

Performance analysis of adults with Acquired Brain Injury making errands in a virtual supermarket

E Sorita^{1,3}, P A Joseph^{1,2}, B N'Kaoua¹, J Ruiz^{2,3}, A Simion², J M Mazaux^{1,2}, E Klinger⁴

¹EA 4136 Handicap et Système Nerveux, Université de Bordeaux,
Rue Léo Saignat, Bordeaux, FRANCE

²SMPR Tastet Girard, CHU Bordeaux,
Place Amélie Raba-Léon, Bordeaux, FRANCE

³Institut de Formation en Ergothérapie, CHU Bordeaux
Rue Francisco Ferrer, Bordeaux, FRANCE

⁴Interaction Numériques Santé Handicap, ESIEA
Rue des Docteurs Calmette & Guérin Laval, FRANCE

¹*eric.sorita@chu-bordeaux.fr*

ABSTRACT

Virtual Environments (VE) offer the opportunity to analyze the performance of people with Acquired Brain Injury (ABI) in Instrumental Activities of Daily Living (IADL). A number of studies have been carried out with the Virtual Action Planning Supermarket (VAP-S) among adult populations with cognitive disorders. Dysexecutive components such as planning have been identified from VAP-S outcome measures. The aim of this study is to explore the links between patients' performance, daily life integration and data from neuropsychological tests. 50 adults with ABI in chronic stage (mean delay post onset = 54 ± 53 months) were recruited from a social and work integration program. A Principal Component Analysis (PCA) including a neuropsychological battery, the community integration questionnaire (CIQ) and performance in the VAP-S. The PCA raises four factors that explain 70% of the total variance. These factors show that the performance in the VAP-S cannot be only explained by executive functioning but dynamically mix high and low cognitive processes. Interesting questions also raise to know if performance in the VAP-S would only reflect cognitive disorders or conversely an adaptation level from preserved capacities. Functional performance in VAP-S virtual environment offers promising information on the impact of neuropsychological diseases in daily life. Executive functions impairment is showed. However other cognitive components are involved in VAP-S performance.

1. INTRODUCTION

Cognitive disorders have devastating consequences on functioning in daily living. According studies, they affect from 40 to 70% of the people with stroke (Godefroy et al, 2011) and causes long term integration problems for people with Traumatic Brain Injury (Le Gall et al, 2007)

In order to assess the impact of cognitive impairments in daily life functioning, virtual reality settings appear to be close to ecological assessments made in real life settings (Rizzo et al, 2004; Morganti et al, 2004). Environmental conditions can be better controlled and standardized while reliable indicators of behaviour can be recorded. So in using virtual environment settings two main concerns are raised: 1) What are the links between real and virtual performance for people with ABI? 2) What are the relationships between virtual functional performance and cognitive functioning?

The Virtual Action Planning Supermarket (VAP-S) simulates a medium sized supermarket which was designed for assessing and training individuals to plan and perform a shopping task (Marié et al, 2003; Klinger et al, 2004). It was used in several studies, by several teams, and for various populations. Moderate to high correlations were shown with subtests of executive functioning, notably planning, among various population with CVA, schizophrenia, MCI, Parkinson Disease (Klinger et al, 2006a; Josman et al, 2006, 2009, Werner et al, 2009). Klinger also showed that assessment with VAP-S was more sensitive in detecting cognitive impairment than the traditional neuropsychological tests (Klinger et al, 2006b). However the relationships between a

comprehensive neuropsychological battery, functional performance in the task, and functioning in daily life have to be further explored.

2. METHOD

A retrospective study was conducted from data of patients with ABI, who attended a psycho-social program aiming to improve social and professional integration. For inclusion we only selected the records where all the data of the selected tests were recorded. Patients who had brain injury before the age of 16 years old were excluded. One record was also excluded because the patient presented visual impairment. Thus 50 patients were included in this study from the psycho-social program from 2009 to 2012. On the one hand we collected data from the neuropsychological evaluation (episodic memory, prospective memory, working memory index, perceptual organization index, processing speed, gonogo errors, divided attention omissions, visual scanning omissions) and global scores in the CIQ (Willer et al, 1993), a questionnaire that measures the level of independence in daily life. On the other hand we collected data from the VAP-S. Current clinical practice with the VAP-S follows a procedure that includes a time for familiarization. During this time that lasts less than 15 minutes, patients are trained to correctly perform the interactions within the virtual supermarket using the direction pad to move in the supermarket and the mouse to select items. This time is followed by the evaluation where the subjects have to purchase 7 items according to a shopping list. The virtual environment was projected onto a wall screen in a darkened room. The subjects were seated in front of a table on which were the keyboard and the mouse. To describe the performance of the patients in the virtual supermarket, four outcome measures from the VAP-S were selected for this study: number and duration of pauses, duration of move (which is the time subject moves to seek items) and the number of errors in selecting the shopping list items. An error is considered each time the subject selects an item that is different from the list or tries to select an item more than once. There was no time pressure for purchasing the items. If patients do not find the seven items, they can leave the supermarket after having paid or not the selected items. From the data described above, a Principal Component Analysis (PCA) was done.

3. RESULTS

Patients were relatively young (mean age: 34.96 ± 10.84), predominantly males (75%), and generally low-educated (mean level of education: 10.70 ± 2.18). The sample was mostly composed of people with Traumatic Brain Injury (TBI: 66% of the sample) and people with stroke (24% of the sample). Among the 50 patients, only two did not find the 7 items. One patient found 6/7 items and the second patients found 5/7 items before leaving the supermarket. The preliminary analysis showed that data were appropriate for PCA (Kaiser-Meyer-Olkin measure of sampling adequacy = 0.685; Bartlett's test of Sphericity, $\chi^2 = 491.471$; $p = .000$). The PCA raised a four factors model that accounted for 70 % of the total variance (table 1). Factor 1 links prospective memory, episodic memory, processing speed and perceptual organization to all the outcomes measures of performance in the VAP-S. This factor looks like an efficiency factor: the better cognitive efficiency was in these processes and the more efficient the performance was into the VAP-S. Factor 2 combines a level of efficiency in episodic memory with inhibition errors, and the total time of move and stops. Factor 3 combines the community integration, the global cognitive functioning, the divided attention and the visual scanning with the stops during functional performance in VAP-S. This factor appears to be related to a level of cognitive efficiency associated with a better level of integration in the community. Surprisingly an increase in the number and duration of stops in the performance is also observed in this factor related to this level of cognitive efficiency and community integration. Factor 4 combined inhibition errors, omissions in visual scanning and number of errors to select items. But in this factor the association of errors or omissions with a level of efficiency with working memory is difficult to interpret.

4. DISCUSSION

The primary aim of this study was to explore relationships that combine neuropsychological processes, a virtual daily task and level of community integration. The VAP-S confirms its sensitivity to cognitive impairment and to a lesser extent to community integration. It seems interesting to explore more deeply what kind of predictive relationships could be done between a virtual environment like the VAP-S and level of dependence in daily life. The PCA raises factors that combine low and high level of cognitive processes. These kind of combination could better reflect or be close to daily life functioning. But some combinations are difficult to interpret. For instance, factors 1 and 2 appear to show a significant role of episodic and prospective memory in order to do a shopping task using a shopping list. This links are highlighted in studies (Okahashi et al, 2013; Knight et al, 2006). In these studies memory impairment was clearly related to the number of time the subjects had to look at the

shopping list. In these studies however subjects have to actively open the shopping list whereas in the VAP-S the shopping list is always displayed. Factor 2 is somewhat difficult to interpret. It combines a certain memory efficiency with impairment in inhibition and increase in duration of moving. Could it be a dysexecutive factor? Factor 3 shows an increase in the number and duration of stops. But this increase is rather associated with some levels of efficiency (in community integration, in a global cognitive efficiency, with less omissions in divided attention and visual scanning). Maybe, we can assume that the number and duration of stops may both reflect cognitive impairment but also conversely for some patients a better efficiency (or strategy) in searching for items? Factor 4 could also relate to an executive (behavioral) sub-factor? For instance Giovanetti et al. (2008) showed in using a naturalistic Test that commissions of errors were related to a specific impairment in executive functioning.

Table 1: Component matrix.

	Factor 1	Factor2	Factor3	Factor4
Community Integration Questionnaire (CIQ)	.200	.271	.536	-.193
CAMPROMPT	.609	.215	-4.5E-02	6.45E-02
WAIS-III, Perceptual Organization Index	.450	-.274	.484	.195
WAIS-III, Processing Speed	.513	-.175	.490	.252
WAIS-III, Working Memory Index	.354	-8.3E-02	.588	.491
Grober Buschke, third immediate free recall	.669	.524	-.176	-6.8E-02
Grober Buschke, third immediate cued recall	.713	.536	-8.9E-02	-1.2E-02
Grober Buschke, delayed free recall	.727	.479	-2.8E-02	-.102
Grober Buschke, delayed cued recall	.718	.584	-.120	-2.7E-02
Test of Attentional Performance Gonogo, errors	-.289	.559	-5.9E-02	.566
Test of Attentional Performance Divided attention, omissions	-2.0E-02	.249	-.586	-.253
Test of Attentional Performance Visual scanning, omissions	-.304	.323	-.426	.546
Number of pauses	-.594	.559	.477	-.193
Total duration of pauses (second)	-.632	.568	.404	-.194
Total duration of move (second)	-.469	.694	.335	-.171
Total number of errors of selection of items	-.450	.359	-.141	.529

Note : **Boldface indicates values >.400**

5. CONCLUSION

The use of virtual daily living tasks in a rehabilitation setting opens several perspective. VAP-S for instance could be used as a screening tool when there is a suspicion of cognitive impairments that could impact activities of daily living. Another asset that brings virtual reality in cognitive rehabilitation strategy is the ability to train the brain according to a global approach that is daily-life-oriented and not only discreet processes-centred.

6. REFERENCES

- Giovanetti, T, Bettcher, BM, Brennan, L, Libron, DJ, Kessler, RK, and Duey, K, (2008), Coffee with jelly or unbuttered toast: Commissions and omissions are dissociable aspects of everyday action impairment in Alzheimer's disease, *Neuropsychology*, **22**, 2, pp. 235-245.
- Godefroy, O, Fickl, A, Roussel, M, Auribault, C, Bugnicourt, JM, Lamy, C, et al, (2011), Is the Montreal Cognitive Assessment Superior to the Mini-Mental State Examination to Detect Poststroke Cognitive Impairment? A Study with Neuropsychological Evaluation, *Stroke*, **42**, pp.1712-1716.

- Josman, N, Hof, E, Klinger, E, Marié, RM, Goldenberg, K, Weiss, PL, and Kizony, R, (2006), Performance within a virtual supermarket and its relationship to executive functions in post-stroke patients, *Virtual Rehabilitation, 2006 International Workshop on*, pp. 106-109.
- Josman, N, Schenirderman, AE, Klinger, Shevil, E, (2009), Using virtual reality to evaluate executive functioning among persons with schizophrenia: A validity study, *Schizophrenia Research*, **115**, 2-3, pp. 270–277.
- Klinger, E, Chemin, I, Hubner, G, and Marié, RM, (2004), A virtual supermarket to assess cognitive planning, *Cyberpsychology & Behavior*, **7**, 3, pp. 292-293.
- Klinger, E, Chemin, I, Lebreton, S, and Marié, RM, (2006a), Virtual Action Planning in Parkinson's disease: A Control Study, *Cyberpsychology & Behavior*, **9**, 3, pp. 342-347.
- Klinger, E ,(2006b), Apports de la réalité virtuelle à la prise en charge de troubles cognitifs et comportementaux, *PhD Thesis in Informatique Thesis in ENST*, Paris, 228 pages.
- Knight, RG, Titov, N, and Crawford, M, (2006), The effects of distraction on prospective remembering following traumatic brain injury assessed in a simulated naturalistic environment, *Journal of the International Neuropsychological Society*, **12**, 1, pp. 8-16.
- Le Gall, C, Lamothe, G, Mazaux, JM, Muller, F, Debelleix, X, Richer, E, and Barat, M, (2007), Programme d'aide à la réinsertion sociale et professionnelle de jeunes adultes cérébrolésés: résultats à cinq ans du réseau UEROS-Aquitaine, *Annales de réadaptation et de médecine physique*, **50**, 1, pp. 5-13.
- Marié, RM, Klinger, E, Chemin, I, and Josset, M, (2003), Cognitive planning assessed by virtual reality, *VRIC 2003, Laval Virtual Conference*, pp. 119-125.
- Morganti, F, (2004), Virtual interaction in cognitive neuropsychology, In *Cybertherapy, Internet and Virtual Reality as Assessment and Rehabilitation Tools for Clinical Psychology and Neuroscience* (G Riva, C Botella, P, Légeron, & G, Optale, Eds),. Amsterdam, IOS Press, © 2004, 2005, 2006.
- Okahashi, S, Seki, K, Nagano, A, Luo, Z, Kojima, M, and Futaki, T, (2013), A virtual shopping test for realistic assessment of cognitive function, *Journal of neuroengineering and rehabilitation*, **10**, 1, pp. 59.
- Rizzo, AA, Schultheis, M, Kerns, KA, and Mateer, C, (2004), Analysis of assets for virtual reality applications in neuropsychology, *Neuropsychological Rehabilitation*, **14**, 1-2, pp. 207-239.
- Werner, P, Rabinowitz, S, Klinger, E, Korczyn, AD, and Josman, N, (2009), Use of the Virtual Action Planning Supermarket for the Diagnosis of Mild Cognitive Impairment, *Dementia and Geriatric Cognitive Disorders*, **27**, 4, pp. 301-309.
- Willer, B, Rosenthal, M, Kreutzer, JS, Gordon, W, and Rempel, R, (1993), Assessment of community integration following rehabilitation for traumatic brain injury, *The Journal of head trauma rehabilitation*, **8**, 2, pp. 75-87.