PRESENCE AND INDIVIDUAL DIFFERENCES IN VIRTUAL ENVIRONMENT: A USABILITY STUDY

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ABSTRACT

The present study assesses the usability of a desktop virtual reality system in the light of individual differences and sense of presence. The issues we focus on are the performances achieved for spatial tasks and the induced level of satisfaction. The results indicate the impact of each considered variable upon time demanded to accomplish task but not upon its accuracy. Findings also indicate gender-based and presence-based differences upon user's satisfaction with the system.

Keywords

Usability, virtual reality, navigation, individual differences, sense of presence.

1. INTRODUCTION

The basic goal of (collaborative) Virtual Environments (VE) is to create a place for people to (inter)act [15]. User's satisfaction and performances associated with tasks being performed within VE, address the issue of usability. A specific goal is to provide a sense of presence, which was often mentioned as a desirable side effect of any technologically-mediated interaction [8,10,13]. The present paper addresses the usability of a VE from a double perspective: that of individual differences and user's sense of presence.

There has been little systematic work investigating how individual differences impact upon the usability of virtual environment systems in terms of spatial task performances [16]. As Waller pointed out, this fact is regrettable because "individual differences probably account for more variance in computer task performance than do differences in either the design of computer system or in the procedure used to train people" [16]. The individual differences we focused on were gender and prior computer games experience.

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Gender is considered an independent variable with a clear impact upon spatial tasks, studies indicating that generally these differences favour men [9]. Later evidence has shown that the gender influence on spatial tasks can be heightened when they are performed in the context of VEs, as compared to those performed in the real world [16].

As Waller noticed, the level of prior experience in working with computers and feeling comfortable with them could have a great impact on computer task performances [16]. How this general computer experience could be transferred to tasks performed within virtual environments remains an unanswered question. However, it seems that prior experience could also be quite predictive within this context [17]. Since all our subjects had prior experience of working with computers, we took into account their computer games experience. The task characteristics enabled us to consider that this issue could influence the results, providing a deeper level of analysis.

Presence was defined as a psychological phenomenon, through which one's cognitive processes are oriented towards another world, either technologically-mediated or imaginary, to such an extent that he or she experiences mentally the state of being (there), similar to one in the physical reality [13]. As Slater argued, it is necessary to investigate under the circumstances under which presence "can be a benefit or a detriment to performance" [1]. To date few studies have focused on the question as to whether the sense of presence in VEs can be related to task performance [18].

Study Hypotheses

Our study design takes the shape of a quasi-experiment, by assigning as independent variables users' gender, their previous computer games experience and their level of sense of presence induced during interaction. By statistical manipulation we aim to investigate the effect of these variables upon system usability expressed in terms of task performances and level of satisfaction. We formulated

several working hypotheses: H1. Male group will achieve better task performances, than female group, H2. Male group will experience a higher level of satisfaction in rapport with system usability, H3. The greater users' computer games experience is the better are task performances, H4. The greater users' computer games experience is the more satisfied they are in rapport with system usability H5. The greater the sense of presence experienced, the better users performed, and finally H6. The greater the presence experienced, the more satisfied users are.

2. EXPERIMENTAL DESIGN

ECHOES System

This study utilises ECHOES [12], a VE developed for supporting technicians in the maintenance of engineering artefacts. The ECHOES training environment is comprised of a virtual multi-storey building, each one of the seven levels containing numerous rooms (e.g. lobby room, conference room, training room, library etc.). The rooms are furbished and associated with each room there is a cohesive set of functions provided for the user. Subjects can navigate from level to level via the use of a virtual lift.

Navigation

Within the virtual environment, the user set of actions is restricted, consisting mainly of navigation and locomotion, object selection, manipulation, modification and query [5]. As Sayers noticed, navigation has been found to be central to the usability of interfaces to virtual environments on desktop systems [14]. The experimental design comprised exploration and search tasks, both grounded on navigation.

In order to gain familiarity with the environment and learn movement control, the subjects were asked to look for a particular object within the virtual building for about 25 minutes. This particular exploratory task was preferred to that of free wandering through the virtual building, grounded on the assumption that it could lead to an increased level of motivation and activation of cognitive resources. Furthermore, subjects were asked to find a particular room in the virtual building, namely the library. The time needed to accomplish this task acted as an indicator of the level of spatial knowledge acquired within the VE. The *sample* consisted of 18 postgraduate students from the Computer Science Department, 11 males and 7 females, within the age range 25–38.

3. METHODOLOGY

There are two modalities of measuring usability, both of which are used in our study [11]. *Objective methods* consist of performance measurement, in terms of users' behaviour in accomplishing tasks, while *subjective methods* consist of users' attitude measurement, regarding their interaction with the system. In our study, objective measures consisted of time spent on searching tasks and number of collisions encountered during navigation. Considering the subjective measurement, there are several questionnaires already developed for assessing user's satisfaction [3]. However, none of them focus on measuring user's satisfaction in rapport with a virtual reality system. Thus, for the purpose of this research, we developed a questionnaire designed to measure this aspect. It contained initially 20 items measured with a 7-point Likert scale from 1-not at all satisfied, to 7-completely satisfied. Sense of presence was measured using a questionnaire devised by us, for which previous findings suggested that it leads to both reliable and valid measurements [13].

4. RESULTS AND DISCUSSIONS

The first objective targets the assessment of system usability in terms of induced level of satisfaction and task performances. We start by processing the results provided by the user satisfaction questionnaire. Using the criterion of 0.33 as the cut-off point [6], 8 items were deleted. The Cronbach's alpha coefficient, $\alpha = 0.79$ indicate that the questionnaire provides reliable measurements. The results structured according to the dimensions and variables developed for questionnaire construction are presented in Figure 1.

Dimensions	Variables	Med	Mean (SD)
1 Satisfaction	Frustration	2	2 (1.2)
2 Satisfaction	Rooms	3	3.3 (1.2)
regarding	Objects	3	3.2 (1.4)
space config	Depth	4	3.6 (1.5)
3. Satisfaction	Along X axis	3	2.8 (1.7)
regarding	Along Z axis	3	3.3 (1.2)
movement	Rotating	3	2.6 (1.3)

Figure 1. User satisfaction results

Users' overall satisfaction with the system is above average, since the level of frustration induced by the interaction proved to be very small. Satisfaction regarding space configuration and movement is average, with a peak on depth perception.

4.1. Users' individual differences

In order to test the impact of our independent variables upon system usability, we ran *t-tests*, comparing the performance achieved and the level of satisfaction experienced by groups of users, such as male and female along gender variable; novice and experts along computer games experience. We consider as experts individuals having more than one year experience of playing computer games.

Individual Differences		Usability: Performance: Time (sec.) Mean (SD)	Time (sec.) *t*-Test	Collision (no.) Mean (SD)	Collision (no.) *t*-Test	Satisfaction Mean (SD)	Satisfaction *t*-Test
Gender	Male (n = 11)	59.45 (33.37)	*t = 2.62* *p* < .05 *df* = 16	53.90 (35.48)	t = .081 *p* > .05 *df* = 16	41.50 (7.66)	*t = -2.73* *p* < .05 *df* = 16
	Female (n = 7)	133.00 (84.63)		55.50 (43.02)		31.00 (7.07)	
Game Exp.	Novice (n = 7)	141.57 (76.20)	*t = 3.44* *p* < .01 *df* = 16	66.83 (36.34)	t = 1.03 *p* > .05 *df* = 16	36.66 (7.39)	t = -.30 *p* > .05 *df* = 16
	Experts (n = 11)	54.00 (30.99)		47.10 (37.31)		38.10 (10.06)	

Figure 2. *t*-Tests presenting the impact of individual differences upon system usability

As shown in Figure 2 some differences were significant at the level .05. Findings suggest that the male group required a significantly shorter time for carrying out the searching task (H1), and accordingly experienced a significantly higher level of satisfaction in rapport with the system, than the female group (H2). However, the lower number of collisions encountered by male group did not indicate a significant difference comparative to the female one.

The role of prior computer games experience upon task performances was significant with respect to the time spent on the searching task (H3). The level of satisfaction experienced by the expert group is higher but not significantly to validate (H4). However, the number of collisions encountered by the group which was previously exposed to computer games was not significantly lower than that of its counterpart. Analysing the way in which these two groups of users perceive the system characteristics, we found another significant difference, related to system controllability (z = -2.1, p = .02). Thus, users previously exposed to computer games considered the system to offer too little control. These subjects did not find the task challenging and did not become motivated enough to perform with a high level of accuracy.

4.2. User's sense of presence

The second objective focuses on investigating the impact of sense of presence upon system usability. Thus we considered two independent groups, identified on the basis of their score for presence, with the cutt-off point to the 33th percentile.

As shown in Figure 3, two differences were significant at the level .05 and demonstrated that persons who experienced a greater level of presence (Group 1), performed the searching task in significantly less time (H5) and experienced also a greater level of satisfaction regarding system usage (H6). However, the same group performed less accurately. In fact we found a high positive correlation between presence and number of collisions (r = .54, p < .05).

Presence	Usability: Performance: Time (sec.) Mean (SD)	Time (sec.) *t*-Test	Collisions (no.) Mean (SD)	Collisions (no.) *t*-Test	Satisfaction Mean (SD)	Satisfaction *t*-Test
Group1 (n = 11)	61.8 (38.4)	*t = -2.1* *p* < .05 *df* = 16	61.2 (31.1)	t = .64 *p* > .05 *df* = 16	40.0 (8.6)	*t = 2.2* *p* < .05 *df* = 16
Group2 (n = 7)	127.7 (89.8)		47.5 (51.8)		30.2 (7.3)	

Figure 3. *t*-Tests presenting the impact of sense of presence upon system usability

In other words, the more the user acts within the environment in terms of moving, navigating, or even bumping into things, the more present he/she becomes.

5. CONCLUSIONS

We devised a questionnaire for evaluating user's satisfaction in interacting with a virtual reality system. There is a lack of tools developed for this kind of interface and their associated range of user tasks. The findings indicate that the questionnaire provides reliable measurements, while further work should be done to validate it.

With respect to gender differences, the female group accomplished the searching task in a significantly longer time and consequently experienced a reduced level of satisfaction in interacting with the system. These expected gender-related differences follow the line of findings in the area of spatial abilities that indicate better performances for males [7]. Another issue validating this idea is that the performances, which are not related with spatial abilities, such as the number of collisions during navigation, do not differ significantly between female and male groups.

With respect to the impact of computer games experience upon the task performances, we found that the results of the expert group differ significantly from those of the novices, in time for accomplishing task, but not in the number of collisions. In other words, the prior experience has an impact upon the efficiency but not the effectiveness of task performance. An explanation for this result resides in the fact that the previous exposure to computer games shaped users' expectations. They complain about lack of control because their set of actions is restricted to navigation. Since the tasks were not challenging enough to motivate an adequate level of cognitive loading, their performance lacks accuracy.

The relationship between presence and task performance proved again to be difficult to establish, suggesting that it should be considered in the broader context of task characteristics. Results indicate that sense of presence does support task performance, in terms of resources spent e.g. time.

However, within our testing experiment, the user's set of actions was limited to navigational tasks. Thus, the only way of increasing interaction with the system consisted in collisions occurring during navigation. This "added interaction" with the system leads to an increased sense of presence but it also leads to less accurate performances. What we can conclude is that if the system design targets user's immersion, then the whole set of interactions between the system and its users should be carefully conceived to avoid interference with task performances.

However, our results only suggest some trends, and they do not stand for causal relationships between investigated variables. Due to the task characteristic, e.g. navigation, it is more likely that an extraneous variable, such as spatial ability could be found responsible for the identified gender-based differences or maybe even for the impact of presence upon performances. Probably the more users' set of abilities match the task requirements, the easiness of performing brings enjoyment and eventually a higher level of presence.

6. REFERENCES

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