The Impact of the Display Type and Content to a Game Adaptation

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ABSTRACT

This study examines the impact of the display type (form) and content (game) to the PC -game adaptation. An ordinary table-top display (cathode ray tube; CRT) and a near-eye display (NED) suitable for mobile gaming are compared in two different driving games. A measurement model based on a large dataset (n=2182) is applied to study psychological aspects of the game adaptation. This model integrates two constructs considered important for the game adaptation: involvement and presence. The results show that the content affected the subjective sense of presence. However, the form did not have an effect on the presence. These results indicate that NED's are capable of supporting similar adaptation to the game worlds as compared to CRT's. However, the results also weakly indicate that playing with a CRT increases the evaluations of interaction. The study shows the advantages of using multidimensional measures in studying a rich human-computer interaction.

Categories and Subject Descriptors

K.8.0 Personal Computing: General: Games; I.6.8 Gaming; H.5.m Information interfaces and Presentation Miscellaneous

General Terms

Measurement, Human Factors, Theory

Keywords

Digital games, Mobile display, User experience.

1. INTRODUCTION

Advancing technology enables the use of mobile devices in various tasks and contexts of use. They have become capable of performing more and more demanding tasks, but the display quality may limit their use. Although the resolution of the displays in mobile devices has recently increased significantly, the small size of the display is likely to limit and hinder experiences otherwise received from the content. This problem is especially emphasized with entertainment content like games or movies [4]. Audio-wise these devices are comparable to any desktop device because of the well developed earphones.

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1.1 Near-Eye Displays

Near-eye displays (NEDs) provide one solution for the display size problem. With such display it is possible to create a large virtual display in front of the users' eyes and thus to solve the user experience problem created by the small display. Technically, a NED is often a micro display, which is expanded with optics to correspond a display having an angular size of a desktop display or even a TV -screen. Usually NED is head-mounted and near to eye. It can also be a handheld, cellular phone –sized display, into which the user peeks in.

Because NEDs enable to create a large screen into a mobile or head-mounted system it can be very effective in manipulating the perceived visual environment. NEDs make it possible to play games or watch movies in a big screen resolution. We already know that these new environments will trigger completely new psychological, social behavior and experiential patterns. However, there might be some problems related to the simulator sickness symptoms created by the displays [2].

1.2 Mobile Gaming

Digital games have become a large scale entertainment. Besides arcade halls and homes more and more games are played with mobile devices such as mobile phones and handheld consoles. The motives to play games vary across the players but a game should always meet certain expectations on the behalf of the user in order to become entertaining and provide good enough user experience.

The psychological study of the gaming experience is in its infancy. The concept of the sense of presence, which is being there in a mediated environment [6] has been considered relevant in studying gaming experience [9]. It has already been studied in a PC context [11,15] as well as in small screen PDA's [4]. Majority of the previous studies have been concentrated on the physical presence and its three components: spatial awareness, realness and attention [6,11].

1.2.1 Measurement model

We have been working on a theoretical measurement model concerning a holistic user adaptation into the game world [16]. The model is composed of two major psychological constructs: 1) involvement and 2) presence.

In our preliminary model an involvement –construct is considered as a directing force of intrinsic motivation [10]. Involvement includes two distinct but correlated dimensions: importance and interest [7]. **Importance** is dominantly a cognitive dimension concerning the meaning and relevance of the stimulus (e.g., playing the game matters to me), whereas **interest** is composed of emotional and value-related valences, such as "playing was exciting" [10].

The other part of our model –the sense of presence – is composed of the following five components: physical presence (spatial awareness and realness), attention and time distortion, role engagement (being part of the storyline), social presence (spatial awareness and being there together actively) and emotional arousal. Also the evaluation of the game interaction (e.g., speed, range, mapping) was measured in our model [12]. Although interaction was omitted from our final measurement model, it is among the measured components in this study.

1.2.2 Testing the model with a NED

To find out how a NED impacts on the game adaptation and to test our measurement model an experiment was set up. Since the experience received from the mediated stimuli is likely to depend on both the form as well as the content of the presented stimuli we varied them both [1]. Also the impact of the background variables (e.g., gender) on the adaptation process was investigated.

As the previous studies have shown the screen size has an effect on the subjective evaluations of the sense of presence [3,4,5]. Our hypothesis was that a large near-eye display might provide good presence which in turn would lead into better user experience in general. As previous studies have shown, presence is considered as a prerequisite of more positive experiences in various mediated environments [8,14].

2. METHODS

2.1 Participants

120 participants were tested. They were mainly university students from the faculty of behavioural sciences and the department of computer science. There were 60 males (50 %) and 60 females (50 %). The mean age of the participants was 24.4 (SD=3.7) years.

The participants were selected by applying the background questionnaire. Based on the background questionnaire answers we excluded participants who did not like driving games, did not have any computer game playing experience or who reported playing computer games for six hours or more every day. Also the vision of the participants was screened.

2.2 Technology

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. There were two different display conditions 1) Olympus Eye-Trek FMD-700 near-eye display (NED) and 2) a 21 inch Sony Trinitron GDM-F520 cathode ray tube (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.

2.3 Task & Procedure

Four different test groups were formed (30 participants each) and a 2x2 test design was used. Two of the groups played 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 NED and the remaining two groups of both games conditions used the CRT monitor.

The participants were instructed to proceed in his/her own pace and try not to ask instructions during the game play. 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 in the EVE –Experience Questionnaire (EVEQ-GP).

2.4 Scales Used in EVEQ-GP

To measure user experiences an EVEQ-GP –questionnaire was used. EVEQ-GP is a developmental tool, which includes 180 items (1-7 Likert-scale and semantic differentials), measuring different experiential aspects related to human computer interaction. EVEQ-GP also includes 26 background questions.

The measurement model used in this study to measure game adaptation includes 83 items. To learn more about the origin and previous use of the items the reader is referred to [14,15]. These items have been factor analytically extracted into eight scales measuring interaction, presence and involvement [16]. The formation of the measurement scales is based on the principal axis factor analysis with Orthogonal direct oblimin (delta=0) rotation. The analysis consisted of 2182 participants reported gaming experiences in both in laboratory conditions and the Internet. Table 1 shows the descriptions and Cronbach's alphas of the each scale used in this study.

2.5 Data Analysis

The difference between four experimental conditions in adaptation scales was analyzed by multivariate discriminant analysis. Discriminant scores from the analysis were computed and used as new variables. These variables were analyzed in a General

Table 1. Description and reliabilities of the scales used.

Name	Nro.of items	alpha	Description
Role Engagement	12	0,88	captivated and enclosed into the role provided by the storyline and narrarative
Attention	12	0,87	time distortion, focus on the game world instead of the real world
Interest	6	0,83	interesting, exciting as well as lively
Importance	8	0,83	meaning, relevant as well as close, personal and sensitive
Co-Presence	14	0,85	feeling of sharing a place with others, being active in there
Interaction	9	0,70	speed, range, mapping, exploration, predictability of own actions
Arousal	5	0,74	active, stimulated vs. passive, unaroused
Physical Presence	17	0,87	feeling of being transported into a real, live and vivid place

Linear Model (GLM) multivariate procedure to further investigate the impact of the display and gender to the adaptation. All the analysis was conducted with a SPSS 13.0 statistical program.

3. RESULTS

A direct discriminant function analysis (DISCRIM) was carried out using the factor scores of the eight scales measuring interaction, involvement and presence as predictors of membership in four experimental groups. The four experimental groups were named as Need for Speed played with NED (NFS NED), Slicks'n'Slide played with NED (Slicks NED), Need for Speed played with CRT (NFS CRT) and Slicks'n'Slide played with CRT (Slicks CRT).

Since DISCRIM is highly sensitive to both univariate and multivariate outliers they were both detected and significant outliers were transformed as suggested by Tabachnick and Fidel [13].

Three discriminant functions were calculated with combined $\chi^2(24) = 72{,}79$, $p < 0{,}001$. After removal of the first function the association between the studied groups and predictors was not significant ($\chi^2(14) = 20{,}40$, $p=0{,}118$). Although the second function did not separate the group means significantly, it was interpreted alongside the first function. The first two functions accounted for 75,8% and 21,4% respectively, of the between group variability. The loading matrix of correlations between the predictors and discriminant functions is presented in Table 2.

Table 2 shows how emotional arousal, physical presence, co-presence and role engagement –the four out of five presence scales contribute on the first discriminant function. Attention, the fifth presence scale in our model, doesn't load on either of the first two functions. This indicates that the studied groups do not differ in attention. The first function is named as presence. Interaction and interest load on the second function. The other involvement scale, importance loads on the 3rd function and doesn't separate the groups.

Figure 1 shows how two first functions separate the four experiential conditions. Presence separates the content: both NFS groups are closer to the presence predictors than Slicks groups. NFS CRT condition is close to arousal and NFS NED to a role engagement, physical as well as co-presence. Interaction and interest show tendency to separate the display conditions. However, the second function was not significant.

Table 2. Results of discriminant function analysis of interaction, involvement and presence scales.

Predictor Variable	Function		
	1	2	3
AROUSAL	**0,80**	0,25	-0,09
PHYSICAL PRESENCE	**0,57**	-0,52	0,22
ROLE ENGAGEMENT	**0,38**	-0,13	0,34
CO-PRESENCE	**0,30**	-0,14	-0,29
INTERACTION	0,09	**0,73**	0,37
INTEREST	0,31	**0,45**	0,20
IMPORTANCE	-0,04	0,06	**0,54**
ATTENTION	0,11	-0,03	**-0,35**
Canonical correlation	0,61	0,38	0,16
Eigenvalue	0,59	0,17	0,03

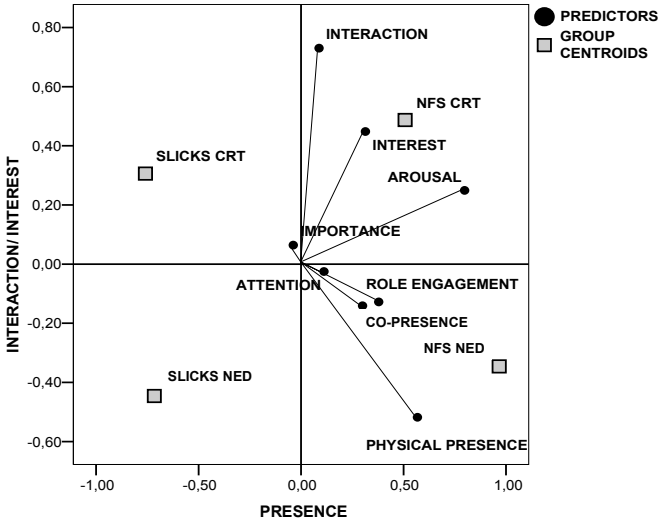

Figure 1. Plots of group centroids and eight predictive scales on two discriminant functions.

Although the classification of the participants was not the main aim of this study it was examined in order to find out how well the predictor scales classify groups as compared to the classification done by a chance.

The classification results indicated that 55,8% of the original grouped cases were correctly classified. This is well above to the 25% that would have been classified by the chance alone. The stability of the classification was checked in cross-validation. The cross-validation dropped the correctly classified cases to the 46,7%. This indicates a fair level of consistency in the classification scheme.

3.1 Interactivity and Interest

To further analyze the tendencies between the two display conditions a new variable for display was formed. It included two groups: NED (n=60) and CRT (n=60). The relationship between the two display groups, gender (male-female) and the two discriminant functions was examined in a GLM multivariate procedure.

The GLM revealed that males evaluated playing in both display conditions more interactive and interesting than females $F(1,120) = 6.25$, $p < .05$, partial $\eta^2 = .05$). Both genders also evaluated playing with a CRT more interactive and interesting as compared to playing with a NED ($F(1,120) = 19.75$, $p < .001$, partial $\eta^2 = .15$). Although both the effects were significant the size of the effect, that is, the partial η^2 was low in both cases. Either gender or display had no effect on the Presence function.

4. DISCUSSION

This study investigated the impact of both display type (form) and game (content) to the psychological PC -game adaptation. Two different displays - a near-eye display and a tabletop CRT - were compared in two different driving games. The main aim of the study was to examine the suitability of a NED to a gaming situation. A NED can provide a large screen into a mobile gaming device, thus overcome the experiential breakdowns found in

handheld gaming devices [4]. In current study also a preliminary measurement model of a game adaptation was tested. The model consists of two psychologically relevant constructs: involvement and presence. Also the evaluated level of interaction was included in this study.

The results showed that a NED was able to provide equal levels of presence as compared to a CRT. Actually, a fast paced 1st person driving game played with NED was the closest group to physical presence, co-presence and role engagement. The similarity between the studied displays in the sense of presence supports the suitability of NED's for gaming, as far as other psychological issues, such as simulator sickness are considered [2].

On the other hand, the level of presence was clearly discriminated by the two game contents. A fast paced 1st person driving game elicited more presence than a more static 3rd person driving game. This finding is in line with the previous studies concerning the effect of the content on presence experience [4,5,15].

There were also less substantial indications that a NED elicited lower level of both interactivity and interest as compared to a CRT. These findings could be explained by the difference in screen size. Although the size of a screen did not effect on the experienced presence, it may have decreased the evaluations of interaction. However, the role of the screen size in evaluated interactivity needs more investigation. The further analysis revealed that males reported higher level of interaction than females. Since the difference was same way in both display conditions it doesn't explain the difference between the two displays.

4.1 Measurement Model

The scales used in this study predicted well the experimental groups, which validates our measurement model. The multidimensional presence measure used in this study worked well although attention was absent. The equal role of attention in each experimental condition is similar to that of Laarni and his colleagues [4]. They concluded that games in generally are engaging and draw our attention. Our study also indicated that the games and display conditions were evaluated equally important.

The division of the involvement –construct (interest and importance) could be explained by both the different experimental conditions and gender. Games were considered equally important in all the groups. Those playing with a CRT considered playing more interesting as compared to those playing with a NED. Also, males considered both games more interesting than females. These findings support the distinct but correlated nature of these two dimensions of involvement [7]. In our measurement model interest and importance formed one unite dimension alongside the presence. All in all the results showed the need for multidimensional approach in order to understand a rich psychology involved in a user experience.

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