

EMOTIONAL PRIMING OF DIGITAL IMAGES THROUGH MOBILE TELE-SMELL AND VIRTUAL FOOD

Abstract

The sense of smell has been recognised as an important factor governing our emotions and memory. Nevertheless, it remains the most underexplored sense and is still a relatively new modality in the domain of Human-Computer Interaction. In this paper, we examine the effect of olfactory cues on the emotional perception of digital images on mobile devices with a hardware tele-smell device, *Scentee*. Using a set of scents ranked by their pleasantness, participants rated their emotional response to two sets of digital images displayed on a handheld mobile device. The results revealed that the addition of scent significantly modulated the emotional perception of the images. The effect was especially noticeable when scents had a contrasting emotional valence to the image content. We also introduce the application of *Scentee* to virtually share a multi-sensory dining experience.

Keywords

Smell, Food, Emotion, Affective User Interface, Handheld Devices and Mobile Computing

Introduction

Smell plays a major role in our emotional lives (Herz 2002). Smell was discovered to have been the very first sense developed by organisms (Hatt 2008) and is deeply rooted in the limbic system of our brain, an area that governs emotion, behaviour and long-term memory. Hence, smell can have a direct and subconscious effect on mood, specific emotions, attitudes, emotional memory, and emotionally conditioned behaviour (Spence 2002). While these properties bear great potential for human computer interaction, the field has largely ignored the sense of smell in its research to date. In recent years, novel technologies have emerged that it have brought smell actuation to an affordable technology and made olfactory research within the reach of the HCI community. Today's technologies are able to exert far greater control over the amounts and intensities of scent that is released. As such, exciting new possibilities for HCI are on the horizon and the time to embrace olfaction as an equal medium surely has come, for both research and industry.



Figure 1: Scentee device. Side view (top left), top view (top right), and separated top view, consists of a main unit and a scent cartridge (bottom).

In this paper, we introduce scent as a new medium for emotional stimulation in the context of HCI and explore the effects of smell on our emotional perception of digital images. We describe our use of *Scentee*, a mobile scent actuator that can be attached to mobile phone, for both HCI research and experience design. The aim of this research is to determine the users' change in emotional perception of digital images when modulated by scent. This can be an important factor for user experience that could potentially benefit and ultimately enhance digital communication.

In this study, as our hypothesis, we specifically tested if olfactory stimulation while viewing digital images can affect and strengthen the viewer's emotional responses to the images. In terms of the method used, we report on a user-based study. The participants were asked to rank their emotional response to two sets of emotionally valenced images that were displayed on a mobile device. Images were viewed with and without the release of preselected, emotionally valenced scents that were actuated using a hardware tele-smell device. The results show that scents were able to affect the viewer's emotional responses and strengthen the emotional responses of the images shown, hereby proving hypothesis. We conclude by proposing future research in the area of olfaction in HCI.

At the end of this paper, we also introduce the future application of *Scentee* as a new revolutionary way in the future of food, to virtually share a multi-sensory dining experience. We collaborated with 3 Michelin-starred restaurant, Mugartiz, to develop a mobile application to be used with *Scentee* device that gives a virtual experience of preparing Mugartiz's traditional first course, enabling the user to prepare a broth by crushing herbs and spices in a Mortar.

Related Work

While humans are able to detect and distinguish between a plethora of scents, they have only a limited ability to distinguish between their intensities (Engen 1959) as well as an inability to name scents. The determination of scent boundaries is rather tied to judgements of pleasantness, which is, as with emotions, poorly articulated with words (Yeshurun 2010). An early study by Engen explained about hedonics in odour (Engen 1988). Yet, while smell is able to conjure powerful emotions through memories (Herz 1995), its capabilities as a trigger for emotions appear not simply to be bound to memories. A study by Alaoui-Ismaili et al. explained how particular smells can induce emotions, including about the relation between self evaluated pleasantness and the physiological expression of emotion using Autonomic Nervous System. They were able to distinguish different autonomic patterns between pleasant and unpleasant odorants (Alaoui-Ismaili 1997, Vernet-Maury 1999).

While olfactory technology has been used for a longer period of time, only recently have applications begun to diversify and are increasingly becoming available. Historically, smell has been used to accompany other media, such as with scented films and virtual reality in Smell-O-Vision, Aromarama, and Sensorama (Ghinea 2012). While these devices would have provided exciting possibilities for HCI research, their impact has remained minimal, possibly due to high price. Regardless of commercial applications, in HCI, olfaction has mostly been used as a notification medium. The most extensive research in the area was undertaken by Kaye, who developed several scent based systems focusing on ambient notification information (Kaye 2001). The systems were developed as a proof of concept and were thus not evaluated in detail, limiting their implications but nevertheless highlighting some of the potential that the addition of smell to digital interfaces poses.



Figure 2: Image Sets for Experiment. 6 images for each set, and each set consists of 2 neutral images, 2 positive images, and 2 negative images.

Experimental Design

Variables and Control Condition

The independent variable (IV) within the framework of this experiment was the exposure to a digital image, which may be combined with the display of a scent. Images are displayed via an application developed for the study, which also controls scent actuation. The dependant variable (DV) was the perceived emotional response to an image and scent combination. The exposure to scent is the stimulus to which participants are subjected under the experimental condition and it may amplify or reduce an emotional response. Therefore, the measurement of the emotional reaction is composite and represents the selection of an emotion and a related intensity level.

In order to record and classify the perceived emotions of participants we expand a valence classification of emotions into eight categories as proposed in the literature (Feldman Barrett 1998, Plutchik 1994). The emotion wheel encompasses joy, surprise, fear, anger, disgust, sadness, trust, anticipation, and neutral. Each emotion can be marked with seven intervals reaching from low to high strength. During the experiments instead of using the full emotion wheel as shown in the left side of Figure 3, we use a simplified version as shown in the right side of Figure 3, which was more suited to the small form factor of the mobile device. The strength of the emotion perceived is indicated by the distance from the origin in the scale of seven. The origin designates a neutral response, which signifies a value of zero. This model has previously been used in HCI studies such as in evaluating emotional priming of mobile text messages using colour lighting and vibro-tactile messages (Pradana 2014), allows comparison with findings for valence (Hancock 2007), and is considered well suited for computational studies (Cowie 2001).

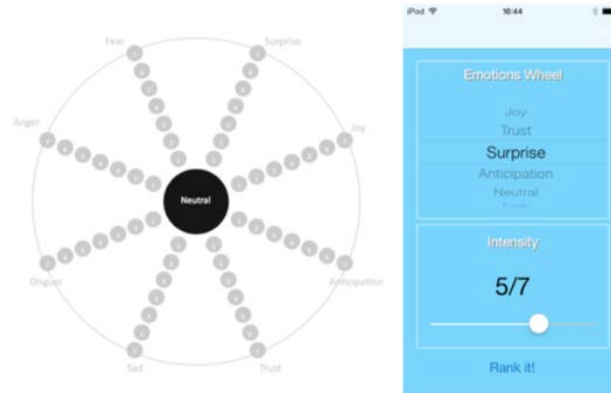


Figure 3: The emotion wheel encompasses joy, surprise, fear, anger, disgust, sadness, trust, anticipation, and neutral. Each emotion can be marked with seven intervals reaching from low to high strength.

Perceptual Parameters

In order to evaluate the effect of scent on ratings of the digital images, a set of scents and pictures was created each of which was marked for its emotional valence.

Two sets of six images each were selected as a base of assessment for participants. Each set of images contained two positive, two negative, and two neutral emotionally valenced images. Selection criterion was the image must be universally understood to be in a certain emotional valence of images. As this initial mode of selection incorporates a certain aspect of arbitrariness, participants were asked to rank their emotional response to the images, results of which were used as a control variable as described above. The images used are shown in Figure 2.

5 scents were selected to be used as part of this study. Each was selected according to its universal pleasantness or unpleasantness. Two positive scents (natural orange and strawberry aroma), two negative scents (fecal smell and earthworm (scent of earth and mould) aroma), and one neutral scent (water) were selected.

Setting and Participants

The study was conducted at City University London and at The University of Oxford. 22 people in total took part in the study. The participants were required to have a normal sense of smell and vision (or corrected-to-normal vision). Olfactory function was tested using Sniffin' Sticks, which tests for odour threshold, odour discrimination and odour identification (Hummel 1997).



Figure 4: Participants were asked to look at images and rate their emotional response to one image at a time using a smartphone with a Scentee device.

Method

Participants were shown images in two phases. The first phase was conducted using only the mobile device without *Scentee*. In this phase participants were asked to look at images from the first set of images and rate their emotional response to one image at a time, advancing to the next image when participants felt comfortable with their rating without any intervention by the conductor of the experiments. During the second phase of the experiment, participants were instructed to evaluate each image five times, each will be performed with a different scent from the whole set of smells selected for the study. This phase required active intervention by a study supervisor whenever a person advanced to the next image in order to exchange the *Scentee* device and associated scent. In order to prevent a change in participant's expectations, the *Scentee* device was exchanged for all images. The participants were given a 60 second break between each image and scent exposure in order to reduce any effect of lingering scent. Upon completion of the test session, the participants were questioned to briefly give feedback on their experience in reference to the experiment in order to gain insights into whether certain factors that could be improved in follow-up studies.

Results

We analyzed the emotional responses of the stimulus with the valence analysis method. Based on the emotion wheel, the positive value of valence consists of those emotions located on the right side of the x- axis, and the negative value of valence consists of emotions located on the left side of the x- axis. In this method, we take the strength of each emotional response (range 1 to 7), and multiply negative valence emotion scores by -1, score neutral as 0 and then calculate the average valence for each stimuli.

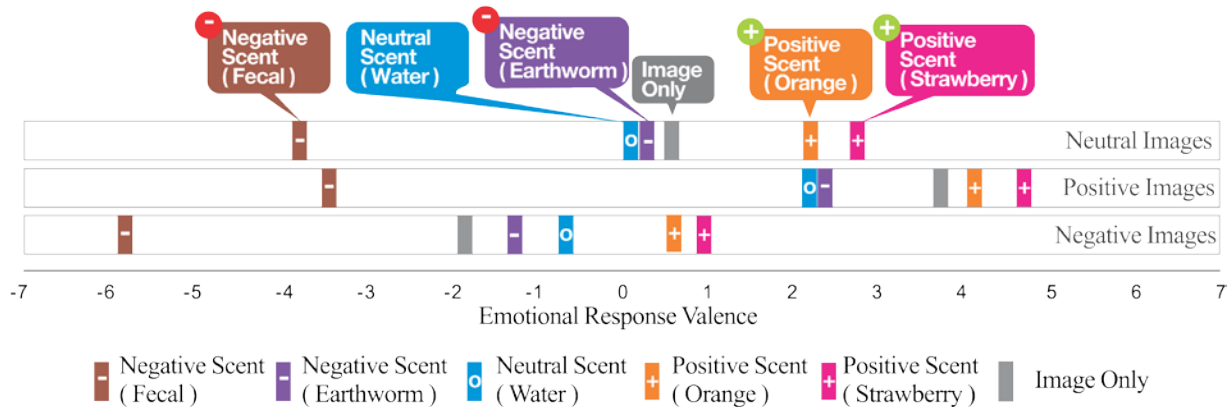


Figure 5: Experiment Result. The emotional response average for each image category (neutral, positive, and negative) mapped from scale -7 to 7.

Based on the descriptive statistics shown in Figure 5, we can see how the valence changes as we augment different scents to the picture. Based on these results, we can see and analyze how much the valence changes when scent is augmented compared to the image only stimuli. This gives us an indication of the effect that a certain scent has on changing the valence of the emotion. From Figure 5, we can see that the positive scents modulated the perceived emotion the most when in conjunction to negative pictures, with the greatest changes in valence seen with strawberry scent and negative picture with a mean 2.75 valence change in the positive direction. On the other hand, negative scents showed a similar characteristic by eliciting the highest change in valence when in conjunction with positive pictures. The scent of faeces hereby showed highest valence changes with a mean of 7.12 valence change in the negative direction.

Application of Scentee in The Future of Food

Scentee brings the sense of smell in a portable form which is attached into our daily mobile communication device. There are many possibilities that can be achieved with this smell device, and as smell plays an important role when combined with taste from our taste buds to form a flavour, *Scentee* has a strong potential to bring new fresh air in the future of food, for example sharing a virtual dining experience without having to physically attend the dining room.





Figure 6: Chef Andoni Luíz Aduriz of Spain's three Michelin-starred restaurant introduced the virtual dining experience app at Madrid Fusion in January 2014.

We collaborated with 2 Michelin-starred restaurant, Mugaritz, in San Sebastian, Spain, which is currently listed as the fourth best restaurant in the world. We developed a mobile application to be used with *Scentee* device that gives a virtual experience of preparing Mugaritz's traditional first course, enabling the user to prepare a broth by crushing herbs and spices in a Mortar. The aim is not only to give preview for prospective customers of Mugaritz, but also to give a new perspective for people who may not have the opportunity to physically travel to San Sebastian and dine at the Mugaritz to virtually experience the real smell of food prepared by one of the world's top chef. The development of this application took place at the end of 2013, and was unveiled to the public at Gastronomy Festival Madrid Fusion in January 2014.

Background

Many years ago, a rather intuitive idea came to mind; a theory that guests visit restaurants not just for the pleasure of eating, but to live a memorable experience. We believe that what our brain wants is to amplify its repertoire of experiences, to be surprised, to be excited, to be provoked and most importantly to be evolved. We thus feel that it is necessary for people to live through an experience in a restaurant, and in the particular case of Mugaritz, this premise is taken more profoundly. Our obsession to decipher the keys behind this hypothesis grew and from this intuition, one of the mechanisms that we feel best understands an experience is in fact, a dish, or better yet said, a moment.

From a neuro-linguistic study we completed with El Jardin del Junio, we were excited to find the possibility that the "lived moment" is the most important question for people that come to Mugaritz. So we asked

ourselves, if the “lived moment” is indeed the most important question they have, how could we reinforce it; by expanding it or rather, making it more “memorable”?

We believe this question was best answered in our mortar dish from 2013-2014. High-quality spices brought from around the world were crushed on a hot surface. They contained delicate fragrances which are freed in a very elegant form. The perfume of these spices send a very clear and even subtle message; for this reason, the act of “crushing” opens the possibility for the guest to ‘feel’ the impact of an aroma at its most crucial moment. It is a dish we realised brought people from around the world to live a complicit moment, reinforcing the search of a memorable experience.

We thus asked ourselves, if we could expand this sensorial experience further; could this be brought to other more individual dishes? The world of aromas, images, sounds as a digital surprise is a new form of dealing with sentiments, to provoke new sensations, widen our horizons in gastronomy and evolve the universe of personal emotion.

Liberating aromas through the *Scantee* technology helps us widen our possibilities, our memories, it is a new way to have ‘fun’ and share experiences. We find ourselves face to face with a ‘digital’ plate, associating aromas to experiences, memories and personalising a meal through the lived moment.

Software Implementation

The basic idea of the application is to provide a virtual experience to enable users to prepare a broth by crushing herbs and spices in a Mortar. The software needs to recreate a grinding experience of the herbs and spices, not only visually, but also provide a real sound and smell of the dish. The software was implemented as an iOS app and works with the *Scantee* device that connects to the iPhone. By taking advantage of the built-in accelerometer inside the iPhone, we can acquire user’s hand movement to mimic grinding action and give feedback in visual and sound change, and release the fragrance of the dish when the user finished the grinding process.



Figure 7: Partial views from the top of the mortar provided by the app. By gently moving the iPhone around, mimicking grinding action, a zoomed-in view of what is inside the mortar is provided and will change its position inside the mortar based on the hand movement, giving the real visual experience of grinding on a real mortar. The herbs appearance is also changed as user grinds through different phases.

Before the user opens the app, they need to plug in the *Scantee* device into the iPhone. When the app is opened, a partial view from the top of the mortar is provided, and the user can see what is inside the mortar: ungrinded herbs and spices.



Figure 8: A user experiencing virtual herb grinding from the app

By holding the phone horizontally and gently moving the iPhone around, mimicking grinding action, a zoomed-in view of what is inside the mortar is provided and will change its position inside the mortar based on the hand movement, giving the real visual experience of grinding on a real mortar. The actual sound recorded from the mortar is also provided. The user needs to move the phone around through three phases of full rotation before they can actually finish the grinding process and enjoy the fragrance of the dish diffused by the *Scentee*. The flowchart of the app is shown on Figure 9.

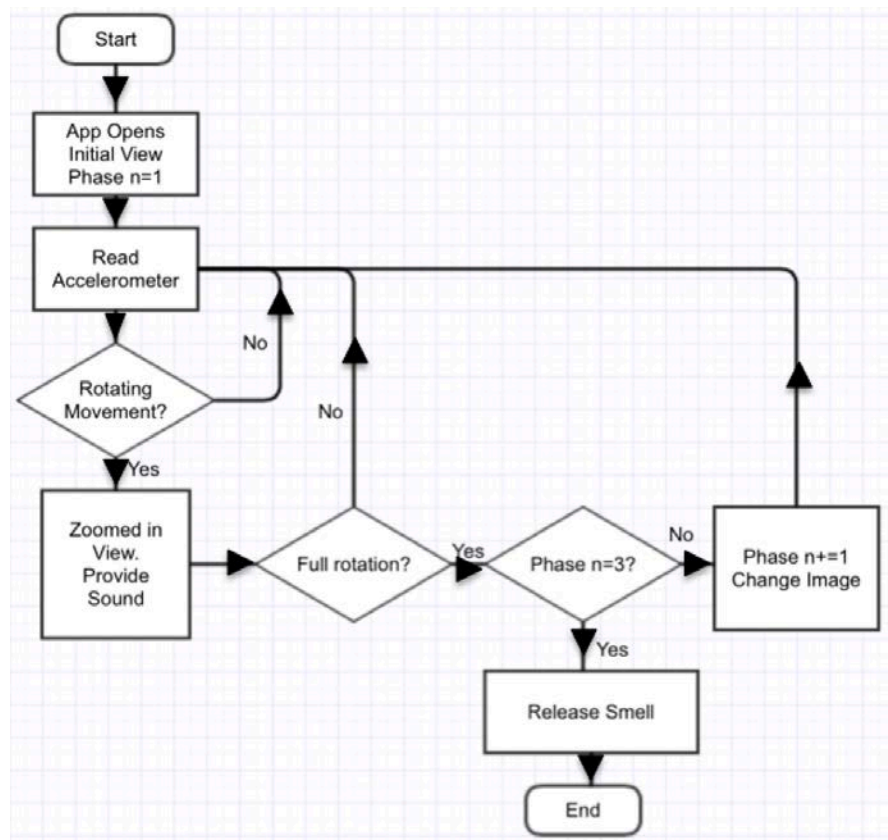


Figure 9: Flowchart of the virtual grinding app

Discussion and Future Work

When working with scents, the selection process is of major importance, but as no standardised procedures exist, one is currently left to use subjective means of selection that will affect study results, as we can see in the Earthworm scent. While we had selected it as a negative scent, it actually had a mostly neutral effect on participants ratings. Furthermore certain scents resulted in more extreme ratings than others. The most direct effect on emotional responses was shown by the fecal scent. Whether this was due to the obvious incongruence of scent and most images, as would be suggested by literature (Piqueras-Fiszman 2012) or if the scent was simply the most realistic or intense smelling is not clear. We therefore propose further research that elicits whether negative scents are more generally perceived as negative than positive scents.

Working against common problems of scent research in HCI

Upon being questioned, participants mentioned that they did not feel as if scents were lingering or mixing. Having been water and alcohol based, these scents seemed to disperse more quickly than oil based scents that we had purchased and were tested out during preparations. It is also possible that short puffs of vapourised scent as emitted by Scentee played a role in their property to not linger as only miniscule amounts of scent are vapourised during each puff.

Limitations, Reliability, and Validity

Naturally, our results are subject to limitations that may have altered them to a certain degree and need to be reconsidered and potentially eliminated in further research. The participants were from a select circle of students and those otherwise associated with the Universities involved; and whilst certain stipulations were made, the participants cannot convincingly be said to be representative of the population overall as they were furthermore mainly from Western, Educated, Industrialised, Rich, and Democratic (WEIRD) societies (Henrich 2010). A major limitation of design, which we have yet to concur to resolve, is the possibility that test subjects are rating their response to the scent rather than the image itself. In the same line, the selection and categorisation of smells and images was undertaken by the researchers without any guiding framework, as this line of research is quite novel, hence the latter cannot be considered objective. As a future work, we are implementing The International Affective Picture System (IAPS), which was being developed to provide a set of normative emotional stimuli for experimental investigations of emotion and attention and compare the results with our current study (Lang 2008).

Contribution of Scentee in The Future of Food

We developed a mobile application to be used with *Scentee* device that gives a virtual experience of preparing Mugaritz's traditional first course, enabling the user to prepare a broth by crushing herbs and spices in a Mortar. This implementation of a new technology is a revolutionary way, and we hope that it will set a trend for the future restaurants to provide an exciting experience for their prospective customers and to give a new perspective for people who may not have the opportunity to physically dine at their restaurant to virtually experience the real smell of the food prepared by their chefs.

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