

## **PREFACE**

### **Special Issue: Multisensory Human-Computer Interaction**

Marianna Obrist (University of Sussex), Nimesha Ranasinghe (National University of Singapore), & Charles Spence (University of Oxford)

Every day, in their real-world interactions, people utilize their senses (all of them) and various facial and bodily expressions. For example, even a simple experience such as having a coffee with a friend involve multiple sensory information and input/output (I/O) channels such as smell, taste, vision, haptics, and sound. Thus, information from these very different sensory channels is combined in order to create compelling experiences and memories.

However, currently, our interactions with technology are dominated by visual, auditory, and, to a lesser extent, tactile interfaces. The chemical senses (i.e., smell, taste, and the trigeminal sense) are still mostly neglected, often treated as ‘lower’, or somehow more primitive, senses with seemingly little to add to the field of human-computer interaction. However, given the immediacy of touch and the ubiquity of taste and smell, not to mention their importance to health, safety, work, leisure, pleasure, and a person’s sense of emotional well-being, future multisensory experiences with interactive technologies could potentially have a major impact on society and consumer markets, creating entirely new product, technology, and service opportunities. More importantly, multisensory experience research promises to deliver a step-change in our understanding of the human senses as interaction modalities and potentially also revolutionize existing interaction paradigms within the field of Human-Computer Interaction (HCI).

This special issue is dedicated to research that goes beyond audio-visual interfaces, focusing instead on touch, smell, and taste for multisensory HCI (inspired by a workshop on Multisensory HCI organised at ACM CHI’16, see Obrist et al., 2016b). We set our original focus in understanding what tactile, gustatory, and olfactory experiences we can design for, and how we can meaningfully stimulate such experiences when interacting with technology. Apart from designing HCI applications and understanding digital multisensory experiences in consumer applications, we also highlight the importance of understanding the limitations that come into play when users need to use, or engage, more than one sense at a time.

#### **Editorial overview for this special issue**

In this issue, we present four articles that will hopefully help to promote thinking beyond mainstream HCI. Below, we provide an overview of the content of the special issue and relevant opportunities for multisensory HCI that have been interwoven with expert statements from both academia and industry.

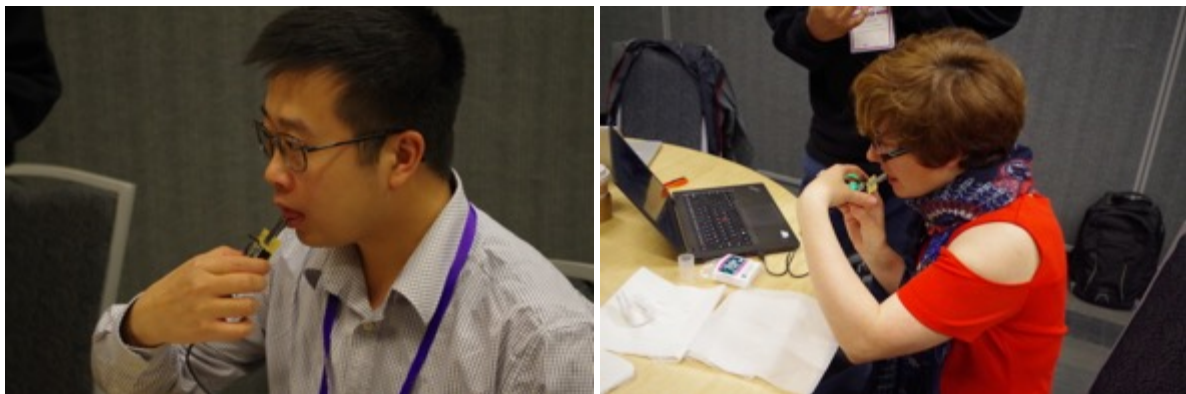
In their article entitled, “**Haptic Experience Design: What Hapticians Do**”, Oliver Schneider, Karon MacLean, Colin Swindells, and Kellogg Booth describe the evolution from simple vibrotactile stimulation using haptic technology through to a more complex ecosystem of multisensory and multimodal systems, defining the design space for haptic experience. They present insights from interviews with professional haptic designers and experts, allowing them to identify key challenges, but also design opportunities around the underutilized sense of touch (see Gallace & Spence, 2014, for a review).

Meanwhile, Franceli Cibrian, Oscar Pena, Deysi Ortega, and Monica Tentori present some of their recent work on “**BendableSound: Designing an Elastic Surface to Support**

**Neurologic Music Therapy sessions of Children with Severe Autism**". In their article, the researchers emphasise their co-design work with children with autism and teachers. The authors show how the combination of movements when touching a fabric and sounds can deliver therapeutic benefits. The hope is that this work will inspire future research into novel elastic multisensory surfaces.

In the next article, "**Exploiting Haptic Facets: Users' Sensemaking Schemas as a Path to Design and Personalization of Experience**", Hasti Seifi and Karon MacLean categorise the attributes of haptic sensations into a meaningful framework, not just for design but also for the end users' customization of vibrotactile effects. Five haptic facets are presented, based on how people describe vibrations: Physical, sensory, emotional, metaphoric, and usage examples, which are made available through a dedicated 120-item vibration library.

Finally, we (as editors and Carlos Velasco) provide a review article on "**Digitizing the Chemical Senses: Possibilities & Pitfalls**" – an overview on the state-of-the-art for HCI, highlighting the key possibilities and pitfalls of the senses of taste, smell, and the trigeminal system (see Figure 1). We summarize key research with respect to the following questions: What do you want to digitize? Why do you want to digitize it? How do you plan to digitize it? What are the limitations, both technical and psychological, to digital transmission/delivery that are relevant to the chemical senses?



*Figure 1: Multisensory HCI workshop at CHI 2016: Trying digital taste stimulation.*

Taken together, those articles represent unique use cases and reference points for multisensory HCI research (Obrist et al. 2016a). In recent years, we have witnessed progress in multisensory experiences involving touch. It is going to be key for HCI to leverage the full range of tactile sensations (e.g., vibrations, pressure, force, balance, heat, coolness/wetness, electric shocks, pain and itch, etc.), taking into account the active and passive modes of touch (note that psychologists refer to the former as haptics) and its integration with information from the other senses. This will undoubtedly provide new tools for interactive experience design, and will hopefully help to uncover the fine granularity of sensory stimulation and emotional responses.

Communicating emotions is not trivial, and emotional content can be delivered through multiple senses. Just imagine, for example, that you are watching a horror movie. Both the music and images may elicit fear in the viewer. It is necessary to combine physiological recordings and self-assessment measures in order to model (and ultimately predict) the emotional responses of a user under conditions of multisensory emotional stimulation.

*“We've come a long way. From entertainment to “serious” applications, I/O is no longer simply tapping keys and looking at the visual results. Exploring and expanding I/O through touch, from swipe to tap to hold, through sound, from desktop sounds to voice user interfaces, and through directional eye gaze are already part of everyday HCI. It's early days for models of smell and taste. It's even earlier days for any kind of meaningful sensory integration where fully embodied, multisensory interaction is part of HCI. Understanding our senses, and exploring how our senses affect how we think and behave, is a new and exciting frontier. As with all research that explores how to augment or transform human experience and expand human potential through technological innovation, we need to also address existential and ethical issues in how we interpret and apply what we discover.”*

**Elizabeth F. Churchill, Google, USA**

*Director of User Experience at Google and ACM Distinguished Scientist working in the area of HCI, computer mediated communication, mobile/ubiquitous computing, and social media.*

*“The time is ripe for innovative uses of new modalities as technology spreads ever further into our lives. An area of focus at Glasgow is in-car interaction design. Traditional physical dials and controls are being replaced by touchscreens, which can be harder to use when driving and may require drivers to take their eyes off the road. The use of novel modalities such as thermal or tactile feedback on the steering wheel, haptic touchscreens, ambient light from around the cabin, or 3D sound can help convey complex information to drivers without distracting them from driving and supporting them in the handover of control in autonomous situations. Given further research, the chemical senses will also be able to contribute, with smell providing an alternative form of feedback. Allowing drivers, and users of all types of devices, to use all of their senses and control capabilities enables a rich and effective multimodal interaction with technology.”*

**Stephen Brewster, University of Glasgow, UK**

*Professor of Human Computer Interaction at the School of Computing Science. His main research interest is in Multimodal HCI, sound and haptics and gestures.*

Recently, it has been shown that users can use ultrasound mid-air haptic stimulation to reliably communicate their emotional state, revealing specific design implications based on the spatial, directional, and haptic parameters of stimulation (Obrist et al. 2015). Combined with the recent discovery of C tactile (CT) afferents indicating the affective aspects of touch in neuroscience (see McGlone & Spence, 2010), the “affective” design space is enriched and will allow us to create novel emotional interfaces and more immersive experiences (Gallace & Spence, 2014).

Moreover, multisensory design is captured as an interesting medium in the context of those working with individuals with sensory disabilities (e.g., those who are blind and/or deaf). Two of the papers in this issue focus particularly on work with those children with disabilities. They showcase how touch, taste, and smell can provide a different and very often a more meaningful means for these individuals to interact with their environment. We believe this will further inspire future research exploring multisensory interactions to assist those with sensory disabilities (in particular, people with deaf-blindness – who only have the senses of touch, taste, and smell to interact with the outside world) and consequently improve their quality of lives.

Considering that the future will likely become even more digitised and computerised, it is essential to understand how we can design for those yet underexploited senses in HCI, and for those communities who, thus far, may have been somewhat excluded. Below, we elaborate further on those lines of thought, presenting recent work and expert opinions with the aim of inspiring those designers and developers with an appetite for innovation.

### **Opportunities for Multisensory HCI**

Here, we want to take the opportunity to highlight that there are opportunities to enhance designers' and developers' abilities to create meaningful interactions and make use of the whole spectrum of multisensory experiences. However, there are still many challenges when it comes to studying taste and particularly smell, especially related to inter-individual variability, varying olfactory preferences over time, individual sensitivity and allergic reactions to chemical stimuli, and the relative importance of crossmodal influences.

As a community, we need to explore and develop design methods and frameworks that provide both quantitative and qualitative parameters for sensory stimulation. In the case of touch, the process is well facilitated through the proliferation of haptic technologies (from contact to contactless devices), but we are still in the early stages of development for taste and smell where the fundamental mechanisms of taste and smell perceptions still need to be worked out. We do not yet know entirely how to digitize these senses in the context of HCI compared with others like sound and light, where we can measure frequency ranges and convert them into a digital medium (bits). While there has been some excitement around the delivery of digital taste, the delivery of digital smell (e.g., by electrocuting the nostrils) looks to be a long way off, if not impossible (Weiss et al., 2016).

*“Commonly designers and artists use audio-visual media to express certain ideas and emotionally move an audience. The artist does not cause this emotion itself but, rather, uses a medium to transmit meaning and thus causes a response in an audience. Moving away from the visual dominance within current design practices opens up a new vocabulary for more powerful and immersive artistic expressions and new strategies for meaningful interaction and experience design. That requires new technologies, tools and a deeper understanding on how the often forgotten lower senses like touch, smell and taste influence the human body as an interaction space for storytelling and design.”*

**Marcel van Brakel, Polymorf, The Netherlands**

*Founder of cross media group Polymorf. He works as independent media designer, play writer, librettist and film and theatre director.*

*“For the world’s most creative chefs, research in the field of sensory science has already had an impact on how they design their dining experiences. Technology on the other hand has met with a degree resistance, perhaps because many have not understood how to make technology a meaningful and congruent part of a highly multisensory activity such as dining. But that is not always the case, one now finds some of the world’s most exclusive dining experiences drawing upon technology to heighten sensory stimulation and pleasure. It is research such as that presented in this special issue that are essential to further progress.”*

**Jozef Youssef, Kitchen Theory, UK**

*Founder and chef patron of Kitchen Theory and the Gastrophysics Chef's Table. An experimental chef who coupled his Michelin star culinary background with his passion for gastronomy, art and science.*

*“The Reality is not an absolute existence. Rather, our perception shapes reality, as Jakob von Uexküll named it as "Umwelt". We are living in our perceived illusion. Thus, when we add a new, artificial, or alternative perception to our existing ones, it may recreate reality. Multisensory Human-Computer Interaction is an exciting research field because it is not just about new or convenient user interfaces, it is about humans and human-perceived reality.”*

**Jun Rekimoto, The University of Tokyo, Japan**

*Professor in the Interfaculty Initiative in Information Studies with a main research interest is in Human Augmentation and AR. Since 2011 he also has been Deputy Director of Sony CSL.*

In terms of multisensory HCI, not only can we draw upon prior work in the field of HCI, but we can tie our efforts on designing, developing and evaluating novel interfaces back to the rich and extensive knowledge established concerning the human senses within neuroscience, psychology, and sensory science (see Bremner, Lewkowicz, & Spence, 2012; Calvert, Spence, & Stein, 2004). Such a cross-disciplinary approach is likely going to be crucial for the success of sensory interfaces and technologies, in particular in the realm of designing for the chemical senses. It is going to be crucial to determine the meaningful design space for multisensory experience design.

We need to recognize the inherent limitations and capabilities of the various senses (Gallace, Ngo, Sulaitis, & Spence, 2012; Spence, 2014). For example, we rarely experience the sense of taste in isolation. Perhaps, aiming for the psychological flavour sense (Auvray & Spence, 2008) would be a way to go, as we combine taste, olfactory, and trigeminal/oral-somatosensory inputs in our everyday life whenever we eat or drink. Here, it is key to think about congruency and its ability to produce different reactions in the user. At the same time, it is also key to understand the unique properties of each of our senses before designing for their sensory integration in the design of interactive systems. Studying these underexploited senses not only enhances the design space of multisensory HCI but also helps to improve the fundamental understanding of these senses along with their cross-sensory associations.

**Guest Editors**

Marianna Obrist (University of Sussex)

Nimesha Ranasinghe (National University of Singapore)

Charles Spence (University of Oxford)

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