Immersive Virtual Environments for Emotional Engineering: Description and Preliminary Results

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Abstract. This work aims to identify the arousal and presence level during an emotional engineering study. During the experimental sessions, a high-immersion Virtual Reality (VR) system, a CAVE-like configuration, will be used. Thirty-six volunteers will navigate through virtual houses that can be customized and that have been designed for emotional induction. Emotional induction will be obtained by stimulating the senses of sight, hearing and smell. For this purpose, the ambient lighting, music and smell will be controlled by the researcher, who will create a comfortable environment for the subject. Several physiological variables –Electrocardiogram (ECG), Respiratory signal and Galvanic Skin Response (GSR) – will be recorded during the sessions. The obtained results will help furniture companies identify the senses that have more influence on emotions and will be the basis for new studies about user needs in the sector of furniture and interior decoration.

Keywords. emotional induction, emotional engineering, Kansei, CAVE, HRV, respiration, GSR

1. Introduction

Emotional engineering is a field that studies the complex emotional relationships that connect objects, environment, etc. to individuals, with the aim of identifying user needs. The application of immersive virtual environments (VEs) for emotional engineering is a field that has not been widely studied, despite its potential for providing new useful information about human behavior. Nowadays, virtual technology used for emotional engineering studies has been limited to obtain custom prototypes of objects [1-3].

An immersive VE of a kitchen, for example, was used by Nagamachi, founder of Kansei Engineering, in a study on emotional engineering [4]. In this virtual kitchen, the participants could navigate in the VE and they decorated the kitchen. Information extracted from the customized virtual kitchen was used by kitchen designers with the purpose of creating an emotional kitchen. These studies were called Kansei Theory Type V or ViVA system by Nagamachi [4]. A head-mounted display and data gloves were used for this experiment. However, more immersive virtual technologies, such as CAVE-like systems or stereoscopic screens, can be used in any ViVA study.

These kinds of highly immersive systems have been widely used by Slater in studies about presence and arousal of subjects during navigation in virtual worlds [5-6]. Analysis of physiological signals has been used in these works with the objective of studying the relationship between these signals and arousal and presence levels.

In this study, we offer a new approach for the communication, marketing, design and manufacture processes applied to furniture and other habitat products, based on these previous works [4-6]. The goal is to use Virtual Reality (VR) to analyze the arousal and presence levels while participants navigate in virtual houses created for emotional engineering studies.

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2. Method

Kansei Theory Type V was applied in the study, combined with VR. Three VEs were developed with Vizard. Each of them contains a different lifestyle house (Figure 1). A virtual home applicable to a realistic lifestyle was designed for the young social sector (Figure 1a). A VE for a materialistic lifestyle was generated for another social group (Figure 1b), which grouped families with kids. Finally, the third environment was a work environment (Fig. 1c). All VEs were developed from real drafts of homes that were designed by a company dedicated to interior design. During the experimental sessions, a CAVE-like system with head-tracking and stereoscopic vision will be used to achieve a more immersive experience.

Figure 1. Three VEs of three lifestyle houses, a) Realistic lifestyle environment. b) User navigating in the CAVE-like system through the materialistic lifestyle environment. c) Work lifestyle environment.

In the global study that will be conducted, 36 volunteers will be exposed to this VE and will have to freely decorate the house. Sensory stimulation (hearing, sight and smell) will be applied to the subjects while they freely navigate through the custom VE in order to induce positive emotions. Ambient music will be used for hearing stimulation. Changes in illumination of the virtual house, which will depend on the time of the day that we want to simulate, will be used for sight stimulation. To stimulate the sense of smell, it will be necessary to use a scent delivery system (SDS100; Biopac System, Inc.), shown in Figure 2, that will provide different fragrances in the CAVE-like system. Specific software was implemented to allow a controlled stimulation by the researcher.

During the study, physiological signals will be recorded. ECG, respiratory signal and GSR [5-6] will be analyzed off-line (using Matlab) to obtain different parameters, in both time and frequency domain [7-9]. Custom software written in MATLAB will be used for this purpose.

Figure 2. Scent Delivery System. SDS100.

Furthermore, questionnaires concerning presence (SUS: Slater, Usoh & Steed questionnaire [9]) will be completed by the subjects at the end of the experiment.

Previously to this global study, a pilot study has been conducted with the objective of measuring the presence of a small population group when using the system. An additional pilot study will be used for usability testing.

In the following subsection, we are going to comment in more detail on the pilot study on presence.

2.1. Pilot Study

Ten volunteers (five men and five women) aged between 23-30 years old (mean age, 26.80; standard deviation, 1.751) participated in the pilot study. All the participants had normal or corrected-to-normal vision. All participants signed informed consent forms and the ethics committee approved this study.

In this pilot study, subjects had to navigate through the virtual house in two different experimental conditions. In one of them, they navigate through the VE that was presented in the CAVE-like system with stereoscopy for five minutes. In the other condition, they also had to navigate for five minutes through the same environment, but, in this case, it was presented without stereoscopy. The order of presentation of these two conditions was counterbalanced across the participants.

The realistic environment was used for this pilot study. Previously, all the volunteers learned to use the controls to navigate in a training environment. The SUS questionnaire [9] was completed by all participants at the end of each experimental condition.

3. Results

In this section, we present preliminary results about presence in our pilot study and future results which we hope to achieve with the global study.

SUS-mean (mean of all the individual responses to the presence questionnaire) and SUS-count (number of answers to the presence questionnaire with a value equal or greater than 6) factors were calculated for each subject. The mean value of each individual question, SUS-Mean and SUS-Count can be observed in Table 1.

A paired-samples T test was applied to compare between these factors in the two experimental conditions. Significant differences were obtained for SUS-mean, t(9)= -2,885; ρ= 0,018 and values close to significance for SUS-count, t(9)=-2,248; ρ=0,051.

Table 1. Mean of factors calculated with and without stereoscopy.

Variable	With Stereoscopy	Without Stereoscopy
SUS-Mean	5,23	4,65
SUS-Count	2,80	1,50
SUS-Q1	5,70	5,10
SUS-Q2	4,80	5,00
SUS-Q3	5,50	4,90
SUS-Q4	5,40	4,50
SUS-Q5	4,60	3,90
SUS-Q6	5,40	4,50

Other paired-sampled T tests were conducted to analyze differences between conditions in each of the questions. The statistical results are shown in Table 2. Significant differences have been found in all questions except questions two and three.

These results show a difference between the presence levels that subjects felt in the stereoscopic environment and the non-stereoscopic environment.

Table 2. Variable, t(degrees of freedom), and significance.

Variable	t(9)	Sig
SUS-mean (without – with)	-2,885	0,018
SUS-count (without – with)	-2,248	0,051
Q1_without-Q1_with	-3,674	0,005
Q2_without-Q2_with	0,480	0,642
Q3_without-Q3_with	-1,964	0,081
Q4_without-Q4_with	-3,250	0,010
Q5_without-Q5_with	-3,280	0,010
Q6_without-Q6_with	-2,862	0,019

In our complete study, arousal and presence level will be obtained using questionnaires and analyzing their correlation with physiological parameters. This way, we will study the influence on physiological signals of emotional induction during the navigation in the virtual house in the different experimental conditions based on light, ambient sound and scent customization. A file with all actions of the subject during the study will be generated by the system after each test.

4. Conclusions

The objective of the pilot study was to conduct a test where we could measure the presence level that the designed VE provided to the subjects using the stereoscopic environment and non-stereoscopic presentations. Previous section results show greater presence in the stereoscopic environment than in the non-stereoscopic environment. This indicates that users will feel more present in our VEs when they are presented with stereoscopy. Presence is an important measure relating to the subjective experience of participants in studies of VR. If a high sense of presence is provoked in participants by our VE, it will be a good indicator that our study can be a success.

On the other hand, the objective that our complete study pursues is to create a Kansei type V methodology and to use the results and conclusions obtained to help furniture companies identify different ways in which human senses influence emotional responses of subjects exposed to new furniture prototypes. This information will help them to design furniture that is better adapted to their consumers.

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