A Comparison of Scent-Delivery Devices and their Meaningful Use

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Abstract
UPDATED—February 12, 2016. The olfactory system is one of the five basic human senses. Despite the growing amount of visual and auditory stimulation approaches, there is just a very limited number of interactive devices that harness the olfactory communication channel. To fill up this gap, several promising scent-delivery devices have been developed recently. In addition, the availability and affordability of these devices for consumer use have given a great chance to explore their applicability in HCI. However, there is a lack of a comparison framework and design guidelines for applying such devices to different interactive tasks. In this paper, we evaluate and compare four smell-delivery devices currently available on the market to public users. Based on the evaluation and comparison, we propose a temporal-spatial resolution model and guidelines to assist HCI designers in choosing or designing scent-delivery device for their olfactory interaction system.

Author Keywords
Smell; Scent Delivery Devices; Olfactory Experiences.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]; H.1.2 [User/Machine Systems: Human factor.]

Vortex Activ USB is a scent dispensing system designed by **Dale Air** - British company from Whitworth, UK. It allows delivery of 4 individual scents released by exposing their cartridges to four individually controlled fans. Once the driver is installed (automatically under MS Windows), this device can be considered a plug-and-play USB controller. It has an intuitive user interface and is easy to learn to control.

Figure 1: Dale Air Vortex Activ USB with four scent cartridges exposed to four fans

Introduction

Using smell as an interactive mechanism has gained more attention in HCI recently. For example, Olfoto [2] is a smell-based photo tagging tool which uses smell to elicit memories in users. Another example is in Bodnar et. al. [1], where they used smell for notification stimuli. Their results show that smell is less disruptive than visual and auditory modalities. Lai [3] investigated the enhancement of interactivity applying the olfactory interface. Furthermore, Yoshida et al. [4] developed an in-car scent delivery system to fight drowsiness in subjects performing the driving task. Releasing "awaking" smells (peppermint, rosemary, eucalyptus and lemon) he could extend wakefulness.

Despite an increased interest in the exploration of smell-enhanced technologies and the advances in creating a smell devices, there is a lack of implementation guidelines for a specific application context. We still question, which technology should a smell-based device rely on and how will the users be interacting. It has to be understood, which delivery mechanism is suitable for an intended purpose.

There is no "one-fits-all" answer, as it depends on the application context. It has to be clear, however, of what the purpose of the device is and what kind of experience is desired. A need for a model of comparison parameters emerges. Based on it, HCI designers can either choose an available consumer device or create their own, upon suggested parameters and technologies. We establish the model based on following recent devices: (i) Vortex Activ USB[1], (ii) Scentee [2], (iii) oPhone[3] and (iv) Aroma Shooter[4]. Our evaluation and proposed framework are a solid contribution to the growing field of olfactory research in HCI.

[1] www.daleair.com/dispensing/dispensers/
[2] http://scenteeusa.com/products/scentee
[3] www.indiegogo.com/projects/ophone-duo/
[4] http://aromajoin.com/aroma-shooter/

Comparison of Four Scent-Delivery Devices

Table 1 provides an overview comparison of the four scent-delivery devices based on their basic characteristics. In addition to this, we investigated each device further based on two main parameters: their spatial and temporal resolution. Here we defined **spatial resolution** as the expansion of the scent, once released by the device, into the interaction space and the persistence of the scent in that space over time. The **temporal resolution** refers to the speed of the scent delivery to the user's nose, once the scent is released from the device. For example, if the user can smell the scent nearly immediately after release, the temporal resolution is very high.

Device 1: Vortex Activ USB by Dale Air

We tested Vortex Active USB (Figure 1) in a typical office environment. It can be controlled to release maximally 4 scents, either individually or in a combination. This was done by turning the fans on or off manually by the controlling software. However, there is no directional control of the scented stream. For this reason, it is impossible to project the scented air to a precise point or area. Each scent is also limited to a short distance (<5cm) from the scent dispensing point. As a result, users need to keep the device close to their nose to perceive the released fragrance. Further away they would only smell the mixture of all scents, even if only one of them is dispensed. This might be due to the fact that the scent cartridges are not well isolated from each other (despite the device specifications). Moreover, without a good ventilation system, the air surrounding the device was contaminated for 2-3 hours after turning it off. Our findings do however require further exploration. Since one of the tested scents was unpleasant, even a very small portion of it remaining in the air elicited negative emotions.

Scentee is a smell device that emerged from the Japanese market and is now available in the USA. It comes in a form of individual cartridges that need to be charged and can then be plugged into the audio output (e.g. of a smartphone). They are controlled by a simple app, allowing to manipulate the duration and the interval of the scent delivery. This can be useful for application developers, to map scents to particular notifications (e.g. new email or new post from the social media).

Figure 2: Scentee device and its components

	Scent-delivery devices			
Characteristics	*Vortex Activ USB*	*Scentee*	*oPhone DUO*	*Aroma Shooter*
Scent cartridges	4	1	8	6
Scent combinations	16	0	>300000	64
Delivery distance	<10 cm	<15 cm	<10 cm	<50 cm
Smell persistence	long	short	medium	short
Delivery speed	slow	fast	medium	very fast
Platforms	Windows	iOS	iOS	Windows/Linux/iOS
Interfaces	USB	Audio Output	Bluetooth	USB

Table 1: Comparison of scent delivery devices based on their key features.

In conclusion, Vortex Activ USB offers a low temporal resolution, but with a very high spatial resolution, which is however limited due to the mixing of all scents in the air. This feature turns mapping of individual scents to specific tasks or experiences into a challenge. The device is however interesting for ambient notifications, not requiring fast actions. Example for this was presented by Brewster et al. [2].

Device 2: iPhone Smell Device by Scentee
In contrast to the mechanism of Vortex Activ USB (described above), Scentee (Figure 2) pushes the odorized air (in the shape of a 15-20cm long misted cloud) out of the device. This significantly increases the detect-ability of the released scent. This distance of the mist travel is however still considered small compared to the set-ups without the affordance of bringing the nose closer to the scent dispenser. The temporal resolution of Scentee can not be judged high for the whole distance from the device to the subject's nose. Nevertheless, it is significantly higher than in the case of the Vortex Activ USB. One must admit though that the number of good exposures of scented mist is very limited. After approx. 10 releases the signals get significantly weaker: the misted cloud reduces its volume and the concentration of the delivered smell is getting lower. The released scent does not linger long (2-5 seconds), since the mist diffuses quickly and the scent disappears.

Scentee proposes a low temporal resolution, but still higher in comparison to Vortex Activ USB. Although Scentee provides low spatial resolution, it is appropriate for the use in the mobile phone context. Specifically, the scent delivery is kept within a personal user space and discreet, as the scent is less likely to disturb surrounding people. An example for such applications is the "Smell the Bacon App"[5].

Device 3: oPhone by Vapor Communications
In contrast to the previous devices, the interface of the oPhone (Figure 3) is prompting the user to move the nose closer to the scent releasing unit (<5cm) enabling the response of 2-3 seconds. This affordance implies a very low temporal resolution. The device is not suitable for delivering scent signals requiring immediate reaction, but allows

[5] http://scenteeusa.com/blogs/news/13348077-oscar-mayer-uses-scentee-for-the-wake-up-and-smell-the-bacon-app

oPhone DUO by Vapor Communications from Cambridge, MA and Paris, France. First commercial device to enable scent messaging. 8 scent cartridges, creating over 300000 combinations (more than other tested devices). Controlled by an iOS app.

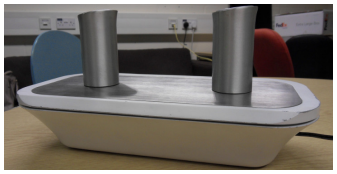

Figure 3: oPhone DUO

Aroma Shooter was developed in Japan, by Aromajoin. 6 scent cartridges with mixing possibilities. Works via USB. Employs scent injection, allowing precise delivery at ~50cm. Has an across platform control interface. Intends various applications in HCI (e.g. scents in movies).

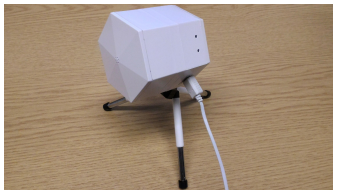

Figure 4: Aroma Shooter

similar distribution patterns as the Vortex Activ USB. The delivered scent stays in the air after the end of the delivery, disappearing slower than with Scentee, but quicker than with Vortex Activ USB. The drawback lies in its maintenance. The scents are absorbed by the output tubes, requiring cleaning after every 10-15 releases.

Temporal resolution of the oPhone is low, similar to the previous two devices. However, this is probably an intended design feature. oPhone's spatial resolution is high, but lower in comparison to the Vortex Activ USB. In contrast, oPhone offers a much higher number of scent combination possibilities. This creates a large potential of mapping the scents to different interactive use cases.

Device 4: Aroma Shooter by Aromajoin
Aroma Shooter has a very good temporal resolution allowing pointing the scent-delivery to a precise target on the distance of up to 50cm. It takes about 2-5 seconds for the user to detect the scent. Moreover, the scent completely disappears within a few seconds after the delivery, which makes its spatial resolution very low.

Discussion and Trade-Offs

Our first attempt was to explore each of the four devices based on their temporal and spatial resolution. However, we are aware that there are many more features to be considered and included in the comparison (e.g. size of the device). From an interaction design perspective, time and space indeed form a good starting point, as they can be linked to specific task, scenarios and interaction goals. Here we propose some application contexts in HCI that are suitable for the parameters of each device.

Due to its injection technology, the Aroma Shooter can be seen as most suitable for quick stimulation. It enables fast perception/reaction, making use of a high pitched sound and the LED light accompanying the olfactory emission. Nevertheless, it is interesting to explore, if such an olfactory stimulus could stand on its own or only reinforcing a much faster auditory or visual stimuli. It could become very beneficial for users with impaired audio-visual channels.

Scentee, in contrast, does not provide as quick scent distribution, but can be easily interacted on an iPhone or an iPad. While on the move, such mechanism can enhance infotainment experiences, such as watching video clips on the phone, enhanced through smell. Such usage requires decent spatial resolution: just like the ring-tone of the phone would play for at least a few seconds, the delivered smell would stay in the space next to the user's nose for a few moments too. Temporal resolution can stay low in such application scenarios (speed of the delivery is not a crucial aspect). Unfortunately, the olfactory interaction is limited to one scent at a time here. Involving a new smell would require exchanging the scent cartridge. If this device will support multiple smells in the future, it would be a highly favored kit for multisensory designers of mobile applications.

Similarly to Scentee, oPhone is suitable for the delivery of a less urgent information. Opposing to the Scentee's portability, the oPhone is currently only useful for desktop applications. The device is optimal for receiving and sending smell messages. Its lingering effect of the dispensed smell might create problems for rapid scent changes, but be beneficial for the tasks with smell persistence requirements.

Because of its capability of spanning the interaction space, the Vortex Activ USB is suitable for ambient uses, such as influencing the mood. Its application for interaction tasks relies on several constraints. The separation of scent cartridges from each other proved itself not suitable for quick changes (within a few seconds) between different smells. Comparing to other devices, Vortex Activ USB also offers

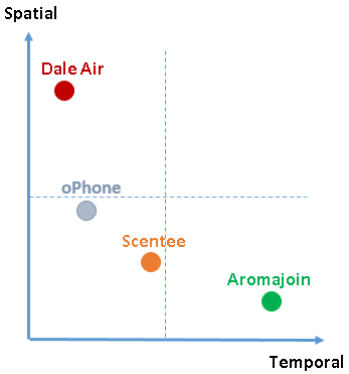

Figure 5: Comparison of 4 scent-delivery devices

a less sophisticated control over the delivery parameters and the choice of scents. For this reasons, we propose the application of this device only for ambient notifications.

As the comparison of the devices shows, there is a trade-off between the temporal and the spatial resolution for each device. In Figure 5 we tried to provide an overview on each device's capabilities based on our initial exploration. This needs to be further investigated to really grasp the differences between opportunities of olfactory stimulation.

Conclusions and Directions for Future Work

We presented four different scent-delivery devices currently available on the market. In addition to underlying their key features, we proposed the model of temporal and spatial resolution as the basis for the comparison. Based on that, we discussed their suitability for different interaction tasks.

Our next step is to design a user study, where we perform the final evaluation with collecting subjective data. We exclude the Vortex Activ USB from this stage, as it had the lowest performance and offered the least control parameters. The remaining 3 devices: Scentee, oPhone and Aroma Shooter will be taken for further investigations. Particularly interesting are the various mechanisms for the automotive context. In this scope we are trying to map their suitability to support the driver and the passengers. That will include various interaction scenarios. Scents could be released as an alarming or rewarding stimulus, enhance the driving experience or provide an added value for the in-car infotainment. Here it will also be crucial to explore controllability and extendibility of the sensations, as well as types of aroma (liquid or solid). These parameters will offer new dimensions for the comparison of scent-delivery devices.

There certainly are many more similar devices available on the market right now. Our proposed model can be used to compare new technologies and control mechanisms with the old ones and the currently available devices serve as a very good basis for setting up a comparison and evaluation model. Our summary does not include all the possible comparison and evaluation criteria, but offers a framework to deal with this complicated task.

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