Integrating the Sense of Smell in an Educational Human-Computer Interface

Miguel A. Garcia-Ruiz¹, Samir A. El-Seoud², Arthur Edwards¹, Jihad Mohamad AL-JA’AM³, Raul Aquino-Santos¹

¹College of Telematics, University of Colima, Mexico
²Princess Sumaya University for Technology, Amman, Jordan
³College of Computer Science and Engineering, Qatar

Key words: Human-Computer Interface, Olfactory Display, Sense of Smell, Education, Memory.

Abstract:

Although audio-visual information has been successfully employed in educational technology, the sense of smell has not generally been considered for integration into human-computer interfaces for education. Olfactory information, however, can serve to complement or supplement learner auditory, visual or tactile channels. Although many general studies exist about how the sense of smell contributes to cognition and affection, little work has been done on how it affects computer learning or how it can be incorporated into interfaces. To explore these questions, a usability study was carried out with engineering students, to see if mint odor assists memorization and information recall during and after reading an educational Web page. Results shown recall improvement when using the odor, and students enjoyed the usability study.

1 Introduction

One of the major pedagogical issues in educational technology has been the use of multimodal interaction (the concurrent use of multiple human sensory channels to interact with a computer interface) in the classroom and in a computer room, exploiting the learners’ human senses to support learning. It has been found in experiments that using more than one human sense in multimedia or multimodal interfaces, particularly in audio-visual software and hardware, is an effective way to acquire knowledge [4], based on the Cognitive Theory of Multimedia Learning [5], the Dual-Coding Theory [12], and other relevant theories. In addition, there is a growing body of research about haptic (tactile) interfaces for learning, which can make use of force and touch feedback for effectively conveying complex information, for example, the structure of a molecule, complementing visual information and allowing a more natural way to inspect it with educational purposes [7]. However, the sense of smell in human-computer interfaces for education has been very much underused worldwide, despite its proven importance for helping remember and relate complex pieces of information [1], especially in enhancing recall, recognition, and attention, all fundamental activities that foster learning. This paper describes an exploratory study about using the sense of smell to assist information learning and recall of an educational Web page. This will serve to start the design and construction of an olfactory human-computer interface for educational applications. The purpose of this paper is to assess the technical issues of using odors in human-computer interfaces, to be used in an educational setting.
An olfactory interface employs one or more natural or artificially-created odors in a computer interface, with a purpose to its human user. The odors can be generated at the interface using mechanical, electro-chemical methods, or using a combination of them. Kaye [3] defines an olfactory icon as a computer-generated scent that conveys meaningful information to its user(s), which is semantically and environmentally related to the information to be conveyed. For instance, a computer display can show a virtual environment of a forest, and immediately release a scent of pine trees, this to enhance the immersion experience to its user.

1.1 Previous Research on Olfactory Interfaces in Education and Training

One of the first technological applications that used odors to convey information and complement other human senses was the Sensorama, an arcade-like cinema projector for individuals that was invented by Morton Heilig in the early sixties. The Sensorama generated odors that corresponded to some projected movie scenes, and made the participant feel immersed in the movie [10]. Between the sixties and late nineties, little research was carried out on olfactory interfaces, particularly for education and training, mainly because of the lack of technological advancements in personal computers with enough processing power, to support odor generation and control, and better ways to recreate, store, and release odors in human-computer interfaces.

One of the most developed olfactory interface application happens in the military training. According to Vlahos [11], the U.S. military, in conjunction with the University of Southern California and theme-park designers, have developed realistic virtual reality simulators to train U.S. soldiers, where the researchers have integrated smells to enhance the ambient of a simulated war zone. The soldiers wear an electronic collar where the scents are generated, and each odor is activated through a wireless network, according to the activities done and events generated in the virtual scenario. For example, when soldiers shoot guns in the virtual environment, they perceive the smell of gun powder, generated by the electronic collar they wear.

[9] Pointed out in their research that using the sense of smell in virtual reality (the computer technology that generates a 3D space that is highly interactive and multisensorial) is an effective way of supporting training and learning, without compromising its users' cognitive load, according to trends they found in their literature review.

[8] Reviewed a number of research projects about the incorporation of odors in medical simulations for teaching and training, since olfactory cues are important in medicine to make a correct patient diagnosis in some diseases. In this paper, the author discussed that today it is technically feasible to use odors in virtual reality simulations for medical training, thanks to recent technological devices for smell production in a computer interface, and ways to activate them remotely over the Internet. This paper showed that adding simulated odors to a medical simulator is an effective way to complement diagnosis and enhance training skills in medicine students.

Past research claims that if educational technology has a high degree of usability, it will assist learning and training more effectively, and will positively impact student extrinsic motivation about its use [14, 15, 16]. Usability is defined as “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [13]. According to Nielsen [17], usability has five quality-of-use
components: Efficiency (how users perform tasks at the interface), learnability (how users learn to use the computer interface), memorability (after returning to use the interface, what users remember about its usage), errors (user errors performed at the interface, and how to recover from them) and satisfaction (the subjective experience of comfort and motivation about using an interface).

2 Preliminary Usability Study

A limited usability study was carried out to assess the experience and the effects of purposely using an odor, while a group of students access and learn a Web page in a typical school computer room. We wanted to see whether it was technically feasible to use an odor in a computer room for educational purposes, as well as how common mint odor can help students memorize complex data chunks, and how mint can help recall that information in a computer interface. We chose mint odor because it has positively been tested with students to help memorization, and particularly to support emotional memory [2]. In this article, Holloway described an anecdotal study carried out with two groups of students. In it, the main task for both was to memorize a list of words. Only one of the groups smelled peppermint while memorizing the words. It was found in the study that the group of students that smelled the peppermint recalled the words 50% better than the control group after one week, when they were re-exposed the odor. It was also found in other studies that odors can be a powerful emotional enhancer in students, and this may help them to cope with anxiety in exams.

2.1 Method

In our usability test, a questionnaire with Likert-style scales was administered to the participants to assess the usability on the mint usage. A knowledge pretest and post test was also administered.

2.2 Materials

Fresh mint leaves (Mentha Spicata) were used in the study. Each participant used a desktop computer with a standard Web browser and Internet connection. A computer room with 26 computers was used for this study, where each participant was seated next to each other in rows.

2.3 Participants

Participants in this study were 26 Computer Science engineering students (22 men and 4 women), with an age average of 21 years. The participants’ composition comprises a typical classroom from our College. None of the participants reported having olfactory-related health problems, such as a cold or anosmia (the physiological incapacity to perceive any odor). In addition, none have used an olfactory human-computer interface before.

2.4 Procedure
At the computer room, each participant was asked to sit in front of a personal computer. First, an experimenter explained the purpose and procedure of the test, and administered a pretest to the participants with the following questions:

1. Approximately, how many odors does a normal human nose perceive?
2. What are the cilia within the nose?
3. Write down the name of the seven types of olfactory cells.
4. Write down the names of two diseases of the sense of smell and describe each.
5. Explain what olfactory fatigue is.

The participants' task was to open, scroll and read this Web page: http://es.wikipedia.org/wiki/Olfato, whose length is about one full letter page. This Wikipedia page contains an explanation of the human olfactory system. Each participant had to take three mint leaves, rub them with their fingers to release their odor, and smell them while reading the Web page. 15 minutes were allotted for this task. There were two groups of participants distributed in two conditions, with 13 participants each. In the first condition, one group had to smell the mint leaves and read the Web page, and the other one just read the Web page.

After the task was completed, a post test with the same questions of the pretest was administered to each participant of both groups. The post test from that was applied to the group that smelled the mint also had the following 5-point Likert scales on the usability of the exercise (1=strongly disagree, 5=strongly agree) to obtain student opinions on the usability of the mint and the interface:

1. The test about the Web page reading and the mint smelling was fun
2. I would like to use olfactory interfaces in the future
3. I had discomfort when smelling the mint and browsing the Web page

3 Results

Figure 1 shows the results of the pretest and post test of the study.

![Figure 1. Number of participants that correctly answered each question of the study.](image-url)
the pretest and post test of each condition.

Figure 2 reports the participants’ opinion about using the mint odor while reading the Web page.

![Figure 2. Likert scale results of each opinion question (strongly disagree-strongly agree).](image)

4 Conclusions

The results of the usability questionnaire show that students enjoyed the test and wanted to use an olfactory interface in educational activities in the future. Moreover, the post test results indicated that students who smelled the mint performed slightly better than the students who just read the Web page. Further longitudinal tests are needed to corroborate this with individual tests and attending to individual differences, since all the students were present in the same computer room at the time of the test. Although the students were seated about 1.5 meters apart from each other, there were possible interactions and influences between them, and possible smell contamination that could affect the results on both conditions.

This usability test served to take into account a number of technical issues about integrating odors in a human-computer interface, to be used in an educational setting such as a computer room, mainly about the storage of the smell source, the method for generating the smell, and the smell removal. In this test, we kept the freshness of the mint leaves by storing them in a small portable freezer with dry ice packs just before the usability test started. Since the smell generation was mechanical (the students rubbed the mint leaves to release its odor), it was a very quick and personal way for releasing the odor. Most of the students that smelled the mint went to wash their hands after the test, and some preferred to stay with the mint odor on their fingers. The latter students commented that the mint “smelled very good,” although some of the students got stains on their clothes soon after rubbing the mint leaves. Moreover, Brewster et al. [1] provides a good guidance on smell storage and dissemination. We have found that all the methods for disseminating odors, as described in [3] and including ours, have technical
advantages and challenges, especially those used for a number of people present in a same room.

Future work aims at replicating the test by carrying out longitudinal studies, to see if olfactory interfaces are well accepted by students of other educational levels, and to see if information recall changes over different periods of time, when odors are integrated in educational human-computer interfaces. We also plan to carry out other well-established usability tests with an individual olfactory interface to support learning, for example, the application of the System Usability Scale questionnaire.

One particular area that multimodal interfaces with olfactory information may prove promising is employing them for the treatment of intellectual disabilities in children in educational settings. Adding odors to learning systems for the intellectually disabled may significantly assist these individuals learn because olfactory information is primarily processed in the hypothalamus, the primitive part of the brain. By stimulating learning by using the hypothalamus, individuals with learning problems may help compliment cognitive processes by employing a part of the brain that is not optimally exploited by employing more common sensory input. Further research is planned for studying technical issues and usability on the integration of olfactory information into multimodal interfaces for cognitive disabled children. We propose carrying out research and development on olfactory/visual/auditory environments that can assist children better employ and integrate their different sensory channels, to support their cognitive abilities.

References:


Authors:

Miguel A. Garcia-Ruiz is with the College of Telematics, University of Colima, Ave. Universidad 333, Colima, 28040, Mexico. (e-mail: mgarcia@ucol.mx).

Samir A. El-Seoud is with the Princess Sumaya University for Technology (PSUT), CS Department, P.O.Box: 1438 Al Jubaih, 11941 Jordan (e-mail: selseoud@yahoo.com ).

Arthur Edwards Block is with the College of Telematics, University of Colima, Ave. Universidad 333, Colima, 28040, Mexico. (e-mail: arted@ucol.mx).

Jihad Mohamad AL-JA'AM is with the College of Computer Science and Engineering, P.O. Box 2713 Doha, Qatar. (e-mail: jaam@qu.edu.qa).

Raul Aquino-Santos is with the College of Telematics, University of Colima, Ave. Universidad 333, Colima, 28040, Mexico. (e-mail: aquinor@ucol.mx).