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Application of Virtual Visualization Tools in Hospitality Environment Experiments

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Abstract

Environmental Design experiments are often plagued by external variables that cannot be controlled in an experimental design. In this study Virtual Reality tools are used to evaluate different types of hospitality environments. Two different Head Mounted Display systems are used in this study and the differences in the level of presence is measured.

Keywords

Virtual Reality, Hospitality Industry, User Perception

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1. Introduction

Virtual visualization techniques and Virtual Reality (VR) tools have come a long way from Morton Heilig's Sensorama in the 50s, to the first Head-Mounted Displays (HMD) in the 60s, and eventually to the modern-day HMDs such as Oculus Rift (Boas, 2013). Over the recent years, VR tools have become popular for testing the visual perception of space. The advantages of the Virtual Visualization techniques include higher ecological validity in comparison to the traditional tools, as well the higher control of the elements of the visual scene, such as illumination and location of the objects in space (Soranzo & Wilson, 2015).

The ecological validity of the Virtual Environment implies that it is not significantly different from the physical environment. Previous research confirms that subjects perform in a similar way in both physical and virtual settings (Heydarian, Carneiro, Gerbera, Becerik-Gerber, Hayes, & Wood, 2015). In particular, no significant differences among participants with regard to color and object recognition and the feeling of presence in the physical room versus its virtual copy were revealed (Martini, Perez-Marcos, & Sanchez-Vives, 2013; Landgrebe, Nyuyki, Frank, Steffens, Hauser, Eichhammer, Hajak, & Langguth, 2008). Consequently, virtual environments provide adequate representation of the physical environments.

Soranzo and Wilson (2014) point out the particular advantages of Visual Virtualization techniques over traditional methods in color perception studies. They emphasize that Visual Virtualization techniques help to overcome the problem of color constancy that is present in the physical environment because the perception of color can be affected by the illumination level. It can be hard to duplicate the light settings in the physical environment but it can be completely controlled in the virtual settings.

In addition, Virtual Visualization techniques help to address the issues related to the color contrast. Colors observed against different backgrounds are perceived differently (Soranzo & Wilson, 2014). Thus, maintaining the quality of color is challenging when the printed pictures of the room with manipulated colors, or the printed samples of colors are presented to participants to analyze their color perceptions. In such cases researchers have low control over the effect of physical surroundings on the perception of the colors on the

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picture. Virtual environments on the contrary provide a controlled visual immersion of participants in the experimental conditions.

Such core concepts as perceptions and attitudes are a product of complex experiences filtered through ones senses. The senses help us comprehend and experience the world around us. However, many hospitality research studies involve only descriptions of a hypothetical experience and later assess perceptions or attitudinal responses to the defined stimuli. Such research design leaves experience component highly limited. To address the problems of limited sensory engagement and hypothetical experiences, the current research project shows how VR tools can be applied in hospitality environment research. Specifically, an example of how Oculus HMDs and 3D Modeling can be applied in a hotel room design experiment is presented.

Immersion and Presence

Immersion has been defined in a number of ways. Immersion is typically used to describe the experience of becoming engaged in the virtual environment experience while retaining some awareness of one's surroundings (Banos, 2004; Singer & Witmer, 1999). Dede (2009) defined immersion as the "subjective impression that one is participating in a comprehensive, realistic experience." Brown and Cairns (2004) describe immersion as "a sense of being cut off from the world you actually inhabit" (p. 1299). In order to gain a better understanding of immersion, it would be pertinent to understand other concepts which are used together with it such as presence, flow and engagement. Presence has been described being similar to immersion and have been defined as "being in a normal state of consciousness and having the experience of being inside a virtual environment" (Brocknyer et al., 2009). Draper, Kaber, and Usher (1998) defined presence as a mental state in which a user feels physically present within the computer-mediated environment. Slater (1994) defined presence as a sense of "being there." according to Slater presence seems to have connotations of a subjective phenomenon. Barfield and Weghorst, 1993; Cho et al., 2003; Dinh et al., 1999; Gerhard, Moore, & Hobbs, 2001; Kim & Biocca, 1997; Nichols, Haldane, & Wilson, 2000; Witmer and Singer, 1998)

Multiple factors can affect the level of the subject's presence in the VR. These factors can be related to personal characteristics, i.e. the level of experience with VR, as well the level of immersion based on the characteristics of the VR equipment itself (Ling, Nefs, Brinkman, Qu, & Heynderickx, 2013; Wilson & Soranzo, 2015). Some significant differences in the VR perception were found between various models of HMDs (Li, Zhang, Nordman, & Kuhl, 2015). Consequently, the current study also examined whether previous experience with VR would impact respondent's presence and level of immersion. Additionally, differences in respondents' perceptions between two models of HMDs were assessed.

2. Method

VR tools were used for a quasi-experimental study. The goal of the experiment was to assess the impact of wall color attributes (saturation, brightness, and hue) on such emotional responses as pleasure, arousal, and dominance. The sample comprised of 141 hospitality students from a Midwestern university. The Best Western Hotel Chain was used for samples of hotel rooms' wall color solutions. Two levels of saturation and brightness were applied to blue and red hue samples obtained from the web search. Consequently, the experiment employed 2x2x2 design with two manipulated hues (red and blue) and two levels of saturation and brightness (high, low). This paper focuses on the level of presence between the two types of HMD's that were employed.

So far, the most common experimental designs for examining color impacts on emotional state included manipulations of environment such as building rooms with walls of different colors or adding decorations with a particular pattern or color to the existing environment (Caan, 2007; Chebat & Morrin, 2007). A simplified version of such approach focused on providing pictures of a room with manipulated colors (Countryman & Jang, 2006). The common drawback of this approach was the lack of control of environmental factors influencing respondents.

The current study overcomes the abovementioned drawback by means of the VR technology. In particular, participants were exposed to one of eight 3D models of hotel rooms using the Oculus HMDs. Each model had either blue or red hue, high or low level brightness, and high or low level of saturation assigned to it. The use of Oculus HMDs helped to implement better control over such environmental factors as the illumination of the room and the positioning of the elements of the room's interior.

The experiment consisted of the following procedures. The flow of the procedures is presented in Figure 1. First, upon subjects' arrival to the experiment lab, they were asked to read and sign the Consent form to indicate that they agree to participate in this study. After that participants received the paper-based survey. At this point subjects only completed Part 1 of the survey that contained questions about the demographic information such as age, gender, ethnicity, as well as the color preference and the familiarity with VR and VR HMDs. After completing it, all participants were randomly assigned to one of the experimental conditions (eight virtual models of a hotel room with two hues of wall

colors manipulated and two levels of saturation and two levels of brightness). All participants were properly trained to use Oculus HMD according to official product instructions. Finally, after the training, subjects were randomly assigned to the 3D hotel room with one of the manipulated color conditions for three minutes.

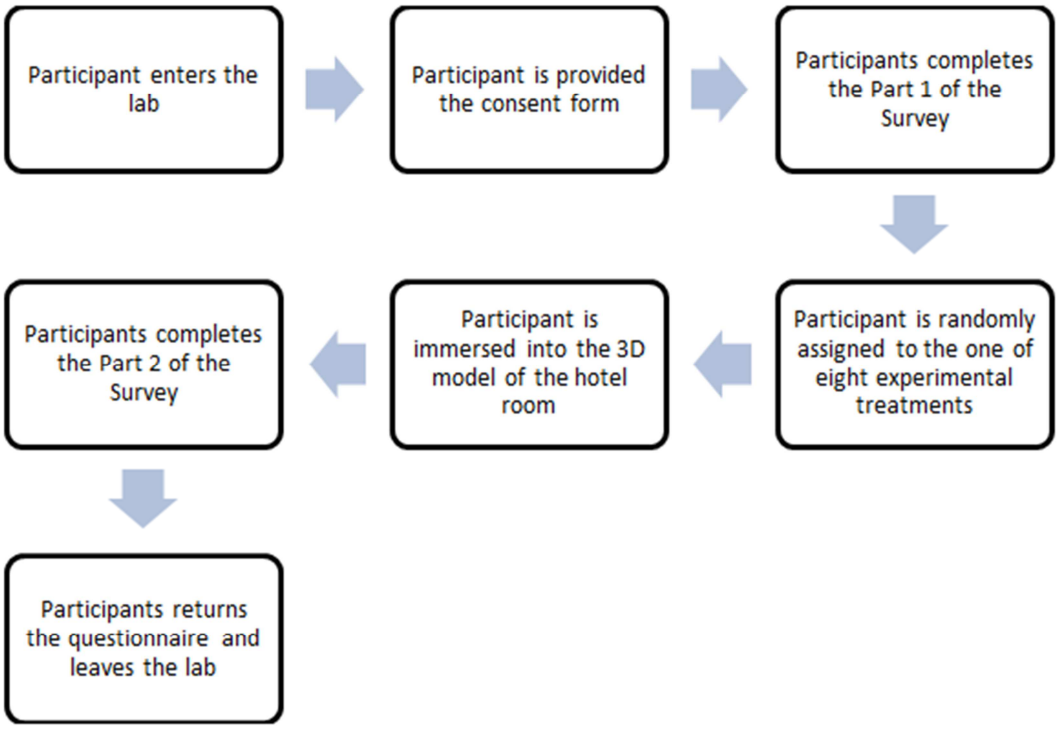

Figure 1. Experimental process flow.

The time frame for the experiment was determined during the pilot study. Three minutes was the average amount of time that pilot study participants needed to build their impression about the model of the room and its colors. No vision calibration equipment was used but participants with impaired vision were allowed to wear glasses together with the HMD system. After the end of the experiment, participants were asked to complete Part 2 of the questionnaire, which measured the level of a participant's presence in the VR. The entire experiment process lasted on average 15 minutes. A research laboratory at a southern midwestern university was used as a physical location for the experiment.

The sample size included 141 participants. A two-stage sampling was used in the study. First, the convenience sampling took place. That is, professors and students, their friends and family from a southern midwestern university were contacted in person and invited to participate in the study. A consent form was explained to participants and signed by them prior to the experiment. All participants were included in the lottery with a chance to win one of eight Visa $50 Gift Cards. All participants were randomly assigned to one of the eight hotel room's models.

Experimental Treatments and Instruments

The paper-based survey was used as the instrument in this study. Part 1 of the survey consisted of questions about participant's demographic information (gender, age, favorite color, familiarity with VR). Questions measuring the subject's awareness of the VR concept and VR tools such as Oculus HMD helped to investigate the effect of technology on the perception of the VR.

Part 2 consisted of a set of questions adopted from the Presence questionnaire, developed by Witmer and Singer (1994) and revised by Cyberpsychology Lab (2004), to measure the level of presence in the virtual environment between two types of HMDs. Thirteen applicable questions were adopted from the Presence scale in this study. The questions were measuring five dimensions of VR Presence: Realism, Possibility to Act, Quality of Interface, Possibility to Examine, Self-evaluation of Performance. The performance of the HMD for each question was measured using 7- point Likert scale.

3D models of the hotel room

The 3D model of the hotel room was used for color manipulations. The participants were immersed in the room environment using the VR HMD. Virtual Reality technology allowed both changing characteristics of the virtual environment easily, as well as fully immersing individuals in a virtual environment. Hence, it reduced the number of external factors that could influence responder's emotional

state or perception of a color and made the measurement of color perception much more accurate than in the previous studies. The model of the virtual hotel room was developed using Unity (Unity 5.4.0 Beta 9). The room had the basic attributes of the hotel room: a bed, a bedside table with a lamp, a closet and the armchair. The picture of the basic model of the hotel room is presented in the Figure 2.

Figure 2. The basic 3D model of the hotel room.

Oculus HMDs

Two models of Oculus HMD systems were used in the study: Oculus HMD DK1 and DK2. Oculus HMD allowed users to be immersed into and explore a 3D virtual environment. The advantage of this tool is that it allowed implementing higher control of the extraneous elements of the environment. In particular, all participants observed the same room with predetermined light conditions. Thus, all participants observed colors within same predesigned parameters. Also, the "content" of the room, such as the location of the furniture and all elements of interior, were controlled. Finally, the effects of texture and smells were eliminated. Based on these facts, Oculus HMD can be considered a more reliable tool for this type of experiment than previously used techniques.

The picture of participants using the Oculus HMD is presented in the Figure 3. The oral permission of participants was obtained to use the picture in the study.

Figure 3. Participants wearing Oculus HMD.

3. Results and Discussion

In total, 141 responses were obtained and 139 of them were usable. The sample was balanced gender wise with 76 females (54%) and 63 males (46%). Age distribution was skewed to the younger ages. Approximately 20% of the participants were below 20 years old, 52% were between 20 and 25 years old, 15% were between 25 and 30, 10% were between 30 and 35, and 14% were above 35 years old.

Two models of Oculus HMD were used during the

experiment (Oculus HMD DK1 and DK2) and were compared for the differences in the feeling of presence in VR environment using the presence questionnaire (Witmer & Singer, 1994; Cyberpsychology Lab, 2004). The scores for the five categories of presence (Realism, Possibility to act, Quality of Interface, Possibility to examine, and Self-evaluation of performance) were obtained for each model. The results of non-parametric ANOVA showed that Oculus HMD DK1 was significantly different from Oculus HMD DK2 in such presence categories as Quality of Interface (Chi-square statistic for Kruskal-Wallis test was equal to 5.24 and significant at the 5% level), and Self-evaluation of performance (Chi-square statistic for Kruskal-Wallis test was equal to 3.08 and marginally significant (at the 10% level). However the differences between the two models were not significant in terms of the realism, the possibility to act and the possibility to examine the environment categories, comprising the core presence categories for this experiment.

4. Conclusion

So far, the most common hospitality experimental designs for examining color impacts on emotional state included providing pictures of a room with manipulated colors (Countryman & Jang, 2006). The common drawback of this approach was the lack of control of environmental factors influencing respondents. The current approach overcomes such shortcoming by means of VR technology. The use of Oculus HMDs helped to implement better control over such environmental factors as room illumination and positioning of the elements of the room's interior.

Two models of Oculus HMD (DK1 and DK2) were compared for the differences in the feeling of presence in VR environment using the presence scale by Witmer & Singer (1994). The scores for realism, possibility to act, quality of interface, possibility to examine, and self-evaluation of performance were obtained for each model. The results of non-parametric ANOVA showed that DK1 was significantly different from DK2 in quality of interface and self-evaluation of performance. However, the differences between the two models were not significant in the core presence categories - realism, the possibility to act, and the possibility to examine the environment. Thus, it was concluded that the differences between HMDs' models did not affect participants' color perceptions in the VR environment

References

[1] Baños, R M, Botella, C, Alcañiz, M, Liaño, V, Guerrero, B, and Rey, B, 2004, "Immersion and emotion: their impact on the sense of presence" *CyberPsychology & Behavior* 7 (6) 734–741.

[2] Brockmyer J H, Fox C M, Curtiss K A, McBroom E, Burkhart K M, Pidruzny J N, 2009, "The development of the game engagement questionnaire: a measure of engagement in video gameplaying" Journal of Experimental Social Psychology 45 624–634.

[3] Brown E, Cairns P, 2004, "A grounded investigation of game immersion", in CHI'04 Extended Abstracts on Human Factors in Computing Systems (ACM Press, New York) pp 1297–1300.

[4] Boas, Y. A. G. V. (2013). Overview of virtual reality technologies. *Interactive Multimedia Conference. Southampton*.

[5] Countryman, C. C. & S Jang, S. (2006). The effects of atmospheric elements on customer impression: the case of hotel lobbies. *International Journal of Contemporary Hospitality Management*, *18* (7), 534–545. Retrieved from http://dx.doi.org/10.1108/09596110610702968.

[6] Dede C, 2009, "Immersive interfaces for engagement and learning" Science 323 66–69.

[7] Draper J V, Kaber D B, Usher J M, 1998, "Telepresence" Human Factors: The Journal of the Human Factors and Ergonomics Society 40 354–375.

[8] Heydarian, A., Carneiro, J. P., Gerber, D., Becerik-Gerber, B., Hayes, T., & Wood, W. (2015). Immersive virtual environments versus physical built environments: A benchmarking study for building design and user-built environment explorations. *Automation in Construction*, *54*, 116-126.

[9] Landgrebe, M., Nyuyki, K., Frank, E., Steffens, T., Hauser, S., Eichhammer, P., Hajak, G., & Langguth, B. (2008). Effects of colour exposure on auditory and somatosensory perception--Hints for cross-modal plasticity. *Neuroendocrinology Letters*, *29* (4), 518.

[10] Li, B., Zhang, R., Nordman, A., & Kuhl, S. A. (2015, September). The effects of minification and display field of view on distance judgments in real and HMD-based environments. In *Proceedings of the ACM SIGGRAPH Symposium on Applied Perception* (pp. 55-58). ACM.

[11] Ling, Y., Nefs, H. T., Brinkman, W. P., Qu, C., & Heynderickx, I. (2013). The relationship between individual characteristics and experienced presence. *Computers in Human Behavior*, *29* (4), 1519-1530.

[12] Martini, M., Perez-Marcos, D., & Sanchez-Vives, M. V. (2013). What color is my arm? Changes in skin color of an embodied virtual arm modulates pain threshold. *Frontiers in Human Neuroscience, 7*, 41-45.

[13] Soranzo, A., & Wilson, C. J. (2014). Virtual environments in visual perception: applications and challenges. *Virtual Reality Technologies, Medical Applications and Challenges*, 73.