The Power of our Sense of Smell: What Technology can learn from Humans?

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Proceedings of the CHI 2017 Workshop on Amplification and Augmentation of Human Perception, May 07, 2017, Denver, CO, USA.

Abstract

Our sense of smell is human's most primitive but very powerful sense. Our understanding of the olfactory system has matured based on advancements in molecular biology, psychology and neuroscience, and advances in the development of scent-delivery devices beyond environmental and healthcare services. With respect to the aim of the workshop – focusing on the opportunities of using technologies to amplify and augment human perception to keep up with technical advances – we would like to argue that we shall use the knowledge on the sense of smell to think about the possibilities to augment technology. This advanced smell-based technology can augment users' experiences with technology (e.g., navigating in virtual environments). Moreover, such technology makes best use of the amplified sensory perception of people with sensorial impairments (e.g., blind and deaf). In the following we provide a brief overview on the olfactory system, unique properties and related challenges for HCI, and conclude with some discussion points for the Amplify @CHI'17 workshop.

Author Keywords

Sense of Smell; Olfaction; Smell-based Technology; Olfactory Experiences; Olfactory Perception.

Figure 1: Dog versus Human smell-tracking abilities [4].

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

The sense of smell for HCI

Our sense of smell depends on sensing chemical molecules in the environment, in other words odours [1]. Odours are defined as a mixture of chemical components (i.e., external volatile molecules) called odorants [2]. Odorants detection is however only a part of the olfactory experience. The olfactory system completes the smelling codification process (i.e., sniffing action) by generating the appropriate associated internal representations in the brain [3], unless it happens on an unconscious level (i.e., under-threshold stimulation).

Interestingly, work in neuroscience has shown that humans, as well as animals, can navigate space both by tracking smells [4, see Figure 1] and by following an olfactory grid [5]. By olfactory grid the authors refer to a map constructed from chemical stimuli, humans are able to define an arbitrary location in the space (as a coordinate location). This human ability to spatially locate olfactory stimuli is explained through avoidance behavior based on contextual factors (e.g., establishing the presence of dangerous cues, or recognizing known and familiar people or places).

Recent work also demonstrated, that humans can discriminate more than 1 trillion of olfactory stimuli [6]. The authors made a parallelism with the discrimination of colours (several million) and sounds (half a million), in order to determinate the resolution of olfaction by testing the capacity of humans in the discrimination of odorants (with a limited shared number of chemical components). The sense of smell surpasses the other senses in the quantity of chemicals components that can discriminate. Taken together, smelling is much more than the simple detection of chemical cues in the surrounding ambient: olfaction has unique properties linked to memories and emotions, and has been defined as the 'poet' of sensory systems within neuroscience due to its complex structure [1].

No other sensory system makes the direct and intense contact with the neural substrates of emotion and memory, which explains why smell-evoked memories are usually emotionally powerful [7]. Prior work has scientifically validated the "Proust phenomenon", the sudden occurrence of a memory containing sensory and emotional components [8]. Memories triggered by odours are older and more emotional than those triggered by verbal cues [9, 10]. The memories related to odours are defined as state-dependent because they are directly linked to the event in which the odour was smelled for the first time [7]. This olfaction-emotion relationship has been shown to be primarily due to the shared common brain pathways of emotions and odour processing [11, see 12, for a review].

Despite of the important and unique direct connections of olfactory stimuli with emotions, memories, and other sensory stimuli, these connections are deeply grounded in subjective idiosyncrasies [13], and hence confront HCI with an important challenge: the *intra-subject variability in the olfactory perception* [14]. Moreover, the *complexity of the olfactory stimulus* defines another key challenge to exploit the sense of smell in a technological context, especially due to the mixture of the chemical molecules that compose each odorant [2]. These chemical mixtures make it very difficult to

reproduce, synthetize, and translate odours into digital information (bits), even though first attempts are made by Ranasinghe et al. [15]. Finally, it is also important to keep in mind that sensory stimulation does not occur in isolation. In fact, we live in a multisensory world and our everyday life is based on a variety of sensory stimulations. In those situations, olfactory stimuli occur and are *integrated with other sensory stimuli* affecting our experience depending on their congruency or incongruency with a situation [16]. Psychologists and neuroscientists in the last few years have increasingly investigated the effects of multisensory interactions in various contexts such as nutrition [17,18] including olfaction (e.g., smells-colours, smells-sounds etc.) [19,20]. The field of crossmodal correspondences provides increasingly insights into the cross-sensory mappings and how a sensory feature in another sensory modality can be stimulated to create a desired experience [21].

Regardless the above challenges related to the complexity of olfactory stimulation, the variability of olfactory perception and importance to account for sensory integration, the sense of smell itself is offering unique design possibilities for HCI.

Discussion points for the workshop

The understanding of how our sense of smell works, processes information and relates to other senses will allow us to build better technology. More specifically we can create richer experiences that will augment human-technology interactions. Moreover, research has shown that smell-based technology can make best use of the amplified sensory perception of people with sensorial impairments (e.g., visual and audio impairments) [22,23].

We would like to stimulate a discussion about specific actions the HCI community needs to take to better exploit the human sense of smell and related opportunities. First, we must determine which olfactory experiences we can design for, and how to meaningfully stimulate them. Second, we need to build on previous frameworks for multisensory design while also creating new ones. Third, we need to design interfaces that allow the stimulation of unexplored sensory inputs (e.g., digital smell), as well as interfaces that take into account the relationships between the senses (e.g., integration of taste and smell into flavor). Finally, it is vital to understand what limitations come into play when users need to monitor information from more than one sense simultaneously (to avoid sensory overload).

Acknowledgements

This project has received funding from the European Research council (ERC) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 638605 and No 737576.

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