Towards a Comprehensive Definition of User Experience for 3D Content

Raquel Navarro-Prieto and Elena Parra

Barcelona Media-Innovation Center
Av. Diagonal 177, 9th floor, 08018 Barcelona
Raquel.Navarro@barcelonamedia.org

Abstract. New developments in the area of 3D content have highlighted the need for the 3D content user experience evaluation within different media such as television, cinema, mobile and games. The goal of this paper is to present a theoretical approach and some preliminary data that tries to address the lack of an agreed definition of user experience, tackling the need for methodological guidelines in measuring user experience with 3D content. We propose that a number of cognitive and emotional processes need to be taken into account in order to fully understand the user experience with this type of content. We present a preliminary study that provides evidence about the importance of memory and attentional processes in the measurement of the user experience with stereoscopic content.

Keywords: user experience, 3D content, Quality of Service, cognitive processes, attention, memory, experimental study.

1 Introduction

The assessment of the subjective user experience has become a critical part of audiovisual quality assessment. In recent years researchers have tried to capture some parts of the user experience through the concept of Quality of Experience (QoE).

QoE has been defined as a subjective measure of performance for a system [1]. It relies on human opinion and differs from quality of service (QoS). Within standardization bodies the topic of QoE has been included into standardization activities for the measurement of QoE on audiovisual content in general, and for specific delivery platforms.

A fine example of the work efforts on this subject is found in ETSI HF STF 354 (Specialist Task Force 354 within the Human Factors Group of ETSI), aimed at providing requirement guidelines for real-time multimedia services with a good QoE. The goal of this set of standards is to provide the basis for objective and subjective measures on user experience for given communication situations, such as video and multimedia communication, and live TV (in the PC or mobile) [2]. Nevertheless, new media formats and communication technologies are setting up new challenges that prove the need to go beyond QoE to a more complete definition of the use experience with innovative content, still not covered by existing guidelines.

F. Alvarez and C. Costa (Eds.): UCMEDIA 2010, LNICST 60, pp. 51–59, 2012.

In particular, new developments in the area of 3D content have highlighted the need for the 3D content user experience evaluation within different media such as television, cinema, mobile and games. We find evidence for the lack of agreement on how to assess the user experience from innovative content in the fact that while widely recognizing the need to understand the sense of immersion in a given content, there is no standard or consensus on what this sense of immersion means or how to measure it.

The goal of this paper is to present a theoretical approach and some preliminary data that tries to address this gap, tackling the need for methodological guidelines in measuring user experience with 3D content. As we describe in more detail in section 2, we propose that a number of cognitive and emotional processes need to be taken into account in order to fully understand the user experience with this type of content.

Research efforts especially within European funded research projects, have addressed and are currently investigating three main aspects related to the user experience from 3D content. First, several studies are focused on measuring perceptual aspects such as the assessment of perceived depth or image quality [3, 4, 5, 7, 16, 17, 18]. These studies have tried to go further than the general International Telecommunication Union (ITU) recommendations for the subjective assessment of stereoscopic television images [6].

A second group of studies is trying to find ways to prevent visual discomfort with 3D stereoscopic content including the effect from variables from the viewing context or from mobile devices [6], [8]. The third group of studies is focused on finding better ways to interact with 3D content [4].

Little attention has been paid to understanding the user experience as a whole, including the complex processes involved in the sense of presence. Recent studies are starting to investigate a wider view of the user experience including aspects of 3D presence. In order to have a complete definition for user experience, we consider fundamental to understand the cognitive processes involved.

In the following section we expand the theoretical framework we propose in order to bridge the gap between the latest technology developments in the area of 3D content and our knowledge on how to measure the impact of this content upon users. Next, in section 3 we present a pilot study conducted with stereoscopic content in order to gather evidence on the involvement of cognitive processes from our theoretical framework. We close this paper with several conclusions from our work, and we discuss the next steps we expect to conduct in this area.

2 Proposed Factors Impacting the User's Experience

In this section we will present several theoretical and methodological research questions that we propose should guide further work in order to investigate user experience with 3D content. In particular we will focus on how cognitive and emotional processes may be involved in the reception, interpretation and interaction with different types of 3D content under different viewing conditions.

2.1 Which Variables Impact User Experience of 2D Content?

As a starting point for understanding user experience with 3D content, we have reviewed which aspects have been shown to have an impact on the user experience with 2D content. In our review, we found many variables that have been manipulated in lab experiments where different types of 2D content have been presented. In order to organize the main results from previous research, we have created two main categories of studies depending if the focus of the research was the impact of the content per se (1st category) or the impact of user's characteristics (2nd category).

1. In the category of research on the impact on QoE of **media specific variables**, three major type of characteristics of the content have been studied:
   I. First, some authors have investigated the effect of showing to the users multimedia content with differences in the way it has been structured. A good example of this type of research is the manipulation of the number of cuts in the content presented to the users. It has been proven [10] that the increase in the number of cuts in a film increases the attention during the time that the user is viewing it, but decreases memory of the events that happen in the film. In addition, [9] investigated the impact of forms, directions, colors and rhythm in the emotional reactions of viewers. In this later case, the authors provide a methodological review about how all these aspects have been studied in many experiments. Some of the conclusions for his review are that the valence of the emotion is correlated with form and colour, while the arousal of the emotions often correlates with rhythm and motion. According to the author: "The result from the analysis of the relationship between the structural property of both audio and visual stimuli and emotion provides support for the theories based on the iconic relationship concept".
   II. Secondly, the manipulation of perceptual variables from the viewing situation has been also shown to have an impact in user's emotions and memory. In particular, it is important not only whether the content is presented in 2D versus 3D in their central focus of attention but also if they are presented with 2D or 3D content in their peripheral vision [14]. Researchers have concluded that an hybrid condition were the users are presented a 3D image in between and overlapping onto two adjacent 2D images creates a higher sense of immersion than viewing the same content all in 3D. Another important effect is the impact of seating position and orientation regarding the screen in the subjective feeling of immersion. [13].
   III. Third, the impact of some intrinsic characteristic to the content like their emotional charge have been investigated showing that sensationalist news are remembered more than emotionally neutral news [10]. In addition, content if the content presented is real or fiction changes the memory and the emotions evoked by that content. [19].

   To summarize the main conclusions of the literature presented, we can conclude that the manipulation of the type of content and the viewing

conditions have an important impact on several cognitive processes from perceptual, to attentional processes as well as memory and emotion [12].

2. The second category of variables that have been studied is the impact of user's personal characteristics on the user experience of a particular content. In particular, the individual variable that has been studied in many occasions is previous exposure to similar content [11], demonstrating that more attention is paid to new information. In addition, viewer's mood could decrease or increase how much they remember from the content [10].

To conclude, we claim that it is very important to integrate all these variables into a framework in order to understand the effects that may emerge from the interaction among all these aspects on spectators, and to test these effects with different types of media.

With the goal of creating such a framework, which will take information from the knowledge already accumulated with research on 2D content, we will discuss in the following subsections two challenges to which we have to pay attention in future research.

2.2 The Importance of a Investigating the Impact of the Variables across Different Types of Content and Contexts

The first aspect that we consider that has not been properly addressed in previous research is the validation of research results across contents and contexts. Up to now these variables have been investigated in the context of a very particular type of content, because they have been focused on answering very specific questions about the quality of particular media.

2.3 The Need to Validate an Appropriate Methodology

The second challenge in order to create a framework for 3D user experience is to be able to investigate how relevant are the factors that have proven to be important for 2D content for immersive media.

When facing this challenge, we encountered the need for a holistic definition for user experience that will allow us to understand which information to gather from the users and therefore, how it needs to be gathered. This definition should go beyond the perceptual factors and include cognitive processes (i.e. memory and attention) as well as the emotional responses and social variables. As we have discussed in the introduction, a considerable amount of work has been focused on how to test the visual perceptual aspects for the quality of the images and amount of visual discomfort, but much less is known about how to objectively measure the degree of engagement and cognitive reactions to the content.

Therefore, the research community will need to focus on creating a corpus of recognized methodologies to measure the relevant variables involved. In our view, in order to reach this goal and a wide consensus on the definition of user experience, we required a multidisciplinary approach. Research from different perspectives will be

complementary and will advance our knowledge in an iterative manner. For instance, a social science observational approach can contribute with laying down the hypothesis. This hypothesis will then be very valuable to a second collaborative step between technology developers and experimental researchers using cognitive psychology. Such an approach would allow testing the laid down hypotheses and setting new research questions in order to reach consented conclusions on what a holistic definition of user experience for 3D media should encompass. Furthermore, we believe this approach will allow going beyond a descriptive approach and predicting how to create media to optimize the users' response.

As part of this multidisciplinary effort, we consider very important to review the work done on Cognitive Psychology about the relevance of several cognitive processes in information processing in general [9]. After this review we can infer an initial hypothesis on the important cognitive processes to measure, attention and memory, and their relationship with the users' emotional reactions [10] in general, and in particular with new media. Indeed, reported research shows the impact of some media characteristic, such as the number of cuts, on memory and attention [11].

In line with this claim about the importance of cognitive processes to understand user experience, we have applied and extended several methodologies used in Cognitive Psychology to measure these processes. In section 3 we report our attempt to apply some of these methodologies to 3D content. To our knowledge, this would be first instance these methodologies have been used to measure user experience from 3D stereoscopic content.

3 Investigation the Impact of Cognitive Processes in User Experience with Stereoscopic Content

As discussed in the previous section, we consider it is important to investigate the involvement of cognitive and emotional processes in the user experience of stereoscopic content. Based on reported previous work, we conducted a trial to examine the impact of memory, attention and emotional reactions. A second goal in this study was to test how cognitive psychology methodologies can be successfully applied in a close to real projection environment. This experiment was conducted in collaboration with Doremi Technologies[1] in the frame of the project 2020 3D media[2]. The sampled users watched the content in an exhibition theater, so the conditions could be as close as possible to a real life environment. Fifteen adult subjects took part as the sample of users, 7 women and 8 men. s we wanted to gather the reactions of end users, None of them were experts in multimedia technologies or content production.

[1] www.doremilabs.com

[2] The goal of this project is to explore and develop novel technologies to support the acquisition, coding, editing, networked distribution, and display of stereoscopic and immersive audiovisual content providing novel forms of compelling entertainment at home or in public spaces. The users of the resulting technologies will be both media industry professionals as well as the general public. More information can be found at: www.20203dmedia.eu/

3.1 Material

In our study we used stereoscopic material created by DOREMI. A set of particular effects present in the stereoscopic material was agreed in order to test their impact:

- Blur effect, in particular motion blur, when the images edges get diffused more as the object moves more quickly.
- Out of screen effect, when an object in the scene gets out of the screen.
- 3D in general, or the effect of viewing the images in 3 dimensions.

In order to ascertain if there was an impact from the type of content, we categorized the content where the particular effects appeared according to two different variables:

- Emotional versus non-emotional content (i.e. an intrinsic characteristic of the content whether it has been created to evoke strong emotions or to inform).
- Real life versus fiction (i.e. whether is has been film or a synthetic produce image).

We chose and agreed to measure the two most relevant cognitive variables that we found important in previous studies with immersive material, namely, attention and memory.

3.2 Methodology

For our study, we measured attention and emotional reaction during the presentation of the content, and memory after the presentation. To measure **attention** we used a cognitive task, namely split-attention, which is widely employed as a standard method for this kind of processes. According to this methodology the user must occasionally perform a "secondary task" (in our case responding as quickly as possible to loud beeps) while performing what is called the "primary task" (in our case watching the stereoscopic material). The main assumption of this methodology is that the measured reaction time (and therefore the attention allocated) to the secondary task is directly related to the amount of attention given to the primary task [15].

Once they finished their viewing we checked their **memory** recall of the content through questionnaires addressing particular elements from the 3D content.

3.3 Results

Since we worked with a small sample of viewers we performed no statistical analysis. Nevertheless, we consider the qualitative analysis of our data is a valuable support to determine if our research merits further study or not.

i. Results on Attention

In Graphic 1 below, we can observe that watching content with the out of screen (OOS) effect impacted users' attention. It can also be noticed that at the precise instant the OOS appears the reaction time to the secondary task (beeps) increases, confirming a higher level of attention to the 3D material (primary task).

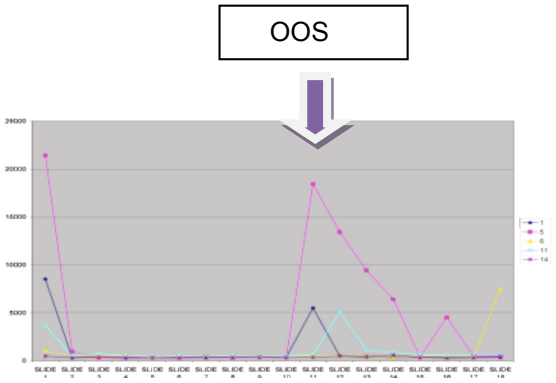

Fig. 1. Reaction time while watching the stereoscopic content

ii. Results on Memory

We recorded the percentages of correctly answered questions. The results were divided depending on the content variables and the type of effect:

1. Content type; here we differentiate reality from animation sequences.
2. Type of effect; here we distinguish out of screen from 3D contents.

First, we detected a tendency in the results, which shows content with OOS effects (mean = 0.50; SD = 0.21) to be remembered better than the material with 3D effect (mean = 0.44; SD = 0.22), as illustrated on Figures 2. Second, as we can see in Figure 3, we found a trend favouring the recall of real content (mean = .046; SD = 0.19) compared to animated content (mean = 0.40; SD = 0.33).

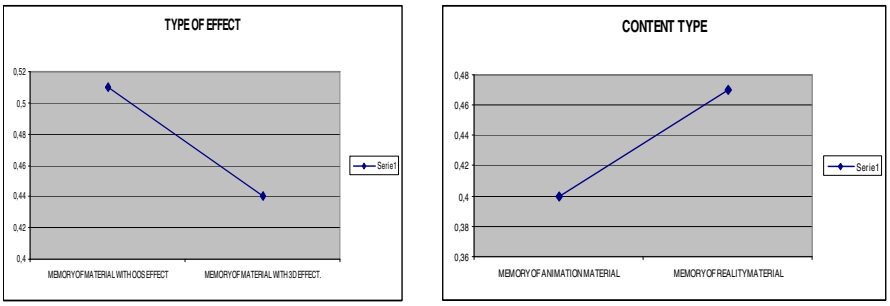

Fig. 2. and **3.** Comparison of remembrance between segments with out of screen effect and segments with 3D effects (left). Comparison of remembrance of real vs. animated material (right).

A hypothesis to be tested in future research is if the type of content has a direct effect on memory, and thus influences attention; which would mean both processes are involved in the feeling of immersion from the content.

4 Conclusions and Further Work

At the beginning of this paper we acknowledge the need for a multidisciplinary and comprehensive approach in order to understand what the so called "user experience" means, when users are exposed to innovative content such as 3D. In section 2 we highlight several principles we claim need to be studied in order to reach this goal. Later along the paper we have presented a first step towards gathering evidence on those variables we chose to consider from our theoretical approach.

Our results, while not statistically proven, provide support for the proposed theoretical framework in two main aspects:

First, we have identified interesting trends in the data, which indicate that both attention and memory are relevant cognitive processes to be studied in order to reach a holistic definition of user experience from 3D content. In our case, we found the OOS effect in the content increases both the attention and the remembrance over the watched piece of content.

In our ensuing work we would like to go one step further and record measurements related to the emotional state of the viewer [16], in order to test if a greater sense of immersion in the content is achieved when there is an increase of attention and memory recall.

Secondly, we have gathered some evidence on the outcomes from several effects in the content. In future studies we should consider presenting more controlled contents, where more so called Media Specific variables can be tested. In addition, we would like to use materials where the OOS effect is coupled with changes in other sensory areas such as hearing or touch, to test the effect of different sensorial inputs. In particular, we are preparing a study to investigate the effect of 3D audio.

References

1. Venkataraman, M., Sengupta, S., Chatterjee, M., Neogi, R.: Towards a Video QoE Definition in Converged Networks. In: ICDT 2007 (2007), ISBN: 0-7695-2910-0
2. ETSI TR 102 643, Human Factors (HF); Quality of Experience (QoE) requirements for real-time communication services
3. High Efficiency Laser-Based Multi-User Multi-Modal 3D Display, HELIUM3D, http://www.helium3d.eu/
4. Real 3D – Digital holography for 3D and 4D real-world objects' capture, processing, and display (Real3D), http://www.digitalholography.eu/
5. Mobile 3DTV Content Delivery Optimization over DVB-H System, Mobile 3DTV, http://sp.cs.tut.fi/mobile3dtv/
6. Rec ITU-R BT.1438, Subjective Assessment of Stereo- scopic Television Pictures
7. 3D Phone Project, http://www.the3dphone.eu
8. MacKay, D.G., Shafto, M., Taylor, J.K., Marian, D.E., Abrams, L., Dyer, J.R.: Relations between emotion, memory and attention: evidence from taboo stroop, lexical decision and immediate memory tasks. Memory Cognition 32(3), 474–488 (2004)
9. Somsaman, K.: Emotional expressiveness in visual-sonic integration: A framework for multimedia design. In: Proceedings CHI 2003, pp. 1024–1025 (2003)

10. Kubey, R., Csikszentmihalyi, M.: Scientific American mind. Televisión Addiction, 48–55 (2003)
11. Baños, R.M., Botella, C., Rubió, I., Quero, S., Garcia-Palacios, A., Alcañiz, M.: Presence and emotions in virtual environments: the influence of stereoscopy. CyberPsychology and Behavior 11(1), 1–8 (2008)
12. Prothero, J., Parker, D., Furner, T., Wells, M.: Towards a Robust, Quantitative Measure for Presence. In: Proceedings of the Conference on Experimental Analysis and Measurement of Situation Awareness, pp. 359–366 (1995)
13. Tasaki, S., Matsushita, T., Koshi, K., Wada, C., Koga, H.: Sense of Virtual Reality: Effectiveness of Replacing 3D Imagery with 2D/3D Hybrid Imagery. IEICE Transactions 88-D(5), 851–858 (2005)
14. Lang, A.: The limited capacity model of mediated message processing. The Journal of Communication 50(1), 46–70 (2000)
15. Blonch, S., Lemeignan, M.: Precise respiratory- posturo- facial patterns are realated to specific Basic emotions. Bewegen and Hulpverlening (1992)
16. Häkkinen, J., Kawai, T., Takatalo, J., Mitsuya, R., Nyman, G.: What do people look at when they watch stereoscopic movies? In: S&T/SPIE's International Symposium on Electronic Imaging: Science and Technology. Stereoscopic Displays and Applications XXI, San Jose, California, USA, January 18-21, vol. 7524 (2010)
17. Campisi, P., Benoit, A., Le Callet, P., Cousseau, R.: Quality assessment of stereoscopic images. Eurasip Journal on Image and Video Processing 2008 (2008)
18. Chen, W., Fournier, J., Barkowsky, M., La Callet, P.: New requirements of subjective video quality assessment methodologies for 3DTV. In: Video Processing and Quality Metrics 2010 (VPQM), Scottsdale, United States (2010)
19. Mendelson, A.L., Papacharissi, Z.: Realilty vs Fiction How Defined Realness Affects Cognitive & Emotional Responses to Photographs. Visual Communication Quarterly 14(4), 231–243 (2007)