Investigating the Influence of Odors Visuals Representations on the Sense of Smell, a pilot study

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Abstract

This pilot study researches the representation of smells in Virtual Reality and its association with real smells. Olfactive stimuli in VR remains limited and difficult for effective use. We propose a work-around with a "synesthesia-like" approach (e.g. the smell of perfume is associated to a pink smoke / seeing a violet can elicit its odor; etc.). We present 2 studies (N=14) where: 1/ We compare 3 smell representations (smoke-based, image-based, visually physically-based) to know *the best* representation; and 2/ We compare good / bad real smells with good / bad virtual smells to know how the user associates them.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality

1 Introduction

The more senses are engaged in a Virtual Environment (VE), the more the user feels present inside. Yet stimuli in Virtual Reality (VR) are mainly visual, auditory and tactile. Despite the importance of our sense of smell in daily life, relatively little VR application use odors, because of the difficulty to work with them [2] (i.e. odors must be created and then emitted in the VE). In VR, at the best of our knowledge, there is no studies about virtual smells representations, and its impact on user experience. Here, instead of focusing on "real smells", we focus on "virtual smells" (i.e. users can see the smells but not smell them), to use them to improve *odor awareness* [3]. Ultimately, we believe virtual smells can help people to focus on smells and therefore on objects characteristics, leading to a better presence in the VE.

2 Setup

We developed the *Smell It* application with Unity 2018, and we deployed it on a laptop able to run it smoothly. The user's head and hands were tracked with the Vive Pro[1] and the Vive Pro controllers, and his/her respiration cycles were tracked with a respiration belt[2] connected to a BITalino board[3]. For the task 2 (c.f. Sec. 4) we prepared 3 "smell boxes" (good; bad; empty; c.f. Fig. 2) and a fan.

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[1]https://www.vive.com/fr/product/vive-pro/
[2]https://plux.info/sensors/40-respiration-pzt-sensor.html
[3]https://bitalino.com/en/board-kit-bt

3 Virtual Environment

The VE was a somewhat realistic room (5x5m). The user was positioned in front of a virtual table (of the same height than the real table) and in front a virtual TV. The TV displayed the experiment status (such as: "The next task is about to begin") and the experiment questionnaires (c.f. Tab. 1). The user answered the questions directly on the TV by selecting the answer with a virtual pointer (cast from the controllers) and validating it by pressing a controller button.

3.1 Smell virtual representations

All the smell representation (c.f. Fig 1 and Fig. 2), no matter the type, are based on Unity's particle system, and the particles' size and color all changes along the particle lifetime. Also, the particles' visibility depends of the user's respiration (i.e. the more the user's abdomen is extended from the calibrated abdomen extension, the more the particles are visible).

Figure 1: From left to right: Image representation (i.e. tomato and chorizo textures); Particle representation; Blob representation (i.e. a Metaball system[5]coupled to Unity's particle system); the control condition.

4 Task Design

The participant was instructed to sit and to wear the respiration belt before entering the VE. The participant was also instructed to **always** try to get close to the object, and to try to "really smell it", by inspiring strongly (even if he/she did not smell anything). Once in the VE, the participant had to wait 60 seconds before starting the tasks (to calibrate the respiration belt). The tasks were as follow:

- Task 1. (a) The participant looked at the object (i.e. a pizza) and its smell virtual representation (either the image, the particle, the blob, or the control, c.f. Fig. 1) for 1 minute; (b) After 1 minute, the participant answered the VS questionnaire (c.f. Tab. 1). (a) and (b) were repeated for each virtual representation (randomized between participants), with a 20 seconds break in-between;
- Task 2. (a) The participant looked at the object on the table (i.e. a cake) for 1 minute; (b) After 1 minute, the participant answered the S questionnaire (c.f. Tab. 1). (a) and (b) were repeated for each conditions (randomized between participants, we detail the conditions below), with a 20 seconds break in-between. During the 20 seconds break, the fan was turned on in order to dissipate residuals of real smell (even if there was no real smell).

[5]https://assetstore.unity.com/ packages/tools/particles-effects/dx11-metaballs-120711

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At the end of the tasks, the participant removed the HMD and the breathing belt and had to answer a profil questionnaire, directly on a computer.

4.1 Task 2 conditions

The task 2's conditions were as follow: (1) **No real smell nor virtual smell [N]**, our control condition; (2) **Real Good smell only [RG]**, the experimenter placed at the virtual object position, a box containing a vanilla cake (that the participant, of course, was unable to see); (3) **Real Bad smell only [RB]**, the experimenter placed at the virtual object position, a box containing a vanilla cake mixed with cat and dog food; (4) **Virtual Good smell only [VG]**, a yellow-pink particle representation was visible above the cake; (5) **Virtual Bad smell only [VB]**, a green particle representation was visible above the cake. Note that even if there was no real smell, the experimenter always ran the fan, and always placed a box (empty in that case) in front the participant.

Figure 2: From top to bottom and left to right: bad real smell box (RB); good real smell box (RG); bad virtual smell (VB); good virtual smell (VG).

ID	Item
VS1	Does the visual makes you think about a smell?
VS2	Looking at the visual, how strong is the smell?
VS3	Looking at the visual, would you like to smell something like that?
VS4	Looking at the visual, how enjoyable would be the smell?
S1	Are you smelling something?
S2	Does the visual makes you think about a smell?
S3	Does the smell (or the visual if any) makes you feel something? (eg. hunger, emotion, memory, etc.)
S4	Is it a positive or negative feeling?
S5	Please associate the smell (or the visual if any) to one of the following images (note: the images were similar images than the ones used for valence and arousal in the Self Assessment Manikin test [1], and were explained by the experimenter).
S6	Please associate the smell (or the visual if any) to one of the following images (note: same than above).

Table 1: The Virtual Smell (VS) representation questionnaire and the Smell (S) questionnaire (all on a 5 points Likert scale, except for S4, S5 and S6)

5 Results

We had 14 participants (male = 12), without disease or handicap limiting their ability to smell. We present our results below.

Items	Image		Particle		Blob		Control		ANOVA	
	M	SD	M	SD	M	SD	M	SD	F	p
VS1	2.29	1.73	3.00	1.66	2.50	1.65	3.21	1.67	1.94	0.139
VS2	2.21	1.25	2.64	1.45	2.14	1.10	2.79	1.31	1.91	0.144
VS3	3.29	1.20	3.21	1.31	2.64	1.50	3.14	1.66	0.78	0.515
VS4	2.86	1.35	3.36	1.45	2.64	1.45	2.93	1.33	1.07	0.375

Table 2: ANOVAs results for the VS questionnaire.

For the S questionnaire, all the ANOVAs were below the 0.05 threshold, except for S5 ($F = 2; p = 0.108$). We therefore conducted paired t-test between the specific conditions.

Comparison	VG/VB	VG/N	VB/N	VG/RG	VB/RB
	t - p	t - p	t - p	t - p	t - p
	0.92	1.3	0.43	-5.9	-6.2
S1	0.37	0.20	0.67	4.8e-5	3.3e-5
	2.62	1.16	-1	-1.88	-3.16
S2	0.02	0.27	0.33	0.08	0.007
	1.29	3.60	1.13	-3.2	-2.9
S3	0.22	3.2e-3	0.28	7.2e-3	0.01
	5.1	1.44	-3.1	-1.8	-4.9
S4	2e-4	0.17	8e-3	9.6e-2	2.7e-4
	2.1	3.67	1.1	-3.51	-4.17
S6	0.06	2.9e-3	2.9e-1	3.81e-3	1.1e-3

Table 3: t-tests for the S questionnaire.

6 Conclusion

Overall, our results are not as good as we excepted, as there is no significant differences in the smell representation. Regarding the task 2, the virtual smells have some significant differences when comparing them to the "no smell" condition, hinting that virtual smells have some effect, and might be used for odor awareness. There was only significant differences between the virtual smells and the real smells, therefore; virtual smells are not sufficient to work-around, even partially, real smells.

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