Measuring User Experience in Digital Gaming: Theoretical and Methodological Issues

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ABSTRACT

There are innumerable concepts, terms and definitions for user experience. Few of them have a solid empirical foundation. In trying to understand user experience in interactive technologies such as computer games and virtual environments, reliable and valid concepts are needed for measuring relevant user reactions and experiences. Here we present our approach to create both theoretically and methodologically sound methods for quantification of the rich user experience in different digital environments. Our approach is based on the idea that the experience received from a content presented with a specific technology is always a result of a complex psychological interpretation process, which components should be understood. The main aim of our approach is to grasp the complex and multivariate nature of the experience and make it measurable. We will present our two basic measurement frameworks, which have been developed and tested in large data set (n=2182). The 15 measurement scales extracted from these models are applied to digital gaming with a head-mounted display and a table-top display. The results show how it is possible to map between experience, technology variables and the background of the user (e.g., gender). This approach can help to optimize, for example, the contents for specific viewing devices or viewing situations.

Keywords: User experience, display, games, measurement, theory

1. INTRODUCTION

1.1. Current views on user experience

In many different areas of human-computer interaction the experience received from a technology use is gaining increasing attention. In virtual realities (VR) and movies the concept of the sense of presence is used to describe the special experience caused by the VR- technology and large screens of the movie theatres.[1] The specialists of the display technology are concentrating on the image quality experience[2] and in digital gaming the concept of immersion is used to described the deep engagement to a game.[3] User Experience (UX) is considered essential also in the cognitively and task-oriented field of human-computer interaction (HCI). It has become a popular research topic different from more work-related usability-studies, which have traditionally dominated the field of HCI.[4] Also the optimal experience, that is, flow[5] has become an object of study in various human-computer interaction contexts such as in Internet use.[6]

Many of the above concepts are somewhat mysterious and often times ambiguously used buzzwords in describing human experience. In many cases sound empirical research is absent. The term experience can be used in numerous ways and it can refer to almost any level of human consciousness. In the following we try to define and develop a psychologically grounded framework and expand the concept of the user experience so, that it would cover the relevant psychological aspects in a particular context, in this case in digital gaming.

1.2. The psychology of experience

The online edition of the Visual Thesaurus[7] defines the word experience with the following key points: 1) experience has two meanings: it can be something one has gone through and gained knowledge of or it can be the content of direct

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observation or participation in an event, 2) experience may have both mental and bodily states, and 3) it is closely related to feelings and emotional sensations. Here we consider experience as the content of direct observation or participation in an event, for instance, playing a digital game. This definition rules out life experiences that increase knowledge and form our personality, subjective states like dreams and daydreaming stemming from purely internal images as well as experiences not observable directly to others such as the experience of pain, just to name few forms of experiences that do not fit into our definition.

The "content of direct observation or participation in an event" has also been acknowledged as the primary source of human experience in the early days of psychological science. According to William James[8] we **perceive** the world around us by **attending** to the features and events that **interest** us. Lots of environmental stimuli are perceived but only a little proportion of this is interesting enough to draw our attention and to become a content of our conscious experience. Most of our daily routines are experienced rather automatically or sub-consciously.[9] As long as everything goes as usually, this constant stream of thoughts doesn't require much of either our attention or active thinking. Such a state can also be described as a micro-flow experience,[5] which doesn't elicit intense feelings or peak experiences. We analyze the components of such intense periods of human-computer interaction that are distinct from the constant stream of consciousness and can have a significant impact on the person who is experiencing.

James Dewey,[10] separated so called everyday experiencing from a special experience that he named as **an experience**. According to Dewey an experience has a clear beginning and an end and it has an effect on the one who experiences; strong emotions, assessment of a value system and even changes in behaviour. An experience can be received, for example, from digital gaming. It has a clear beginning and an end and for those who are willing to play, it is likely to provide something special. To understand and even measure such an experience we should understand the perceptions made from the particular environment, the focus of attention and the level of motivation to attend just these particular features.

But what happens when we have the right level of motivation to perceive and attend to a particular environmental feature? Is that the experience then? How is this related to the two other points in our definition in the first paragraph 2) experience may have both mental and bodily states, and 3) it is closely related to feelings and emotional sensations. Forlizzi and Ford[9] list psychological features that influence experience. They include prior experiences, emotions and feelings as well as values and cognitive models in their list. Csikszentmihalyi[11] uses the concept of awareness as a part of our consciousness in which these different psychological components influence and shape the experience. All the information that is attended and perceived long enough, i.e., it is interesting and motivating enough enters into our consciousness and we become aware of it. In our awareness environment is evaluated **cognitively** and **emotional** labels are attached into it. This interpretation process gives every experience a meaning and a value.[10] The perceived features also activate **past memories** in which the current situation is referred and reconsidered.[12] Current features and events as well as past memories evoke emotional responses in our bodies, which are felt as different feelings.[13] These bodily states also deepen the quality and intensity of the experience itself.[10] The components and reciprocal nature of the human experience is sketched in Figure 1.

1.3. Trilogy of mind

There is a fair agreement among psychologists that the structure of awareness includes some version of motivational component, cognitive interpretation and emotional attitude towards the information. In his "Letters on Sensation" Moses Mendelssohn (1729-1789) was probably the first to use the trilogy of mind set of will, cognition and feeling.[14] During the decades in which psychology was concentrating on the stimulus-response relationships and information processing paradigms the trilogy was cut to pieces and studied separately.[15] Although the three components overlap making it sometimes hard to separate them,[16] a useful framework is lost if the trilogy is not considered united. The experiences related to digital gaming cannot be understood without consideration of such a holistic perspective to human mind.

Thus, the dynamical process of experiencing begins from the perception of an environmental feature or event. It gets its quality and intensity in our awareness[10] and continues as we change our focus and act upon our experiences.[11] It may never be possible to fully understand another person's subjective experience. But, if we concentrate on particular observable features of our environment there are likely to be common patterns in various experiences.[10, 17] The investigation of these patterns in restricted environments such as psychologically rich and interactive game-worlds is likely to

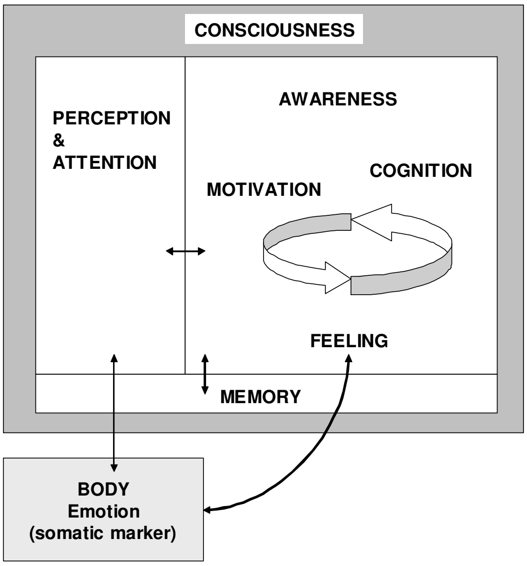

Fig. 1.The reciprocal relationship between body and mind in forming the experience

expand knowledge concerning both the formation of subjective experiences and interactive digital environments themselves. In this sense, digital gaming is becoming an exceptionally rich and valid simulation environment for studying psychological processes.

1.4. The importance of declaring the level of analysis

1.4.1. What

User experience requires understanding of human perception and attention, the relevant aspects concerning the person's history and past and having idea of the person's motivations as well as cognitive-affective evaluations concerning a well defined use situation of a particular technology. These experiential components can be used as a heuristics, that is, as rules of thumb to study user experience. As such multivariate experiential profiles are obtained from several persons a general understanding of the experiences concerning a particular and well defined technology can be formed.

The psychological level of the measurements should be based on the goals of the study, on the nature of the studied technology and it also depends on the participants of the study. For example, in the study of color discrimination or detectability of different shades of light no vast and psychologically deep array of measured subjective variables are needed whereas the situation is quite different when measuring the experiences related to role-playing game with a stereo display. The slight selection of the participants in our studies has, for instance, affected to our measurement methods. Because the participants had at least some motivation to engage digital games we measured motivation with an involvement construct[18]. Involvement describes more of the intensity of the game-player relationship than simply the direction of motivation to engage or not to engage into a game.

1.4.2. Why

Human experience has a long evolutional history while technology has been with us for a century with sparse time to human-related evolution. Hence, human mind is complex, technology is simple. We can assume that humans experience technology with the same psychological 'tools' as we experience events and objects in our every-day living environment. New technology may evoke 'new' experiences such as, for example, the sense of presence during a 1st person-shooter game. However, the psychological components of such an experience already exist in our minds. In the case of presence these basic components causing it are the level of emotional arousal, focus of attention and perceptual-cognitive issues such as spatial awareness and perceived realness.[19]

Experience is a holistic phenomenon. Studying only one component of, for example, the trilogy of mind would leave many open questions. Studying only one aspect of the experience such as the sense of presence would not tell us much about the quality and value of the experience because the motivation and cognitive-affective aspects are then ignored.[20] The need for a holistic understanding of the user is even more emphasized by the future innovations such as ubiquitous technology. When displays and interfaces will be a natural part of our living environment the spectrum of their usability requirements to fulfill satisfactory user experience will increase.

1.4.3. How

Paradoxically, the scientific need for getting objective measures has actually caused the trilogy-of-mind heuristics to decline in psychological research. In order to cope with the demands of the objectivity the trilogy has been cut to pieces. Studies have concentrated solely on those aspects, for example, basic emotions that are in reach of objective measurement methods, such as physiological responses. This has also been reflected in the studies concerning the psychology of digital gaming. In more complex phenomena related to, for example, personality and social cognition the trilogy-of-mind heuristics has continued to guide the studies.[15] To understand the essential aspects of the experiential phenomena in gaming they must be approached by efficient subjective methods. The subject himself is the best expert to describe subjective conceptions of the world around him.[17] Only when the structure of these conceptions in particular context is known there is sense in trying to probe them with objective measurements.

Subjective methods are often understood as interviews and questionnaires. Often interviews only map users' feelings and questionnaires include ambiguous items that form simple scales with bad reliabilities. For instance, the complex construct of the sense of presence is directly asked in few questions that are said to form a presence scale. In such cases participants do not even understand what they are answering when thy mark "5" in below the sentence "I felt present in the virtual environment" in a 1-5 likert scale. If few such items are then summed the result is a scale that does not work. In fact, presence is a good example of a so called latent true score,[21] that cannot be measured straight forwardly, but that should approached by studying its measurable components such as emotional arousal, focus of attention and cognitive aspects of social awareness and perceptions concerning the reality. As these components are combined we can get an idea of the amount and nature of the sense of presence experienced in physically and socially interactive game-worlds.

We have approached the challenges provided by the psychological research in digital game-worlds with multivariate methods. These methods combine previous quantitative and qualitative research done in these environments. We have mainly applied old constructs such as involvement and the sense of presence into our models and studied them in new environments such as games played with head-mounted-displays. The aim of our studies has been to understand and build up a framework that includes the essential components that are needed to understand user experience in today's interactively rich and socially most sophisticated digital environments; game-worlds. The two measurement models that we have developed and their implementation in gaming are discussed in the following.

2. METHODS

2.1. Data collection

The data (n=2182) used in our studies has been collected from both the laboratory experiments and via an Internet survey using EVE –Experience Questionnaire (EVEQ-GP).[22] Both the paper and pencil and online version of the EVEQ-GP were composed of 180 items (1-7 Likert-scale and semantic differentials) measuring different experiential aspects related to human-computer interaction. Also 27 background questions were included. Participants filled in a questionnaire right after the gaming session, reflecting their subjective gaming experience received from that specific game. To learn more about the origin and previous use of the items used in the EVEQ-GP the reader is referred to.[20, 22-24]

2.1.1. Laboratory studies

Two distinct lab experiments were conducted. In the first experiment 240 university students (120 males, 120 females) were examined in a between-subjects 2x2 design in which two different driving games were played using two different displays. Each participant played for 40 minutes, after which they were asked to fill in the EVEQ-GP. The two driving games studied were Need for Speed Underground (NFS), which is a 1st person 3D – driving game with lots of camera movement, horizontal changes and intensive flux. Microsoft sidewinder Gamepad was used to play NFS. Other two groups played Slicks n' Slide 1.30d (Slicks) which is a 3rd person, 2D – driving game with no camera movement and otherwise static environment. The participants used keyboard to play Slicks.

One of both NFS and Slicks groups used Olympus Eye-Trek FMD-700 near-eye display (NED). The remaining two of both NFS and Slicks groups used a 21 inch Sony Trinitron GDM-F520 CRT monitor from the viewing distance of 1 meter. Olympus EyeTrek is a binocular display providing a resolution of 800 x 600 pixels and field-of-view of 30 degrees x 30 degrees. All experimental groups used the same computer (Pentium 4 CPU at 3.00 GHz – Total memory 512 MB DDR-SDRAM). The Display adapter used was Sapphire ATI Radeon 9600 - 256MB (8 x AGP) and Sound card Realtek AC97 Audio.

The participants were instructed to proceed in his/her own pace and not to ask instructions during the game play, if possible. However, they were assisted if insurmountable problems (i.e., technical or otherwise immediate) occurred. The task lasted for 40 minutes after which the subjects filled the EVEQ- questionnaire.

In the second experiment 30 university male students were playing Halo: Combat Evolved. First the participants were allowed to practice the game and then they played two 40 minutes sessions. After the second session they were asked to fill in the EVEQ-GP.

2.1.2. Internet

An online version of the EVEQ-GP (VK2) was used to collect data from the Internet. Participants were asked to recall one particular gaming session with a particular game and fill in the questionnaire keeping that session in mind. It was recommended to fill in the questionnaire right after a playing session. The application development software used to create VK2 was Lotus Domino Designer6.5. Domino Server ran on HP Proliant DL380.

The questionnaire was on-line one month in a home page of the Pelit (Games) –magazine (www.pelit.fi). Pelit is a PC-gaming magazine in Finland, with a leading circulation of app. 38 300 and registered online users app. 27 000. During the first week VK2 was on the main page and the remaining three weeks it was linked in a short news story, which was located in the news section. During one month in the Internet 1912 properly filled in questionnaires were received.

2.2. Data

The data consists of 2182 (1972 males, 210 females) filled in questionnaires. The mean age of the respondents was 21.5 years (SD=6.0). The average time of playing was 127 minutes (SD=111) and the average size of the display used was 19.2" (SD=4.4). 33% of the respondents played daily, 29,6% played at least every other days and 24,5% played often but not every other day. Most (31.5%) of the games played before filling in the questionnaire were First-person shooters (FPS) either online (15.0%) or offline (16.5%). Second popular (15.0%) genre was massive multiplayer online role-playing games (MMORPG) and third (13.1%) was single role playing games (RPG) (13.1%). The most popular single game played was World of Warcraft (n=265), which is a MMORPG. Altogether the data included app. 320 different games, giving a broad scope to the psychology of the digital games. Since the Pelit –magazine is focused on PC –games, 85.2% of the games were played with a PC and 14.8% with a console.

2.3. Measurement models

2.3.1. Adaptation

We formed two measurement models[21] from the whole dataset (n=2182). The first model includes 83 items and it measures user adaptation into the digital environment. The adaptation process describes the way the players willingly form a relationship with a digital game.[23] The theoretical base of the model lies on the psychological studies concerning involvement and the sense of presence. Involvement construct is a central and well established concept in the field of buyer behavior studies.[25] It consists of two dimensions: cognitive importance and valence related interest towards a particular situation or a stimuli.[18] The sense of presence has been studied in a variety of mediated environments, for example, virtual environments, movies and television as well as in gaming.[19, 20, 26-28] Presence locates the user into a mediated world, and establishes a particular relationship between the user and a machine.[29] The research on presence is founded both theoretically and empirically, and it provides a valid framework to study gaming experience in digital game-worlds[30]. Included were also items, which have been previously used to study evaluated interactivity, immersive qualities of the technology and emotional arousal.

2.3.2. Flow and quality of experience

The second model measures flow and quality of an experience.[24] The model includes 56 items, which have previously been used to study the components and correlates of flow[6, 31] and experiential quality[6, 27] in various digital environments. The main cognitive theories of emotion suggest that cognitive interpretations and appraisals of the events in the world are important part of the emotions.[32, 33] There are various appraisal features and components, such as anticipated effort required by the situation, perceived obstacles and sense of control in the situation that are shaping the emotions attached to these events.[33] These evaluations also affect emotional action readiness, which means focusing attention and preparing the person to act in order to attain a desired goal.[32] Emotions cause also physiological changes in our bodies which are felt as feelings.[34]

In the theory of flow, the cognitive evaluation process concerns balance between one's perceived skills and the challenges the situation provides.[5] Human behaviour is explained in terms of situational variables and trough the meaning of the situation to the particular individual.[35] The balance in cognitive evaluation of the skills and challenges is described as a "dynamic state" and "the holistic sensation that people feel when they act with total involvement".[5,p.36] In a state of flow a particular activity is perceived so enjoyable and intrinsically interesting that it is considered worth doing for its own sake.[36] The state of flow is also found to heighten person's sense of playfulness that is, cognitive spontaneity.[31]

2.4. Measurement scales

All in all 15 measurement scales were extracted (139 items). The scales were extracted in two distinct principal axis factoring (PFA) with an oblique direct Oblimin rotation (delta=0). Factor scores with Bartlett's method were computed for each measurement scale for their future use. Eight measurement scales were extracted from the 83 variables measuring involvement and presence (see Table 1).[23] The standard errors of measurement of the scales were good ranging from 0.33-0.71. The reliabilities of the scales are presented in Table 1. The relationships between the measurement scales were further analyzed in a 2nd order PFA. Interaction had a low communality and it did not load on any factor. Thus, it was removed from the model. Role engagement, Attention, Co-presence, Arousal and Physical presence loaded on the same 2nd order factor forming a dimension that was named as presence. Interest and Importance formed another 2nd order factor that was named as involvement. Thus, the 2nd order analysis revealed the latent true scores of involvement and presence. Together these two distinct but correlated dimensions describe the **psychological adaptation** into a digital game.

Seven measurement scales were extracted from the 56 variables measuring flow and quality of experience (Table 1).[24] The standard errors of measurement of these scales were ranging from 0.38-0.63. The reliability coefficients (Cronbach's α) of the scales are presented in Table 1. Since a correlation (oblique) rotation was used also the factor correlations (>.30) were inspected. Factor interpreted as Valence correlated with factors interpreted as Playfulness (.44), Competence (.38) and Control (.33). Within these four also Competence and Control (.35) and Playfulness and Control (.31) correlated. Factors interpreted as Impressed and Challenge (.33) correlated only with each other.

According to our best knowledge these fifteen scales include psychologically relevant aspects and components that can be used to describe, analyze and understand a particular user experience - gaming experience. Taken together these 15 measurement scales measure players' perceptions, focus of attention, motivation to play the game in terms of its meaning and interest, social cognition, basic emotions as well as different feelings received from an interaction, cognitive evaluations based on the users skills and environmental challenges as well as the interactive qualities of the game (see Table 1). All the statistical analysis was conducted with SPSS 13.0 statistical program.

Table 1. The measurement scales and number of items, Cronbach's alphas, short description and relation to our theoretical model.

Scales	Name & nro.of items		α	Description	Psychological Component
ADAPTATION					
1	Role Engagement	12	0,87	Captivated and enclosed into the role and place provided by the story	Perception - social cognition
2	Attention	12	0,89	Time distortion, focus on the game world instead of the real world	Attention
3	Interest	6	0,80	The game was interesting, exciting as well as lively	Motivation -emotion
4	Importance	8	0,90	The meaning of the game, game was relevant, close, personal and sensitive	Motivation - cognition
5	Co-Presence	14	0,89	Feeling of sharing a place with others, being active in there	Perception - social cognition
6	Interaction	9	0,74	Speed, range, mapping, exploration, predictability of own actions	Perception - cognition
7	Arousal	5	0,64	Active, stimulated vs. passive, unaroused	Emotion
8	Physical Presence	17	0,88	Feeling of being transported into a real, live and vivid place	Perception - cognition
FLOW & QUALITY					
9	Valence	10	0,86	Positive valence, happy, not bored or anxious	Emotion
10	Impressed	9	0,75	Amazed and impressed by the game-world, the game elicited real feelings	Feeling
11	Competence	11	0,87	Skilled, competent, enjoying using the skills, clear goals	Cognition - past experience
12	Challenge	5	0,69	Game was challenging, game required the use of my abilities	Cognition - past experience
13	Enjoy	7	0,83	Playing was pleasant, enjoying and exciting, I'll recomend it to my friends	Feeling
14	Playfulness	9	0,78	Ease of doing, creative, live and vivid, not unimaginative	Feeling
15	Control	5	0,71	Feeling of being in control and independent	Emotion

3. RESULTS

3.1. Case 1. Experiential profiles of gaming with a NED and a CRT

In our first laboratory experiment described in the methods, we studied the psychological differences related to playing two different driving games with two different displays.[20, 28, 37] Here we will show how the experience of playing a 1st (NFS) and 3rd (Slicks) person driving games with a normal CRT display differs from playing the same games with a NED (see 2.1.1. for details). We concluded in our previous study[28, p.20] that "…a fast paced 1st person 3D driving game played with NED was the closest group to physical presence, co-presence and role engagement" based on the discriminant analysis. We use all the 15 measurement scales introduced above to compare two display groups of 30 participants in each games (15 males, 15 females in each group, total n=120). Since our previous study showed indications that gender has an impact on experienced interactivity[28] we also included gender into the Univariate GLM model.

When NFS was played with a NED the experienced physical presence was higher than in the CRT condition ($F(1,56) = 7.27$, $p < .01$, partial $\eta^2 = .12$). Gender did not have an effect on the physical presence. In CRT condition the interaction was evaluated higher ($F(1,56) = 4.45$, $p < .05$, partial $\eta^2 = .12$). Gender affected evaluated interaction significantly ($F(1,56) = 10.85$, $p < .01$, partial $\eta^2 = .16$), males considering gaming more interactive in both display conditions. This was also found in our previous study.[28] Any other of the scales used did not differentiated statistically significantly between the two display conditions in NFS. When Slicks was played with both displays and the CRT condition was found statistically significantly more interactive ($F(1,56) = 6.33$, $p < .05$, partial $\eta^2 = .10$) and also in this case males experienced more interactivity in both displays than females $F(1,56) = 7.32$, $p < .01$, partial $\eta^2 = .12$). The rest of the scales used did not show statistically significant difference between the two display conditions in Slicks. We can summarize the differences between the two display conditions as following:

- NED increases the sense of physical presence in a case of 1st person, fast paced driving game
- Interaction is evaluated higher in CRT no matter what content is used
- Males evaluate interaction in driving games higher that females, no matter what kind of a display is used
- Display conditions do not differ in any other scales at least after 40 minutes of playing

3.2. Case 2. Experiential profiles of two different driving games

In this case we show how two different driving games differ within two different display conditions. We have dealt with this topic earlier[20, 28], but here we use our revised and more developed measurement scales as well as more data to examine the differences between the games and how these differences are affected by the different display used. Here we also study in more detail the gender effect on the found experiential differences.

By applying our adaptation model to these four different experimental conditions we found out that in NED condition NFS was considered more interesting $F(1,56) = 6.90$, $p < .05$, partial $\eta^2 = .11$). Males considered both the games more interesting than females ($F(1,56) = 9.81$, $p < .01$, partial $\eta^2 = .15$). When presence construct was investigated the results showed that NFS provided a higher sense of role engagement $F(1,56) = 7.44$, $p < .01$, partial $\eta^2 = .12$) and physical presence $F(1,56) = 12.30$, $p < .001$, partial $\eta^2 = .18$). It also induced more emotional arousal as compared to the 3rd person Slicks $F(1,56) = 28.26$, $p < .001$, partial $\eta^2 = .36$). No statistically significant differences between genders were found in these three scales. In CRT condition NFS was higher only in physical presence ($F(1,56) = 4.98$, $p < .05$, partial $\eta^2 = .08$) and emotional arousal ($F(1,56) = 17.12$, $p < .001$, partial $\eta^2 = .23$) (Figure 2). No statistically significant differences between genders were found in these two scales.

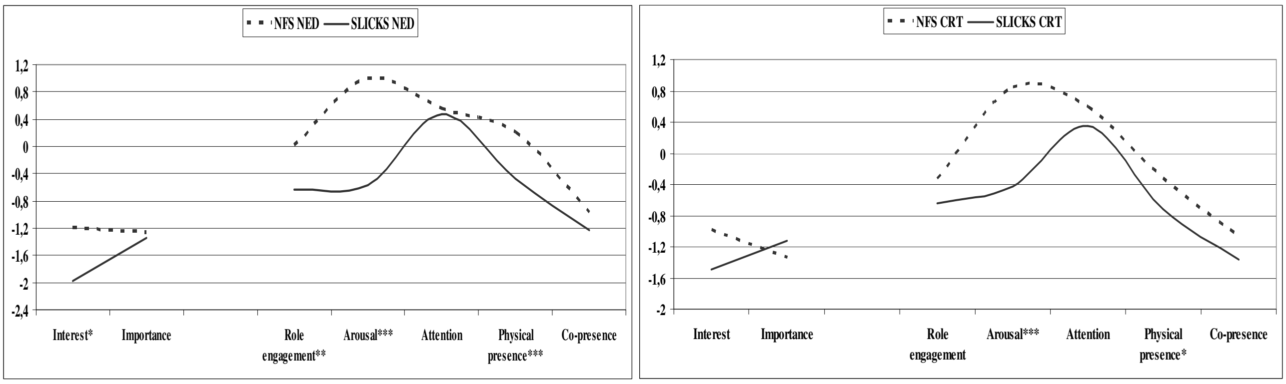

Fig. 2. The mean adaptation profiles of the two driving games in NED and CRT displays (***indicates p<0.001, ** p<0.010, * p<0.050).

Next the two games were studied in the cognitive-affective model measuring the flow and quality of experience. We have also included the measurement scale of interaction into the cognitive evaluation part of this model. In NED condition NFS was experienced more positive to play. The players reported increased emotional valence ($F(1,56) = 6.61$, $p < .05$, partial $\eta^2 = .11$) and enjoyment ($F(1,56) = 10.82$, $p < .01$, partial $\eta^2 = .16$) and they were more impressed and amazed ($F(1,56) = 9.82$, $p < .01$, partial $\eta^2 = .15$) by playing the NFS. Males considered playing both the games more positive in valence ($F(1,56) = 5.63$, $p < .05$, partial $\eta^2 = .09$). However, when the games were compared in the CRT condition NFS was experienced more impressive than Slicks ($F(1,56) = 8.67$, $p < .01$, partial $\eta^2 = .13$) (Figure 3). Also in CRT the males considered playing both the games more positive in valence ($F(1,56) = 7.40$, $p < .01$, partial $\eta^2 = .12$). Gender had no effect on the experienced impressiveness. To summary the main findings of this case:

- Content has more effect on the experience
- Display form affects these differences
- Males consider playing more interesting in NED
- Males experience playing both the games more positive than females, no matter what kind of a display is used

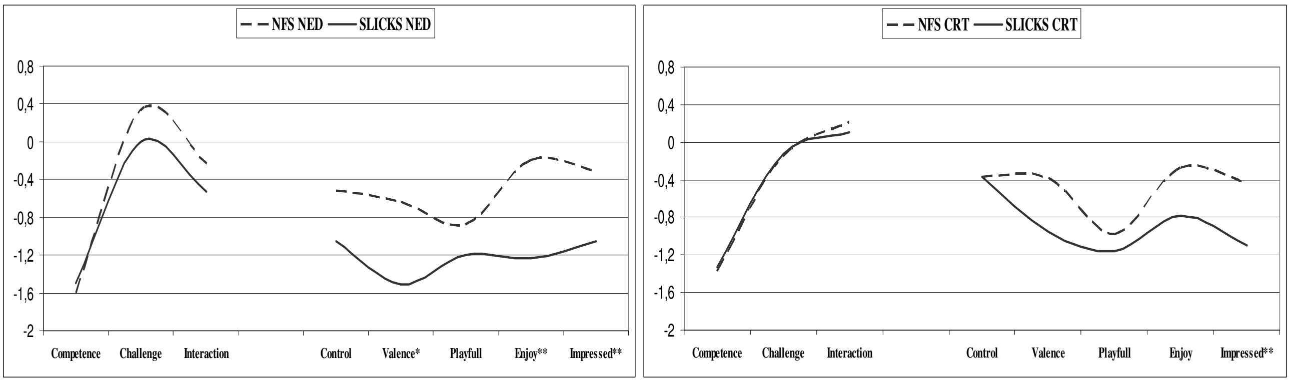

Fig. 3. The mean cognitive-affective profiles of the two driving games in NED and CRT displays (***indicates p<0.001, ** p<0.010, * p<0.050).

3.3. Case 3. Uncovering the presence-space

Our last case deals with the problem related to the use of a simple scale to measure a multidimensional construct. There are studies including simple scales or even single questions to measure, for example, the sense of presence. We have used a five component model of presence including role engagement, emotional arousal, focus of attention, physical presence and co-presence (Table 1) and show above how these different components interact in different display and content situations. In 2nd order factor analysis (details in 2.4.) these five components can be compressed into one dimension that is named as the sense of presence. Although, this presence dimension is composed of 60 variables it acts as a simple scale composed of only a few variables. Compressing data too much causes information loss in a same way as measuring only a part of the multidimensional construct would do.

If we measure presence in Cases 1 and 2 with this 2nd order presence dimension (Cronbach's alfa .61) that includes the five different measurement scales, the results indicate that the display had no presence-related impact on either of the games. When comparing the two games in NED condition with a One-way ANOVA, NFS was experienced to elicit a higher sense of presence ($F(1,58) = 8.69$, $p < .01$). Presence was also higher in NFS in the CRT condition ($F(1,58) = 6.52$, $p < .05$). The problems in these two examples are obvious; in the first one the difference in physical presence within two NFS groups is completely lost. In the latter one the difference is found but it tells little about the nature of it, which makes it hard to evaluate the content in more detail. Also the fact that the differences between the games vary in different display conditions would have been ignored if 'simple' measure of presence had been used.

When we study a complex subjective phenomenon, it is necessary to cover the relevant aspects of this complexity by the measurement scales used. Often this leads to a complex measurement framework as well. Our last example deals with the problem related purely to the measurement of the experience received from a particular content. We studied four different PC- games[38] an offline first-person shooter (FPS) Half-Life 2 (HL2), an online first-person shooter Counter Strike Source (CS), an offline role-playing game Star Wars: Knights of the Old Republic (KOTOR) and a massively multiplayer online role-playing game (MMORPG) World of Warcraft (WOW) (n=60 in each game). All the games are popular and quite different, thus they should elicit different types of experiential profiles to the players.

We studied the experienced presence in these four different games with our 2nd order presence dimension and found no difference between the games. Hence, we broke down the dimension and studied its five components separately in a direct discriminant function analysis. The aim of this method is to form such functions out of the predictor variables (in this case the five presence components) that best discriminate between the studied groups (the four games).[39] This analysis revealed two discriminant functions that were named as action – narrative and physical presence – co-presence (Figure 4). These functions showed how the four games actually differed statistically significantly within the presence dimension.

The examination of this presence-space created by the four games and five presence components reveals a great deal about the unique and game-specific nature of the presence in each games. Figure 4 shows, for example, that the presence in the fast paced online FPS CS is mainly experienced by a high level of arousal and focusing of attention to the game-world. High level of attention and arousal were also characteristics to the 1st person driving game NFS (Fig. 2.). On the other hand, an offline FPS HL2 was in the physical presence end of the physical – co-presence function and closer to MMORPG WOW in action – narrative function than online FPS, although the two FPS's are run by the same game engine. The diversity that the different game content introduced within five presence components describes well the richness of the human experience. How these different presence profiles are related to, for example, the flow and quality profiles of the players or how different display technologies affect the gaming experience of these games is a relevant topic of future studies.

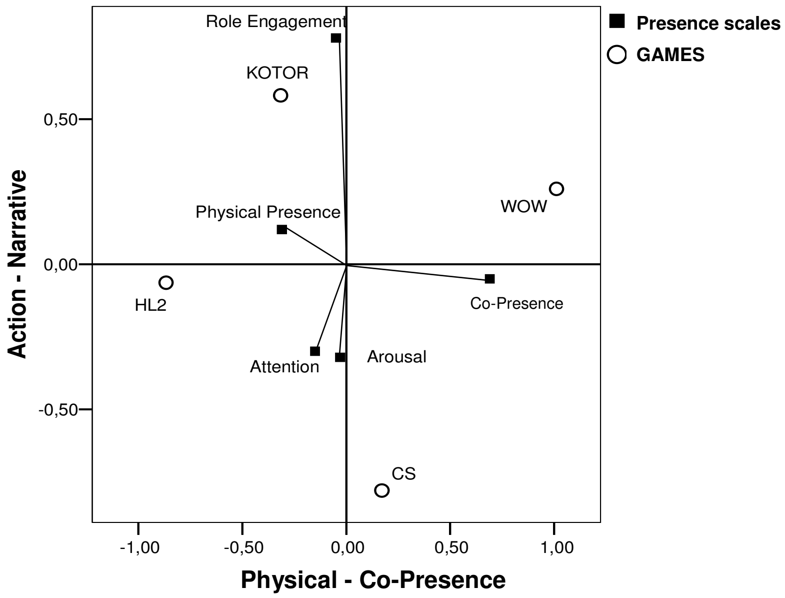

Fig. 4. The presence –space shows how the games are discriminated by the two functions of action-narrative and physical-co-presence. It also shows how the five presence components are related to four different PC-games.[38]

4. DISCUSSION

4.1. Psychology of gaming: a theoretical and methodological framework

The theoretical framework is composed of the very basic psychological components that have been considered relevant in order to understand conscious subjective experience since the early days of psychology. Included are motivation to pay attention and perceive environmental features and events.[8] The framework also deals with the further analysis of these features in the awareness by thought (cognition), will (motivation) and feeling (emotion)[14] and their mixing with previous experiences and memories.[12] This process is essential in the formation of something that is called experience. Since we experience our environment and inner states constantly, we adopt Dewey's concept of an experience[10] to define that particular type of experience that is in scope of this study. By doing this definition we separate it from everyday experiencing and monitoring of one's inner states and we obtain a framework that can be used in various contexts.

Keeping this rich psychological transcription of the human experience in mind we developed two measurement models to study digital gaming. The first measurement model we name adaptation[23] and it is composed of two latent constructs of **involvement** and the **sense of presence**. Theoretically involvement includes two different motivational components of cognitive importance and emotionally charged interest towards a particular situation or stimuli.[18] The sense of presence includes perceptual and cognitive components related to both physical and social aspects in an interactive environment.[1] It also includes the coupling of emotional arousal and focus of attention.[40] Adaptation model describes how the user is forming the relationship with the interactive digital environment and its various features. It also gives a description of the meaning and value as well as the intensity of the experience to the user.

The other measurement model consists of cognitive and affective components that describe the quality of the experience received.[24] It is based on the theory of flow[5]and current cognitive theories of emotions.[32]Besides cognitive appraisal it also includes measures of four different positive feelings and experienced sense of control in a game-world (Table 1). Both the measurement models were tested with a large and comprehensive dataset (n=2182) gathered from digital gaming environments. Game-worlds are studied because of their audiovisual richness and highly immersive and dramatic qualities. Taken together these two parts present 15 well validated measurement scales that are based on an established psychological theorization. Together they measure the holistic human experience and give us an idea of psychologically relevant aspects of the studied technologies.

4.2. Case findings

4.2.1. Case 1.

We studied gaming with a NED and a table-top CRT and found that the applied display technology affected mainly on the perceptual and cognitive evaluations made of the digital environment. The range and magnitude of these differences between display technologies is also affected by the displayed content. The sense of being in a real and vivid place was best supported by the 1st person driving game played with a NED. The finding that the CRT users evaluated to be able to anticipate what would happen next in response to their actions and that they felt they can examine the game-world by observing it did not depend on the content but were related strictly to the display used. The only background variable studied, gender, showed that males evaluated these interactive qualities of the game higher than females in both display conditions.

These findings indicate that some contents (e.g., 1st person game) fit better to a particular display type (e.g., HMD) as compared to other contents (e.g., 3rd person game). The enclosed nature of the HMD seems also restrict the user causing decline in evaluated interactivity. This can be due to unfamiliar and extraordinary technology - CRT represents something that most of the users are accustomed to. In our case this difference did not affect on any other experiential components, for example, the emotional quality. The case may be different in, for instance, prolonged use of a HMD. Gender difference only indicates the importance of studying background of the users. Although the participants of our experiments were slightly selected based on, for instance, the gaming frequency the background variables are still worth of examination.

4.2.2. Case 2.

The game-content had more effect on the experience. However, the used display affected on these differences, as it also did in Case 1. When the two games were played with NED, NFS elicited more feelings of being enclosed and engaged in a real and vivid place and the story in there. It was also evaluated more interesting and emotionally positive, impressive and arousing. In CRT the qualitative difference between the displays was more neutral – NFS was only more real and vivid as well as impressive. This shows again that NED is more suitable for NFS than it is for Slicks. Gender differences in valence and motivation indicate slight attitudinal difference between males and female towards driving games.

This case shows how the experience varies as the game-content is changed. The change is also affected by the display form, which makes it challenging to study these phenomena. This also requires a careful selection of the test content if the goal is to attain a valid measure of the display technology. The findings in Cases 1 and 2 also indicate the need for multivariate measures. If, for example, only the sense of presence or fun and enjoyment had been measured, only superficial aspects of the user experience would have been touched.

4.2.3. Case 3.

The need for multivariate measures is emphasized in the last case. A 'meta' measure of the sense of presence compressing 60 variables into a one scale was used and showed how vague measures it provided. Some of the findings made with a five-component presence measure were totally lost and those found left many questions unanswered. Hence, in order to clarify the difference between these two methods to measure the sense of presence four different games were evaluated with them both. “Meta” measure showed that all the games induced quite a high sense of presence but the examination of the five-component structure showed clear differences between the games within the “meta” measure. All the games elicited something that can be called presence, but they all did it differently. The games formed two distinct dimensions within the sense of presence – one separating physical and social aspects of the game and the other separating drama and narrative aspects from the pure action. This case especially indicates the need for multidimensional approach as the studied phenomena become more complex. A “meta” measure provides some information concerning two different driving games but four different game genres played in two different contexts (online-offline) possess too much challenge for such a scale.

5. CONCLUSION

We suggest a theoretical framework to study the psychology of human-computer interaction. The framework can be seen as heuristics, or rules of thumbs to evaluate the subjective experiences received from various digital applications. Based on the framework we have developed two measurement models, to study today’s interactively and socially most sophisticated digital environments, game-worlds. These measurement models are applied in different experimental cases introduced in the paper. The cases are based on our previous studies[20, 28, 38] and the data as well as the analysis has been complemented here and new findings have been introduced. The results show how it is possible to map between experience, technology variables and the background of the user (e.g., gender).

The value of these results will increase as more data is gathered from bigger (movies) and advanced (stereo) displays and compared to our current findings. The results will also gain more meaning when specific issues such as sickness symptoms are related and compared with them. In future this might lead to a way to optimize the contents for specific viewing devices or viewing situations. The measurement framework is likely to get adjusted according to challenges the new displays and displayed contents will provide. However, the theoretical framework introduced in this study is empirically well founded and can guide our future studies setting the limits on what to measure, why to measure it and how we do it.

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