dopamine.

The hDRD1 is expressed in Escherichia coli before immobilized onto the MCPEDOT NF. And the membrane, which consists of multidimensional carboxylated poly(3,4-ethylenedioxythiophene) (MCPEDOT) NFs with nanorods, is used as a transistor in a liquid-ion gated FET-based biosensor.
We successfully achieved the overexpression of hDRD1 in a bacterial expression system, which has the advantage of simplicity, convenience, low cost, and high productivity. The receptor integrated into the MCPEDOT NF membrane based FET system by covalent bonding.

The FET device can be integrated into a poly(dimethyl siloxane)-based microfluidic system and retain its high performance in fluidics, which results in the generation of large-scale dopamine biosensors with a novel geometry.

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FET BIOSENSOR FOR DETECTION OF TOLUENE GAS

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Here, the ability of toluene binding domain (TBP) of *Pseudomonas putida* interact with toluene using a FET biosensor is presented. Especially, we adopted an easily accessible capturing approach based on silicon binding peptide for the immobilization of toluene binding domain on silicon surfaces. With this toluene binding domain possessing high toluene affinity, silicon binding peptide-tagged TBP was produced as a fusion protein tagged with silicon binding peptide using genetic engineering technique. The biggest benefit of using this straightforward method is that the recombinant fusion protein does not require (Si) surface modification to attain desired functionality, thus enabling easier, faster, and more efficient immobilization of ligands on silicon surfaces. After the purification of corresponding fusion receptor proteins, and the immobilization of silicon binding peptide-tagged TBP onto a FET gate sensing layer, the bioFET for toluene detection was evaluated.

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TWO APPROACHES TO BIOELECTRONIC SENSOR MIMICKING INSECT CHEMOSENSORY SYSTEM

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The reception of chemical cues in the environment is essential for the survival of almost all organisms. Insects rely on a powerful sense of chemical to locate habitats and food sources, to identify mating partners, oviposition sites and predators. For recognition of chemical signals, insects use several families of receptor, including olfactory receptors (ORs), ionotropic receptors (IRs) and gustatory receptors (GRs).
Here, we applied bioelectronics sensors using a couple of GRs of the honey bee, *Apis mellifera.* Although there are only 12 GR genes in *A. mellifera*, taste detection is highly sensitive especially about nectar (sugars) and pollen (amino acids). We first demonstrated that two GRs of*A. mellifera*, AmGr1 and Gr10, are sugar and umami (amino acids) receptors respectively using *in vitro* experiments.

The first approach was that carbon nanotube field effect transistors with floating electrodes (CNT-FET) were hybridized with nanovesicles containing AmGr10. The other was that using microfluidic system AmGr1 expressed cells were compartmentalized into nano-droplets.
The results of these were shown high sensitivity and selectivity.
These systems provide powerful platforms for various applications (e.g. food screening and healthcare). Further studies can be applied for a different sensation, such as olfaction.

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PERSONAL ELECTRONIC NOSE FOR BEER AROMA DETECTION

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Beer is one of the most consumed beverages in the world. The quality of aroma or taste is a key factor for the clients. For this reason, it is important that the aroma remains within quality standards. Traditionally, these controls have been made by beer-taster or chemistry analysis devices. Electronic noses appear as a complement in the decision-making process due to these provide objective data [1].

A wireless electronic nose, WiNOSE, is employed for detection of beer aroma, with the objective of differentiation among aromas in beer samples. This is the previous step to determine if a beer sample includes in the standard. In this process, several types of beers with different aromas have been used. The measurement and control program has been developed in Labview and the data classification with Artificial Neural Networks (ANNs) in Matlab [2].

For the realization of the measures, the beer samples have been prepared, eliminating the gas with a magnetic stirrer without foam generation. Subsequently, the sample is introduced in a vial, which is heated in a thermostatic Bath. The measurements of beer samples have been done by using headspace dynamic technique. The success rate obtained in alcohol-free beers was 100%, while in tests with alcoholic beer samples the success rate obtained was 62%.

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ONLINE SCENT CLASSIFICATION USING MEASUREMENTS FROM AN ION-MOBILITY SPECTROMETRY-BASED ELECTRONIC NOSE

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Transferring scents from one location to another requires the scent to be measured and classified. For measurements we used the ChemPro100i, an ion-mobility spectrometry-based electronic nose (eNose). For classification an approach based on K nearest neighbors (KNN) classifier was used. One problem with the eNose measurement is that it suffers from a transient measurement phase when first placing the odorous object in front of it. Once stabilized, the temporal responses are still volatile, meaning that they fluctuate around the stable state. Furthermore, environmental factors (temperature, humidity, etc.) affect the movement of molecules and hence the measurements with the eNose. Our tests showed that by measuring 30s of ambient air before measuring the scent the impact of environmental factors could be mitigated. Furthermore, by using sequences of measurements, rather than single measurements, from the eNose for scent classification we improved the accuracy of the KNN classifier and used measurements already from the transient phase for classification. The proposed KNN-based classifier also provides information on the trustworthiness of the provided label for the analyzed scent.

BIOELECTRONIC NOSE FOR MIMICKING THE HUMAN SENSE OF SMELL USING GRAPHENE MICROPATTERN (GM) GEOMETRIES

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Introduction: Humans can identify odors by multiple olfactory signals, collected from different receptors in olfactory bulbs. Artificial multiplexed superbioelectronic nose were constructed using highly uniform graphene micropatterns integrated with different human olfactory receptors (hORs). It was operated as transducers, resulting in a high sensitivity and selectivity toward target odorants (minimum detectable level: 0.1 fM). Combinational coding of hORs is essential for odorant discrimination in mixtures by principal component analysis (PCA).

Materiel & Methods: Single--layer graphene was prepared and patterned on a silicon wafer by chemical vapor deposition and a typical photolithography process. Both hOR2AG1 and hOR3A1 proteins were transformed with E. coli cells.

Results: The human olfactory system with several channels conjugated with different receptors can perceive the target odorant molecules in an mixture at low concentrations (0.1 fM); showing an immediate change (<1 s) in current. It was monitored toward similar odorant structures (different numbers of carbon atoms and terminal groups). Finally, the collected data was constructed from PCA analysis, enabling the identification of individual analytes.

Conclusion: To mimic this feature of the human olfactory system, (i) human hORs that interact with specific odorants as recognition elements; (ii) a multiplexed sensing geometry, and (iii) PCA were successfully performed.

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SCENT TRANSFER OVER A COMMUNICATION NETWORK

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We tested a novel method for scent transfer from University of Tampere (UTA) to Tampere-talo (TT). For this purpose, we measured authentic odor (i.e. lemon or jasmine oil) at UTA using an ion mobility spectrometry -based electronic nose (i.e. ChemPro 100i). The measurement data consisted of numbers in text format (i.e. raw data). To transfer the raw data from UTA to TT, we set up a node.js –based web server. Software at UTA transferred the IMS measurements continuously to the server. Then, software at TT acquired the latest 10 seconds of the raw data. Using the average of the raw data the scents were classified using a K nearest neighbors classifier. The classifier compared the averaged sample to a database consisting of measurement data from 22 odors. When the classification result achieved a minimum of 90% trustworthiness, the result was used to initiate a MATLAB script controlling olfactory display prototype to produce the synthetic version (i.e. limonene or synthetic jasmine) of the odor. Typically, already the first classification yielded correct recognition. The tubes from which odor was smelled by the audience at TT were attached to a TV screen showing the real time measurement process of the odors.

ESSENTIAL OLFACTORY RECEPTORS IN STYLET OF THE MAJOR DISEASE VECTOR, *AEDES AEGYPTI*

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The yellow fever mosquito, *Aedes aegypti* (*Ae. aegypti*) is a major disease vector for dengue virus, Zika virus, yellow fever and chikungunya. One of the poorly understood aspects of mosquito blood-feeding behaviours is how they target an optimal site in order to penetrate the skin and blood vessels without alerting the host animal. Here we provide new findings that the piercing-sucking stylet of *Ae. aegypti* is an essential apparatus for the final stage in blood feeding behaviour. Indeed, the stylet possesses olfactory receptor neurons that express two conventional olfactory receptors of *Aedes aegypti* (AaOrs), AaOr8 and AaOr49, together with the olfactory co-receptor (AaOrco). *In vitro*calcium imaging using transfected cell lines demonstrated that AaOr8 and AaOr49 were activated by volatile compounds present in blood. Gene expression inhibition of these Ors interferes with blood-feeding behaviours. *In silico* protein modeling and mutaganasis also demonstrated structural interactions between these Ors and ligands. Taken together, we identified olfactory receptor neurons in the stylet involved in mosquito blood feeding behaviors, which in turn indicates that olfactory perception in the stylet is necessary and sufficient for mosquitoes to find host blood in order to rapidly acquire blood meals from a host animal.

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COMPARISION OF EXHALED BREATH USING E-NOSE AND BLOOD TEST FOR DIABETES

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Introduction: Monitoring of diabetes uses glucose contained in blood, and blood sampling should be done very often. Acetone is known as a specific gas detected in the exhaled breath of diabetic patients. Acetone is produced in the metabolism of the body and travels through the blood to release trace amounts by respiration [1-2]. By monitoring the amount of acetone in the breath to control the condition of diabetes, it can lessen the pain of people than the invasive method of collecting blood.

Materiel & Methods: E-nose for measuring expiration has constructed an electronic nose system-using an array of chemical sensors based on indium and tungsten oxide. Respectively. Sample collection was carried out using a Tedler bag, and SPME fiber was used for sample transfer. Blood test has been carried out normal invasive technique.

Results: The results of aerobic measurement using electronic nose were analyzed by PCA. Diabetic patients and normal subjects are separated and included in the normal group of diabetic patients with HbA1C less than 6%.

Conclusion: It was confirmed that diabetic patient group and normal group were well classified. In diabetic patients, patients with normal glycemic control were found to belong to the normal group in the blood test. The possibility of blood glucose control in diabetic patients was confirmed by exhalation analysis using electronic nose.

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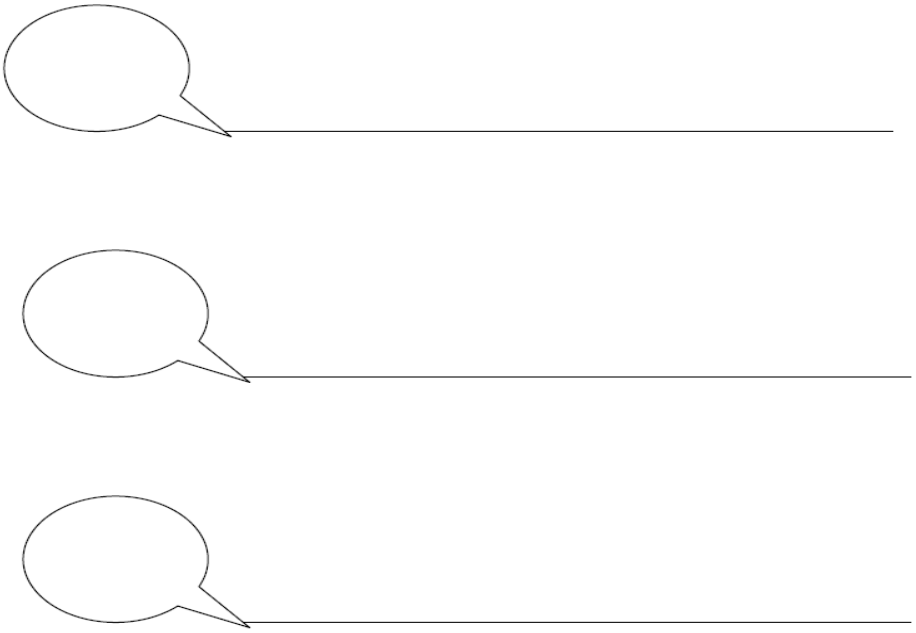
6th DOS Annual Meeting 2018 – Top 3 Ideas



6th DOS Annual Meeting 2018 – My Questions

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