Scented Material: Changing Features of Physical Creations based on Odors

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ACM 978-1-4503-4082-3/16/05.
http://dx.doi.org/10.1145/2851581.2892471

Abstract
Communication between designer and user is a challenge when designing for a wider spectrum of experiences and interfaces (e.g., tangible, multimodal, multisensory interaction). Our research aims to explore non-verbal communication methods for expressing olfactory experiences. In this paper, we present preliminary findings on the effect of scented material on physical creations using scented and unscented modeling clay. We compare features of abstract creations of three groups (i.e., vanilla scented, lemon scented, or unscented material). Our preliminary results confirm pre-existing mappings across shapes and scents. We discuss the various properties of the creations and discuss their relevance based on previous work and in particular its potential for HCI in the design of future interactive experiences.

Author Keywords
Expressiveness; Physicality; Odor; Scented material; Cross-modal correspondences; Creativity.

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

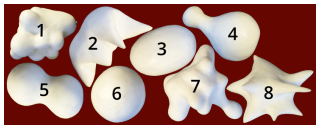

Figure 1: SEI, Sensual Evaluation Instrument consisting of 8 objects with different shapes by Isbister et al. [8]. A non-verbal channel of communication between user and designers for emotional expressiveness.

Introduction and motivation

The increased interest in designing for a wider spectrum of experiences and interfaces (e.g., tangible, multimodal, multisensory interaction) by employing sensory feedback is a new and intriguing challenge for interaction designers. The terminology to express visual and audio experience is mostly established, however other aspects of our interactions, such as the emotional and experiential, remain less explored. In fact, our current vocabulary is so difficult to use when designing for such experiences, that the challenge for designers becomes even greater. In order to improve the communication on unexploited aspects of the interaction, a number of non-verbal approaches have been developed. Among them, the *Sensual Evaluation Instrument* (SEI) [8] is used to elicit affective responses using a set of eight objects with different shapes (see Figure 1). The shapes represent various levels of arousal and valence (positive and negative affective experiences). Isbister et al. [8] do not claim a direct mapping between the objects and emotions, but emphasize the benefit of the objects for stimulating expressiveness, even across cultures [7]. SEI creates a flexible, non-verbal channel of communication between user and designers. Inspired by this work, we aimed to understand to what extent this non-verbal physical approach could be extended towards the sense of smell. Despite being under used in HCI, the sense of smell is an important sensory modality. Odors have been established to affect mood, psychological health [10] and influence cognition and behavioral processes even when they are not consciously perceived [6]. Hence, in our first exploratory study, we investigated the effect of odor (in our case: Lemon and vanilla) on people's expressiveness building on previous correspondences established between odor and shapes .

Crossmodal correspondences and olfaction

Psychologists have known about the existence of crossmodal correspondences for many years, that is, the sometimes surprising associations between abstract features of sensory information (e.g., tastes and colors, or odors and auditory pitch) [11]. Crossmodal correspondences have been found, for example, between odor and color (e.g., [3], [1]). The robustness of such correspondences have been demonstrated both explicitly (i.e., correspondences have been documented to remain stable after 2 years) [3] and implicitly [1]. Intensity of odor concentrations have also been associated with darker colors [9]. Previous work has also shown that the presence of an odor can modify the tactile perception of fabric softness [2]. Most recently, correspondences between shapes and specific odors were identified [4]. According to those findings, specific odors are significantly associated with either angular (lemon and pepper) or rounded shapes (raspberry and vanilla). In our initial study, we used these correspondences as a starting point. We choose the lemon and vanilla scents for two reasons. Primarily, because they have been shown to have opposite associations when it comes to odor shape correspondences [4] and secondly, due to their accessibility and our ability to experiment between multiple over the counter versions to asses which works best with the modeling material.

We scented white, odorless modeling clay (see details on the material used below) with either lemon or vanilla scent to investigate the effect of the scented material on people's expressiveness, more specifically to explore the distinctiveness of abstract creations (sculptures and drawings). In the following, we present the details of the study and discuss the preliminary results, which give rise to future work.

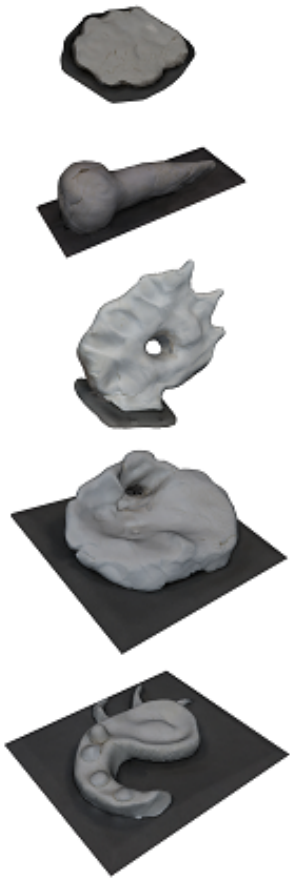

Figure 2: 3D reconstruction of some *vanilla* shapes.

Exploratory study

The main goal of this first exploratory study was to explore whether the different odors would lead to clearly identifiable differences in creative outputs (i.e., referred to as sculptures, drawing, and coloring). In the following we present the details on the study material, the set up and procedure.

Material used: Clay and odors

As a base material for the participants' sculpting we chose the Staedtler Fimo Air Light Clay, which is an air drying clay made of 97% natural material similar to china clay (kaolin) (article number 8131). This material fulfilled the two main criteria we were looking for in the modeling clay: (i) keeping its texture even when the scents were added to it, and (ii) of being considered odorless. Moreover, the material chosen for the study was white so to minimize potential crossmodal correspondences between color and odors, as identified in previous works [3], [1].

The added scents were off-the-shelf food flavoring odors used primarily for baking and easily found in a common grocery store. In the case of the lemon scent, we used Waitrose Cooks Homebaking lemon extract, composed of rapeseed oil and 12% lemon oil. For the vanilla scent we used Waitrose Cooks Homebaking vanilla extract, composed of water, ethanol, and 3% vanilla extract. The procedure of mixing the scents into the modeling clay was done by gradually adding the scent while kneading the material. Each participant was provided with 75g of clay in a sphere like shape that was either scented with vanilla or lemon, or an unscented sample of the base material. We considered the amount of clay enough to create a reasonably complex yet small object in the time given for the task.

Set up and procedure

Participants were randomly assigned to one of the three groups (scent 1, scent 2, unscented material), and asked to complete three creative tasks. For each task two minutes were allocated. The short time was chosen so to avoid too complex creations, as well as to maximize the effect of the *inspiration* preventing the participants to *over-think* their tasks. The study took place in a quiet room with the participant facing a bare wall.

The first two tasks consisted of creating two abstract (not figurative) pieces in sequence, either drawing an abstract piece with a pencil or molding an abstract piece (sculpture) with scented/ unscented clay. The order of the first two tasks was randomized. The third and final task for each participant in all three groups was a coloring task for the created drawing. This task was added to assess potential crossmodal carry-over effects that could have arisen while interacting with the scented material.

Once all tasks were completed, participants were asked to give a short explanation about their creations. We asked them to explain their drawing/object, as well as the process of creating it. We also asked how they liked to work particularly with the modeling clay, and if they noticed any odors. Finally, we asked for reasons behind choosing specific colors for their drawing. These questions aimed to elicit any explanations and details on the creative process and potential influences, which would help us in explaining the final creations. In total, each session lasted no longer than 15 minutes, including a short introduction and debriefing.

Participants

A total of 17 participants (12 males, 5 female) took part in this first exploratory study. Volunteers were recruited from the HCI research team and University staff, schools of engineering and informatics (including members from the administration and technical team). Overall we collected feedback from 17 participants: Group 1 *vanilla* (6 participants), Group 2 *lemon* (6 participants), and Group 3 *unscented* (5

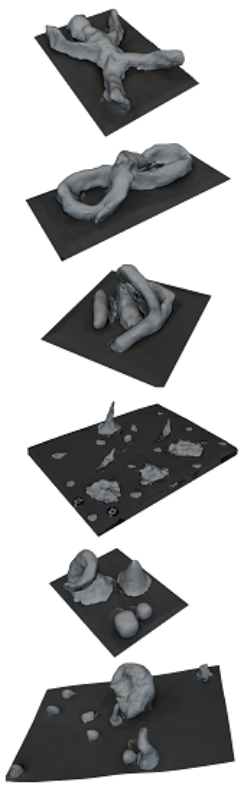

Figure 3: 3D reconstruction of some *lemon* shapes.

participants). Out of the 17 physical creations (sculptures), we had to exclude one creation in the *vanilla group* due to the nature of the task not being fully understood and the outcome not being an abstract piece but a literal representation of a dog's head. The remaining 16 sculptures were used for the preliminary analysis. Example of sculptures from each scented group can be seen in Figures 2, 3, and 5.

Preliminary analysis results

Despite the small number of participants, a preliminary analysis of the data was performed in order to spot trends in the abstract creations for the three groups. At this stage, the analysis only focused on the immediate effect of scent on the molding task, without assessing possible crossmodal carry-over effects by looking at the drawings and coloring of the drawings. Three participants out of six in the groups *vanilla* and *lemon* were able to spot the scent in the clay. In the unscented group, three participants stated that the clay had an odor itself (described as chemical odor), despite the specification of the material being classified as odorless. For the present study, we assumed that the vanilla and lemon scent were able to cover up the faint odor of the clay. In order to compare the different groups, four elementary features were measured for each of the sculptures.

In particular, the height, length, and depth of each sculpture were combined to compute the area of a parallelepiped (a prism with all rectangular faces) in which the sculpture could be included. Moreover the number of parts the creation was composed of, the number of spikes the creation had, and the number of separate bodies enclosed in the creations were considered (see the two exemplary creations from each scented group, Figure 4). Results from this initial exploration are showed in 6.

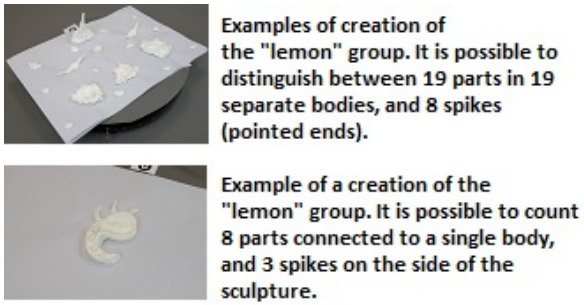

Figure 4: Examples of sculptures produced with lemon and vanilla scented modeling clay.

Despite the small number of participants, a rough assessment of the differences between groups was performed by using a non-parametric ANOVA (Kruskal-Wallis rank sum test) and Conover's-test for multiple comparisons with Bonferroni correction. The analysis showed that the *lemon* sculptures tended to occupy a bigger area than the ones from the *vanilla* group (Kruskal-Wallis chi-squared=6.98, $p<0.05$, Conover's-test $p<0.05$). Although no statistically significant differences were found in the number of spikes ($p=0.8$), parts ($p=0.3$), and bodies ($p=0.06$) of the sculptures from the different groups, the boxplots highlight some clear trends. Indeed, sculptures molded with lemon-scented clay tended to have a higher number of spikes, parts, and bodies than unscented and vanilla-scented sculptures.

Future analysis based on 3D models

Alongside collecting features from the sculptures, we plan to examine the effect of any interaction between the scented clay and the choice of colors in the third task. If a cross-modal carry-over effect will be confirmed, we would expect a difference in the choice of colors as in [1].

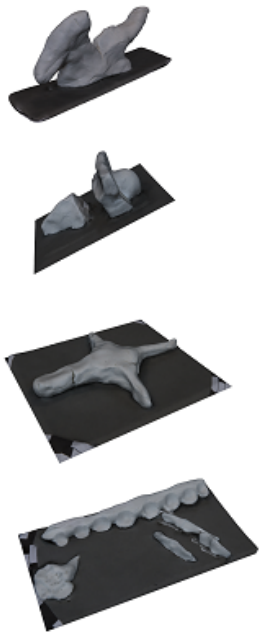

Figure 5: 3D reconstruction of some *unscented* shapes.

In case of absence of carry over effect, a further study will be performed in order to investigate the importance of the source of the smells.

To this aim, the effect of olfactory stimulation on creativity will be tested both when the smell is coming from the creative material (as in the present study), or when is instead disperse in the ambient. Moreover, to better assess the differences between sculptures, we used photogrammetry techniques to accurately reconstruct the sculptures as 3D models (Figure 7). This technique was chosen because a 3D scanner large enough to scan some of the sculptures was not available.

The 3D models will be used for a larger study using crowdsourcing. We plan to compare the models by similarity and apply multidimensional scaling under the assumption that if an effect of the scent is present, then it is possible to identify three main clusters in the multidimensional distribution, namely lemon, vanilla, and unscented.

Discussion and directions for future work

Given the restricted number of scents used and small sample size reached in this initial study, little can be said on the particular way each odor affects the shape creation. However, results are encouraging in that they indicate the influence of scent in the physical creations. Our results are therefore in line with previous work regarding our cognitive and perceptual mechanisms [11].

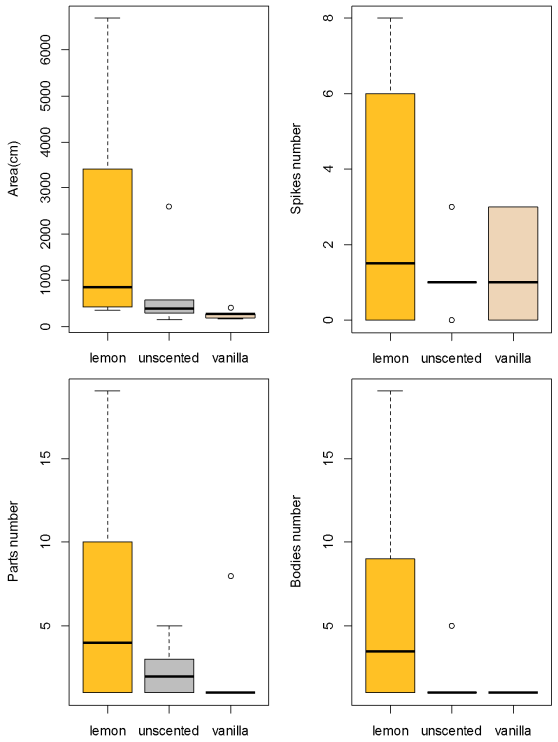

Figure 6: Boxplot results for the three groups in terms of Area (upper left), Spikes numbers (upper right), Parts number (lower left), and bodies'number (lower right). In boxplots, the darker line represents the median of the data, the lower whisker the first quartile, the upper whisker the fourth quartile, and the box area the second and third quartile.

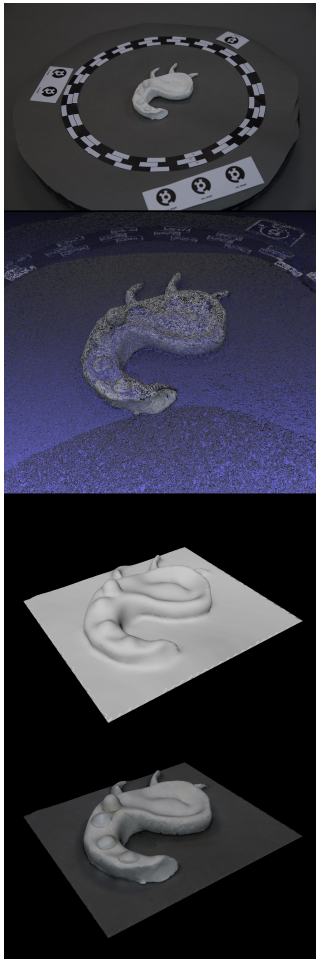

Figure 7: 3D reconstruction process exemplified by one physical creation.

Indeed, during the last decades, research on synaesthesia and crossmodal correspondences has provided important insights for the search of cross-sensory relationships [5] proving that cross-sensory associations occurring between senses are broadly intuitive and do not depend on cultural and/or historical circumstances. It is not surprising then, that groups of participants are influenced by odors in creating similar shapes. Our initial results support the idea that an odor-shape correspondence exists, not only in passive associative tests such as the ones showed in Hanson-Vaux et al. [4], but even in an active, free association creation session. Interestingly, this also suggests that odor can direct the outcome of a creative task and introduces the question "how much creativity can subconsciously be influenced by such crossmodal correspondences". Finally, this work shows that existing non-verbal methods and design communication tools, such as SEI [8], could be extended through scent and hence provide another non-verbal communication channel between designers and end users.

While the primary aim of the present research is to collect information on the crossmodal association between odor experiences and shapes to create a nonverbal communication tool for olfactory experiences, the relevance of this paper for HCI is not limited to it. In fact, this study hints that best practice when designing an interface for a given sensory experience is the exposure of the designer to the experience he/she is designing for during the design process.

Conclusions

The insights gained from this first exploratory study on the effect of scented material on a persons physical creation, show that the previously identified mapping between scent and shapes are reflected in creative tasks. This will allow us to further investigate the relationship between shapes and smells, helping to create non verbal tools for expressing olfactory experiences. Furthermore, the findings encourage an expansion of this research considering new participants and new varieties of odors, as well as a more comprehensive research on the effect of sensory stimulation and crossmodal correspondences on creativity.

Acknowledgments

This work was supported by the EC within the Horizon2020 programme through the ERC (Starting Grant Agreement 638605). Special thanks go to our volunteers for supporting this research as well as to Katherine Isbister for her positive feedback on our work and sharing the 3D models of the SEI for future work.

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