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From Olfaction to Emotions: An Interactive and Immersive Experience

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The causal relationship between olfactory perception and human emotions has been widely studied and accepted by various fields including, but not limited to, health, marketing, and multimedia. In this work-in-progress paper, we present an olfactive, interactive and immersive experience taking place during the *World Creativity & Innovation Week* in Nantes, France, in April 2022. Through this experience, we aim to observe and exploit the existing relationship between smells and emotions by measuring, in real time, participants' physiological reactions (e.g., heart rate and skin conductance) to a given olfactive stimulus. Based on the obtained signals, appropriate multimedia content, implemented in collaboration with local partners, is interactively displayed in the room with a view to further immerse the participants in their experience.

Additional Key Words and Phrases: Emotions, olfaction, interactivity, immersion, multimedia

1 RELATIONSHIP BETWEEN OLFACTION AND EMOTIONS

1.1 General introduction

The sense of smell, widely known as *olfaction*, can be considered "primary", in that it is one of the first senses which appeared in evolution [1]. Indeed, animals usually need to quickly react to their environment, and smelling something generates fast responses on behalf of the brain. Odours are also used to mark territory, detect predators, or even develop social relationships. This can be possible thanks to chemosignals [2], a type of pheromones which can be found in urine, sweat, and tears. The main goal of chemosignals is to generate a reaction, such as running away. To do so, the brain response has to be effective. And the olfactory sense is effective, therefore odours can be directly processed by the limbic system [3]. Within this system, the amygdala and hypothalamus are of particular interest to us because they do not only process smells, but also emotions, mood, and memories. Affects and emotions are in fact fundamental to human experience, as they can strongly impact our cognition, perception, and daily tasks, such as communication or even decision making.

As a matter of fact, several research works have proven that emotions and odours are connected, and that smells can influence emotions [3, 4]. It has for instance been shown that lavender can yield relaxation and decrease anxiety [5]. As mentioned previously, processing detected odours is almost immediate, and thus does not travel through consciousness. Consequently, emotions can be easily influenced, and this topic has been under investigation over the last decades. Delplanque *et al.* have studied the effects of familiarity on the influence of odours on emotions [6]. They showed that there was indeed a causal relationship, yet that there were also two distinct olfactory domains, i.e., pleasantness vs. unpleasantness. Familiarity helps a pleasant odour to become even more pleasant, but unpleasant ones do not necessarily become pleasant with time. In summary, the familiarity of a smell can influence emotions, but the smell itself can also be an influential factor on said emotions. A year later, Chrea *et al.* put forward the link between the emotional and olfactory vocabulary [7]. For instance, "heavy" odours were associated with negative feelings, while "sweet" scents were linked to happiness, or at least to feelings of well-being.

1.2 Applications

The influence of odours on emotions has been used in several domains, including health, marketing, and automotive industry for example. Indeed, aromatherapy has been used to treat certain troubles such as anxiety and depression [3]. Scent marketing has appeared as a whole marketing strategy, involving the diffusion of

chosen scents to improve clients' global experience [8]. This strategy uses the *Proust phenomena* to create "odour-combined memory recall", and make consumers remember specific products [9]. In the case of the introduction of autonomous (i.e., self-driving) vehicles, olfaction has been used in the literature for different purposes. Detjen *et al.* have for instance evaluated how user experience and, consequently, the acceptability of autonomous vehicles (linked to security, safety, performance, but also positive experiences) could be improved [10]. The authors showed that "fun, excitement, beauty, positive emotions and well-being" were the key to a good user experience, and that they could be induced thanks to pleasant odours. On the other hand, Dmitrenko *et al.* tried to decrease negative emotions, like anger, by the use of smells [11]. They found that rose fragrance, among others, could restore relaxation and positive emotions. Furthermore, the same research team also showed how smells could serve to warn drivers of potential hazards [12]. Three fragrances were chosen and combined with a message, i.e., lavender with "slow down", peppermint with "short inter-vehicle distance", and lemon with "lane departure". Participants stated that odours were more useful and comfortable than visual warnings. More recently, in January 2022, the influence of olfaction found a new application in politics, as the French presidential candidate Jean-Luc Mélenchon organised an immersive rally in Nantes, using 360-degree videos, sounds, and diverse fragrances.

1.3 Scent diffusion

Inspired by social spaces, Amores Fernandez [13] defined three types of spaces dedicated to odours, depending on the distance from the origin of the scent-delivery system to an individual. Firstly, the ambient space places the device more than one metre away. Olfactometers and home fragrance diffusers are examples of ambient olfactive interfaces. Then, the wearable space includes the space between an individual and their surroundings. Several research teams have made use of Sniffin' Sticks (Burghardt®, Wedel, Germany) [14], which enable smelling successively several odours. Wearable olfactive interfaces can also be nasal masks, or more specific devices, such as *Essence*, an olfactory computational necklace for virtual reality (VR) [15]. Finally, the biological space positions the device on the individual. Biological olfactive interfaces can be cosmetics pills or even bacterial deliveries.

Odour characteristics can further be classified into different categories. Several scents can be perceived as unique; this is the case of mono-molecular odours, that is to say that one molecule produces a given odour. Yet, in everyday life, scents are most of the time mixtures. According to Thomas-Danguin *et al.*, smelling several odours can be perceived as homogeneous or heterogeneous [16]. In the first case, two possibilities appear: either the blending creates a new odour, it is then called a "blending mixture"; or one odour gets the upper hand on the others, which is a "complete overshadowing". On the contrary, a blending is considered heterogeneous when several odours can be perceived.

1.4 Emotion measurement

Emotions can be assessed using objective and subjective measures [17]. Both have advantages and limitations, as they allow taking into account distinct information regarding individuals' state of mind.

According to most emotional models (e.g., [18] [19]), emotions are accompanied by a variety of psychological and physiological changes that occur automatically and can be specific to the given emotional state. Physiological changes include variations in cardiac, visceral, and muscular activities. Such variations may be measured by heart rate (ECG), skin conductance (GSR), and pupil dilatation. Indeed, as emotions are instinctive, objective measures can be interesting for real time evaluations that require not to break the immersion of the participant into a task. However, physiological measures are mostly sensitive to the level of arousal, which may not be sufficient to distinguish two emotional states (e.g., anger and happiness). This is why facial expressions and behaviours, which are specific to basic emotions [20] as an important part of nonverbal communication, are other types of signals which have been widely studied.

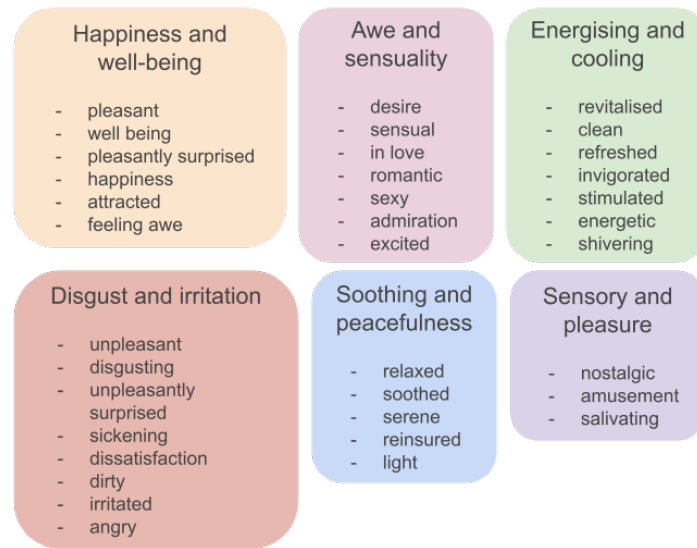


Fig. 1. Illustration of the Geneva Emotion and Odor Scale (GEOS), inspired from [7].

Emotions can also be self-reported using subjective qualitative and quantitative measures, to illustrate how they were experienced. Self-reported measures of emotions often rely on questionnaires that require participants to rate the correspondence between their current state and several adjectives related to basic emotions (e.g., using the Brief Mood Introspection Scale (BMIS) [21]). It is also possible to use questionnaires based on a dimensional approach, asking participants to indicate levels of arousal, valence, and dominance (e.g., with the Affect Grid [22], or the Self-Assessment Manikin (SAM) scale [23]). Such self-report questionnaires are useful to assess the emotional state experienced by a participant, but they may not be the most appropriate to assess emotions elicited by stimuli such as odours.

Several research teams have attempted to create new questionnaires to better associate odours with emotions. In 2009, Chrea *et al.* have for instance proposed the Geneva Emotion and Odour Scale (GEOS) [7]. The GEOS is a tool enabling the assessment of odour-induced emotions, divided into thirty-six items further filed in six categories of emotions, as shown on Figure 1. Porcherot *et al.* adjusted this scale for marketing applications, reducing the number of words per category [24]. The GEOS has further been used in the literature, and adapted to other populations and cultures, e.g., LEOS for Liverpool (United Kingdom), and SEOS for Singapore [25], and eventually to UniGEOS, a universal scale [26].

2 OLFACTIVE EXPERIENCE

In this work-in-progress paper, we describe an empirical investigation and use of the relationship between olfaction and emotions, by setting up an immersive and interactive olfactory experience, happening during the *World Creativity & Innovation Week (WCIW)* in April 2022 in Nantes, West of France. More specifically, as illustrated on Figure 2 and as further detailed below, we aim to offer adaptive multimedia content depending on participants' emotions, previously induced by a pleasant - at least for gourmands - smell.



Fig. 2. Illustration of the conduct of the experience.

2.1 Emotion elicitation

The Lef  vre-Utile (LU) company¹, famous for its *Petit Beurre* (also called *V  ritable Petit Beurre*) biscuits, was founded in Nantes in 1846. In the 1910s, LU employed 1,200 workers and produced over 6,000 tons of biscuits. The *Petit Beurre* fragrance is thus diffused in an immersive "Cube", in which the experience takes place, with a view to invite participants to an olfactive journey. The Cube, represented on Figure 3, is a seventy square metre room with spatialised sound, as well as with a whole stretch of wall composed of immersive screens, which can be used for many experiments and experiences related to digital immersion, like artistic exhibitions or virtual reality testing.



Fig. 3. Illustration of the immersive Cube.

2.2 Multimedia output

Participants' physiological signals are recorded in real-time thanks to wireless sensors. Several sensors can be used, like the galvanic skin response (GSR), electromyogram (EMG), electrocardiogram (ECG), and temperature.

¹<https://lu.fr>

Depending on the outputs of such sensors, and therefore depending on the emotions elicited by the *Petit Beurre* fragrance, different multimedia content (i.e., images, videos, sounds, and lights) are displayed using the Millumin² videomapping tool. Consequently, this immersive experience can be modified and adapted in real time by the participants themselves, based on their reaction to a given odour.

Figure 4 illustrates how the experience is technically implemented. More precisely, data obtained from each physiological sensor are transferred via open sound control (OSC), a communication protocol working over the network, and then further sent to the Millumin software, in charge of displaying new multimedia content.

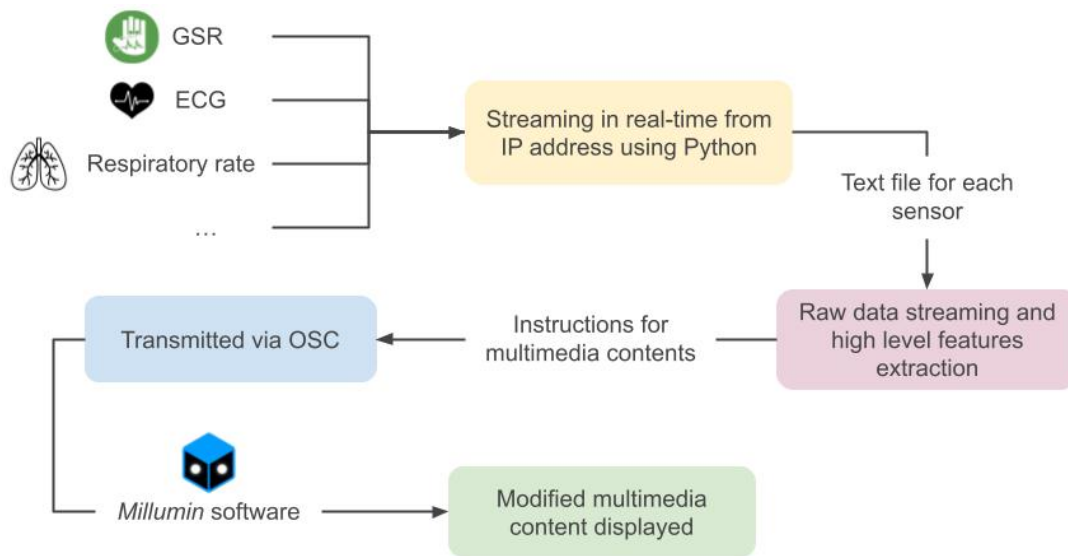


Fig. 4. Illustration of the technical aspects of the experience.

2.3 Immersion evaluation

When participants get out the room, they are asked five closed questions with a view to evaluate their experience. These questions were defined based on the Immersive Experience Questionnaire for Film and TV (Film IEQ) [27]. In fact, and as shown on Figure 5, participants are asked to rate, on four discrete scales, the extent to which: the experience held their attention, they forget their everyday concerns, they interacted with the environment, and they felt emotionally attached to the experience. Furthermore, they are asked whether they would like to live the experience again, in order to assess the quality of our arrangement. Finally, an open question is asked to the participants about their experience.

²<https://www.millumin.com/v4/index.php>

To what extent did the experience hold your attention? (1: not at all, 5: totally)

1 2 3 4 5

To what extent did you forget about your everyday concerns? (1: not at all, 5: totally)

1 2 3 4 5

To what extent did you feel that you were interacting with the environment? (1: not at all, 5: totally)

1 2 3 4 5

To what extent did you feel emotionally attached to the experience? (1: not at all, 5: totally)

1 2 3 4 5

Would you like to live the experience again?

Yes No

In general, what did you think about the experience?

Fig. 5. Illustration of the questionnaire delivered to the participants, inspired from [27].

3 PERSPECTIVES

To summarise, with this olfactive, immersive and interactive experience, we want to directly visualise the influence of a given fragrance on emotions, and to offer real time modifications of the multimedia ambiance. It can be noted that we decided to use scents to obtain physiological reactions, given the important relationship between olfaction and emotions, but any sense (e.g., taste) could be used for this experience.

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REFERENCES

- [1] Codrut Sarafoleanu, Corina Mella, M Georgescu, and C Perederco. The importance of the olfactory sense in the human behavior and evolution. *Journal of Medicine and life*, 2(2):196, 2009.
- [2] Elisa Calvi, Umberto Quassolo, Massimiliano Massaia, Anna Scandurra, Biagio D’Aniello, and Patrizia D’Amelio. The scent of emotions: A systematic review of human intra-and interspecific chemical communication of emotions. *Brain and behavior*, 10(5):e01585, 2020.
- [3] Ioannis Kontaris, Brett S East, and Donald A Wilson. Behavioral and neurobiological convergence of odor, mood and emotion: A review. *Frontiers in Behavioral Neuroscience*, 14:35, 2020.
- [4] Sylvie Muffat and Jean-Louis Garillon. L’aromatique émotionnelle: une nouvelle dimension de la fonction olfactive. *Hegel*, (3):287–295, 2014.

³<https://www.westcreativeindustries.org/>

- [5] Miguel A Diego, Nancy Aaron Jones, Tiffany Field, Maria Hernandez-Reif, Saul Schanberg, Cynthia Kuhn, Mary Galamaga, Virginia McAdam, and Robert Galamaga. Aromatherapy positively affects mood, eeg patterns of alertness and math computations. *International journal of neuroscience*, 96(3-4):217–224, 1998.
- [6] Sylvain Delplanque, Didier Grandjean, Christelle Chrea, Laurence Aymard, Isabelle Cayeux, Benedicte Le Calve, Maria Ines Velazco, Klaus R Scherer, and David Sander. Emotional processing of odors: evidence for a nonlinear relation between pleasantness and familiarity evaluations. *Chemical Senses*, 33(5):469–479, 2008.
- [7] Christelle Chrea, Didier Grandjean, Sylvain Delplanque, Isabelle Cayeux, Bénédicte Le Calvé, Laurence Aymard, Maria Inés Velazco, David Sander, and Klaus R Scherer. Mapping the semantic space for the subjective experience of emotional responses to odors. *Chemical senses*, 34(1):49–62, 2009.
- [8] Rachel S Herz. The emotional, cognitive, and biological basics of olfaction: Implications and considerations for scent marketing. *Sensory marketing*, pages 117–138, 2011.
- [9] Bernadette Emsenhuber. Scent marketing: Subliminal advertising messages. *Informatik 2009–Im Focus das Leben*, 2009.
- [10] Henrik Detjen, Sarah Faltaous, Bastian Pflöging, Stefan Geisler, and Stefan Schneegass. How to increase automated vehicles' acceptance through in-vehicle interaction design: A review. *International Journal of Human–Computer Interaction*, 37(4):308–330, 2021.
- [11] Dmitrijs Dmitrenko, Emanuela Maggioni, Giada Brianza, Brittany E Holthausen, Bruce N Walker, and Marianna Obrist. Caroma therapy: pleasant scents promote safer driving, better mood, and improved well-being in angry drivers. In *Proceedings of the 2020 chi conference on human factors in computing systems*, pages 1–13, 2020.
- [12] Dmitrijs Dmitrenko, Emanuela Maggioni, and Marianna Obrist. I smell trouble: using multiple scents to convey driving-relevant information. In *Proceedings of the 20th ACM International Conference on Multimodal Interaction*, pages 234–238, 2018.
- [13] Judith Amores Fernandez. *Olfactory interfaces: toward implicit human-computer interaction across the consciousness continuum*. PhD thesis, Massachusetts Institute of Technology, 2020.
- [14] Thomas Hummel, B Sekinger, Stephan R Wolf, Elisabeth Pauli, and Gerd Kobal. 'sniffin'sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chemical senses*, 22(1):39–52, 1997.
- [15] Judith Amores and Pattie Maes. Essence: Olfactory interfaces for unconscious influence of mood and cognitive performance. In *Proceedings of the 2017 CHI conference on human factors in computing systems*, pages 28–34, 2017.
- [16] Thierry Thomas-Danguin, Charlotte Sinding, Sébastien Romagny, Fouzia El Mountassir, Boriana Atanasova, Elodie Le Berre, Anne-Marie Le Bon, and Gérard Coureaud. The perception of odor objects in everyday life: a review on the processing of odor mixtures. *Frontiers in psychology*, 5:504, 2014.
- [17] Iris B Mauss and Michael D Robinson. Measures of emotion: A review. *Cognition and emotion*, 23(2):209–237, 2009.
- [18] Paul Ekman, Robert W Levenson, and Wallace V Friesen. Autonomic nervous system activity distinguishes among emotions. *science*, 221(4616):1208–1210, 1983.
- [19] Richard S Lazarus. Progress on a cognitive-motivational-relational theory of emotion. *American psychologist*, 46(8):819, 1991.
- [20] Paul Ekman. Basic emotions. *Handbook of cognition and emotion*, 98(45-60):16, 1999.
- [21] John D Mayer and Yvonne N Gaschke. The experience and meta-experience of mood. *Journal of personality and social psychology*, 55(1):102, 1988.
- [22] James A Russell, Anna Weiss, and Gerald A Mendelsohn. Affect grid: a single-item scale of pleasure and arousal. *Journal of personality and social psychology*, 57(3):493, 1989.
- [23] Margaret M Bradley and Peter J Lang. Measuring emotion: the self-assessment manikin and the semantic differential. *Journal of behavior therapy and experimental psychiatry*, 25(1):49–59, 1994.
- [24] Christelle Porcherot, Sylvain Delplanque, Sophie Raviot-Derrien, Bénédicte Le Calvé, Christelle Chrea, Nadine Gaudreau, and Isabelle Cayeux. How do you feel when you smell this? optimization of a verbal measurement of odor-elicited emotions. *Food Quality and Preference*, 21(8):938–947, 2010.
- [25] Camille Ferdenzi, Annett Schirmer, S Craig Roberts, Sylvain Delplanque, Christelle Porcherot, Isabelle Cayeux, Maria-Inès Velazco, David Sander, Klaus R Scherer, and Didier Grandjean. Affective dimensions of odor perception: a comparison between swiss, british, and singaporean populations. *Emotion*, 11(5):1168, 2011.
- [26] Camille Ferdenzi, Sylvain Delplanque, Plinio Barbosa, Kimberly Court, Jean-Xavier Guinard, Taomei Guo, S Craig Roberts, Annett Schirmer, Christelle Porcherot, Isabelle Cayeux, et al. Affective semantic space of scents. towards a universal scale to measure self-reported odor-related feelings. *Food Quality and Preference*, 30(2):128–138, 2013.
- [27] Jacob M Rigby, Duncan P Brumby, Sandy JJ Gould, and Anna L Cox. Development of a questionnaire to measure immersion in video media: The film ieq. In *Proceedings of the 2019 ACM International Conference on Interactive Experiences for TV and Online Video*, pages 35–46, 2019.