Impact of the physical field of view on the performance in a purchasing task in the VAP-S for patients with brain injury

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ABSTRACT

In VR-based cognitive rehabilitation, there is a particular interest in subject's performance in the virtual tasks in which the patients are engaged. This performance is function of many factors among which the characteristics of visual information delivered by the virtual system. This study was designed to examine the impact of the physical field of view (PFOV) on the performance in a virtual task in the Virtual Action Planning Supermarket (VAP-S) among patients with brain injury and control subjects. Results show that, for all the participants, there is no significant difference between the main VAP-S variables in two experimental configurations (large FOV and small FOV), except for the number of incorrect actions that increases in the small FOV situation. We conclude in suggesting some explanations about the impact of the PFOV on patient use of the visual VAP-S information.

1. INTRODUCTION

After stroke or traumatic brain injury, cognitive rehabilitation aims the recovery of autonomy thanks to training in Activities of Daily Living (ADL). Due to the frequent lack of efficient resources to deliver the necessary interventions for patients rehabilitation, therapists are interested in functional virtual environments (VE) (Rizzo et al, 2004) that afford the simulation of instrumental ADL, e.g. doing shopping in a virtual supermarket (Klinger et al, 2004). The information related to the task has to be delivered in an appropriate way by the virtual system in order to allow the patient to perceive it, to extract the best conclusions and thus to generate successful reactions. Given the necessary choice of an adequate device to display visual information, we are interested in the impact of the physical field of view (PFOV) on information perception and on the performance in the virtual task. PFOV refers to the observable space that is seen at any given moment by both eyes fixing right forward. Its range is about 120 degrees, surrounded on both sides by a 30 degrees crescent of monocular vision (Zanglonghi et al, 2000). It can be modified by varying the screen size. The use of the large screen is often accompanied with the intuition that such display affords a better presentation of the information and a stronger feeling of immersion. However there is a lack of research that demonstrates empirically how users benefit from the increased size of the screen (Ni et al, 2006a).

Miscellaneous works studied this question with healthy people, mainly in spatial memory tasks, adopting two approaches in the choice of the PFOV: the first one keeping a constant PFOV and the second one making vary the PFOV.

The first approach consists in maintaining a constant PFOV by adjusting the viewing distance to screens with different sizes (Figure 1). This configuration inducing the same FOV whatever is the size of the screens, the result is that objects seen under the same visual angle have exactly the same size on the retina whatever is their real size on the screen (Rodieck, 2003). So in this approach, the size of the information that the user perceives is the same in the various types of display.

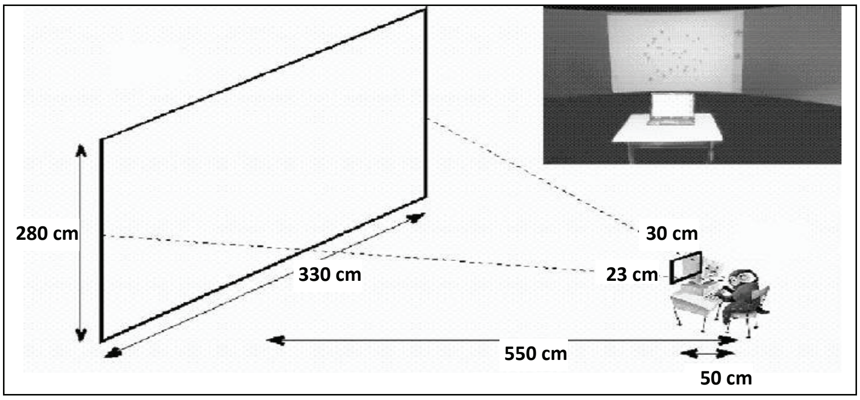

Figure 1. *Two screen sizes for a constant PFOV (variable distance).*

In their study, Patrick et al. involved 48 participants in a spatial recognition task in a VE for which they had to reproduce the cognitive card (Patrick et al, 2000). In this work, two configurations were implemented, leading to a PFOV of 42°. In the first one, users were placed at a distance of 0.69 m from a screen of 0.53 m width. In the second configuration, users were placed at a distance of 2.66 m from a projection screen of 3.35 m width. Their results showed that participants have a bad appreciation of distances in the small screen situation which may be due to the big variation of the PFOV because of user's head movements during the experimentation. In their works, Tan et al. designed two experimental conditions in which users were placed in front of screens of 0.36 and 1.93 widths at a distance of 0.64 m from the small screen and 3.45 m from the large screen, leading to a FOV of 52° (Tan et al, 2006). Participants were involved in two different tasks: a spatial orientation task in a 3D complex VE and a reading comprehension task. Results showed that in case of egocentric strategies (i.e. the user considers his point of view as if he is in the environment), the big screen allows the amelioration of user's performance in spatial orientation tasks. But no difference was found between the two configurations in the reading comprehension task.

The second approach consists in keeping the same viewing distance to two screens with different sizes in order to increase the PFOV and so the size of the objects on the retina (Figure 2). In their study, Ni et al. placed the user at about 0.61 m from two screens of 0.50 m and 1.20 m widths, inducing a FOV of 48° with the small screen and 90° with the large screen. Results showed that increasing the screen size, and thus the PFOV, improves the efficiency in spatial navigation tasks (Ni et al, 2006a).

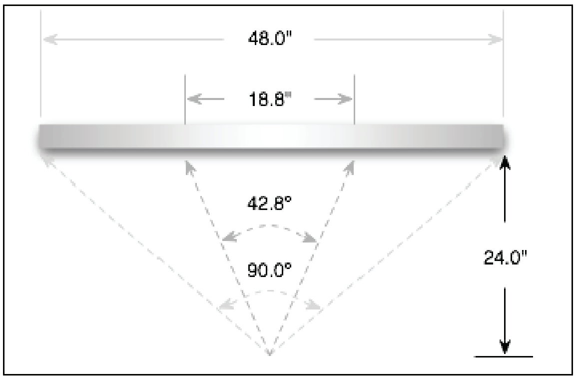

Figure 2. *Two sizes of screens for two PFOVs (constant distance).*

Through related works, we observed the important role attributed to the PFOV on tasks performance in VE. In order to design adapted VR-based training conditions for cognitive rehabilitation, we wish to study this question in the context of patients with brain injury. The main objective of this work is to study the impact of the PFOV on the performance in a shopping task in the VAP-S (Virtual Action Planning Supermarket) among control subjects and patients with brain injury.

2. METHOD

2.1 Participants

Nine patients after stroke, hemiplegics at chronic phase, (1 M and 8 F, mean age= 54.3 ± 13.9) and twenty-two control subjects (12 M and 10 F, mean age= 29 ± 10.2) were included in our study.

Figure 3. *The Virtual Action Planning Supermarket.*

2.2 Instrumentation

The VAP-S (Klinger et al, 2004; Klinger, 2006) was designed to assess and train the ability to plan and execute the task of purchasing items on a shopping list. Operating the VAP-S includes a series of actions, described as a task, and allows an analysis of the strategic choices made by clients and thus their capacity to plan, such as the "test of shopping list" (Martin, 1972). The VAP-S simulates a fully textured medium size supermarket with multiple aisles displaying most of the items that can be found in a real supermarket. There are also four cashier check-out counters; a reception point and a shopping cart. Some obstacles, like packs of bottles or cartons may hinder the advance of the shopper along the aisles. In addition, virtual humans are included in the supermarket such as a fishmonger, a butcher, check-out cashier and some costumers. While sitting in front of PC screen monitor, the participant enters the supermarket behind the cart as if he is pushing it, and moves around freely pressing the keyboard arrows. He is able to select items by pressing left mouse button. The test task is to purchase seven items from a clearly defined list of products, to then process to the casher's desk and to pay for them. Twelve correct actions (e.g, selecting the correct product) are required to completely succeed the task. Many variables can be calculated from the recorded data such as the total distance traversed by the patient, the total task time, the number of correct actions and the number of incorrect actions.

Many studies showed the efficiency of the VAP-S as a tool for cognitive assessment among various populations such as Parkinson disease (Klinger et al, 2006), Mild Cognitive Impairment (Werner et al, 2009), and Schizophrenia (Josman et al, 2009).

2.3 Experimental conditions

Our objective was to design two experimental conditions, one with a large screen (Config L) and the other with a small screen (Config S). In order to define the two configurations, we referred to the knowledge on human FOV (Zanglonghi et al, 2000) as well as on the VR-based studies that explored the relation between size of screen and the performance in VEs (Patrick et al, 2000; Tyndiuk et al, 2005; Ni et al, 2006a; Ni et al,

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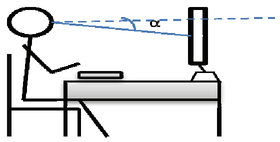
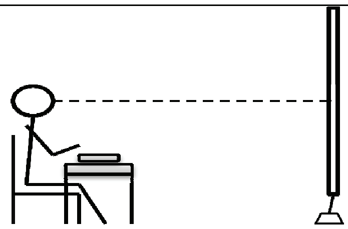
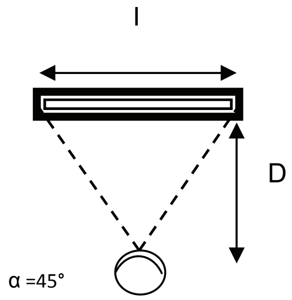
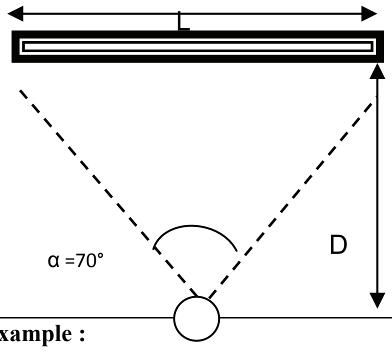
2006b; Tan et al, 2006). We chose a pragmatic approach considering the means used in the university hospital of Bordeaux, so we used a video-projection on a classic wall screen. The PFOV was modified by adjusting two parameters: the size of the screen and the distance between the users and the screen. We found a limitation in increasing the PFOV: the distance between the patient and the screen had to stay long enough to not induce troubles with space exploration and head movements. For patients comfort we chose a PFOV of 70° for the large screen and 45° for the small screen (Table 1).

Table 1. *Experimental conditions: Config S (small screen, PFOV= 45°) and Config L (large screen, PFOV= 70°).*

	Config S	Config L
Position of the user in front of the screen	 The center of the screen is under the horizontal line containing the user eyes.	 The center of the screen belongs to the horizontal line containing the user eyes.
PFOV		
Distance from the screen **D = (L/2)/tg (α/2)**	**Example :** **If** L = 0.4m **then** : D= 0.48 m *(tg(22.5) = 0.414)*	**Example :** **If** L= 2 m **then** : D=1.43 m (tg(35)=0,7)

2.4 Procedure

All subjects carried out a familiarization session in which they had to buy 3 items geographically well distributed in the VAP-S. Then they were engaged in an assessment session: they had to purchase seven items from a clearly defined list of products without any time constraint. Each subject carried out twice the assessment session within a one week period: once in "config S" and once in "config L" ("S then L" or "L then S"). The comparison variables are the total distance traversed by the patient (DP), the total task time (T), the number of purchased items (NbA), the number of correct actions (BA), the number of incorrect actions (MA), the number of pauses (NbP), the duration of pauses (TP) and the time to pay (Tp).

2.5 Statistics

Descriptive data analysis (means, standard deviations, ranges) were used to describe the population and the main variables. Each subject being tested in two configurations, it is then an intra-subjects experiment (Kinnear and Gray, 2005). According to the type of the sample, we chose the t test to analyze the significance of the differences.

3. RESULTS

Participants' data in their performance in the VAP-S are presented in Table 2 for the patients and in Table 3 for the control group. According to the results, it seems that the performance of the patients was better in Config L than in Config S. For example, the number of incorrect actions in Config S (33) is almost the double of the number of incorrect actions in Config S (18). The mean distance crossed in the task is also smaller in Config L (311 m) than in Config S (350 m). On the other hand, control group results were almost equivalent in both configurations except the number of incorrect actions which was significantly higher in Config S than in Config L.

Table 2. *Performance comparison between Config S and Config L in patients group*

Patients	Config S		Config L		P*
	Patients (1 M and 8 F)	Patients [range]	Patients (1 M and 8 F)	Patients [range]	
Age	54.3±13.9	[23 ; 67]	54.3±13.9	[23 ; 67]	-
NbA	7	[7 ; 7]	7	[7 ; 7]	-
BA	11±1.8	[7 ; 12]	11.5±1	[9 ; 12]	0.5
MA	33±30	[3 ; 111]	18±15	[3 ; 59]	0.1
Tp (sec)	4±2.9	[1.4 ; 11]	5.4±4.7	[1.6 ; 14.6]	0.3
DP (m)	350,5±137.1	[210 ; 578.4]	311,9±146.8	[147.5 ; 573.2]	0.4
T (min)	23.6±14	[7.5 ; 51.2]	22.8±14.5	[9 ; 55.9]	0.7
NbP	57±35	[17 ; 125]	50±30	[19 ; 114]	0.5
TP (min)	14.4±11.7	[3 ; 38.5]	14.3±13.1	[3.7 ; 45.3]	0.9

Bilateral signification : p<0.05 ➔ significant result

Table 3. *Performance comparison between Config S and Config L in control group*

Contrôles	Config S		Config L		P
	Controls N= 22 (10 F, 12 H)	Controls Extended value	Controls N= 22 (10 F, 12 H)	Controls Extended value	
Age	29±10.2	[22 ; 59]	29±10.2	[22 ; 59]	-
NbA	7	[7 ; 7]	7	[7 ; 7]	-
BA	12	[12 ; 12]	12	[12 ; 12]	-
MA	8±5.4	[3 ; 24]	3.65±3	[0 ; 17]	0.0
Tp (sec)	2.2±1.5	[0.3 ; 5.6]	2.1±1.4	[0.3 ; 5.6]	0.6
DP (m)	175,8±38.1	[135.2 ; 251]	171,7±29.3	[128 ; 261.7]	0.7
T (min)	5.7±1.5	[3.8 ; 10.3]	5.8±2.1	[4 ; 11.1]	0.1
NbP	13±5	[5 ; 22]	13±6	[4 ; 30]	0.3
TP (min)	2.09±2.73	[0.9 ; 3.56]	2.27±1.18	[0.75 ; 5.75]	0.3

Bilateral signification : p<0.05 ➔ significant result

4. DISCUSSION

Results of our experiments show that, for all the participants, there is no significant difference between the main VAP-S variables in both configurations (Config S and Config L), except for the number of incorrect actions which doubles significantly from Config L to Config S. This increase can be explained by the fact that virtual objects are more visible when they are presented in the large screen in Config L. The participants use in a better way the visual VAP-S information displayed on a large screen. Besides, the stimuli which are source of information can also be source of confusion and slowing down if they are too numerous. Another explanation can be suggested: fewer errors occur in Config L because fewer stimuli are seen simultaneously. Moreover we may have expected that the number of stops (NbP) during the task will be higher in Config L, because subjects will stop more frequently in Config L to move their heads to explore the totality of the visual space in front of the large screen. Our results do not validate this expectation. We think that with a better perception of the information in Config L participants do not need to stop frequently to identify the virtual space and objects. We also compared our two groups of participants, and significant performance differences appear between the control group and the patient group. But these results are not evoked in this paper because the two groups are not matched in age.

5. CONCLUSION

This exploratory study is a first step of our research work that aims to identify the best visual interfaces for patients with brain injury. It allowed us to identify the impact of the PFOV on one of the principal variables in the VAP-S. Data collection is going on in order to increase the size of our samples and to get samples more homogeneous in age. Current and further results will be analyzed in order to list recommendations for the choice of display characteristics for experiments among patients with brain injury. This will allow us to find optimal presentations of virtual assessment tasks as well as rehabilitation tasks which avoid spending significant resources in non appropriated systems.

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