An Immersive VR Platform for Assessing Spatial Navigation Memory in pre-dementia Screening: A Study of Feasibility and Usability

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Introduction

Traditional methods for assessing memory are expensive and have high administrative costs [1]. Memory assessment is important for establishing cognitive impairment in cases such as detecting dementia in older adults.

VR systems have been used as assessment tools [2,3] for physical activity [4], cognitive assessment [5], and balance assessment [6]. Studies on non-immersive virtual environments found those effective for assessments [7] due to being accessible and feasible while providing controlled settings for conducting cognitive sessions. A VR platform can equip clinical neuropsychologists with a feasible assessment technology on which the setting (and therefore the assessment outcome) is generalized to real-life settings [8].

This paper contributes the design and evaluation of VR-CogAssess, a new VR platform using photorealistic imagery to assess topological cognitive impairment, i.e. spatial navigation memory, as a tool for pre-dementia diagnosis. The system builds on the VR-Rides platform designed to create exergames integrating panorama images, and maps from Google Maps [9]. We test VR-CogAsses with older adults to explore three goals. First, we investigate the compatibility of VR-CogAssess compared to a Standard PC (SPC) setup in an experiment. Second, we explore the scope of usability considerations needed for VR memory assessment platforms for older adults in order to support their interaction. Finally, we study the feasibility of using a VR platform as a memory assessment tool for spatial navigation for older adults.

Methods

VR-CogAssess (see Figure 1), is a platform integrating an Oculus Rift Head Mounted Display (HMD) and immersive photo-realistic imagery. In a pilot study with healthy older adults (N = 42, age M(SD) = 73.22(9.26)) a landmark recall test was conducted and assessment on the VR-CogAssess was compared against a Standard PC (SPC) setup.

Figure 1:VR-CogAssess Platform

Results

The two conditions were compared in order to establish the extent to which navigation performance, assessment scores, usability, feasibility and perceived competence of setups are comparable in the two conditions.While participants in both conditions had similar

cognitive status (did not declare any cognitive impairment prior to the test), participants in VR were more engaged ($p = .003$), achieved higher landmarks recall scores ($p = .004$), made less navigational mistakes ($p = .042$) and reported a higher level of presence ($p = .002$). Notably, participants in both conditions reported mild aggregated ratings of stress (mean < 2.80).

Conclusions

Dementia is a complicated disease that can be detected using novel assessment tools and technologies developed through multidisciplinary efforts of HCI researchers and clinical neuropsychologists. These findings are promising, showing the feasibility of our immersive VR platform as a potential tool for cognitive assessment based on spatial navigation memory. This study focused on the design and evaluation of VR-CogAssess, proposing a set of five design propositions for maintaining a reasonable level of usability for older adults compared to standard computer setups. These propositions encourage VR systems' design that consider ageing population needs and contribute to their wellbeing.

References

1. Gazova, I. et al. 2012. Spatial navigation-A unique window into physiological and pathological aging. Frontiers in Aging Neuroscience. 4, JUN (2012), 1–6.
2. Chen, S.E. 1995. QuickTime ® VR – An Image-Based Approach to Virtual Environment Navigation. Proceedings of the 22nd annual conference on Computer graphics and interactive techniques. 29, Annual Conference Series (1995), 29–38.
3. Loomis, J.M. et al. 1999. Immersive virtual environment technology as a basic research tool in psychology. Behav. Res. Methods Instr. Comput. 31, 4 (1999), 557–564.
4. Ijaz, K. et al. 2016. Competitive vs Affiliative Design of Immersive VR Exergames. Serious Games: Second Joint International Conference, JCSG 2016, Brisbane, Australia, September 26-27, 2016, pp. 140–150.
5. Davison, S.M.C. et al. 2017. A comparison of immersive virtual reality with traditional neuropsychological measures in the assessment of executive functions. Acta Neuropsychiatrica. (2017), 1–11.
6. Saldana, S.J. et al. 2017. Assessing balance through the use of a low-cost head-mounted display in older adults: A pilot study. Clinical Interventions in Aging. 12, (2017), 1363–1370.
7. Moffat, S. 2001. Age differences in spatial memory in a virtual environment navigation task. Neurobiology of Aging. 22, 5 (2001), 787–796.
8. Spooner, D.M. and Pachana, N.A. 2006. Ecological validity in neuropsychological assessment: A case for greater consideration in research with neurologically intact populations. Archives of Clinical Neuropsychology. 21, 4 (2006), 327–337.
9. Wang, Yifan, Kiran Ijaz, and Rafael A. Calvo. "A software application framework for developing immersive virtual reality experiences in health domain." In *2017 IEEE Life Sciences Conference (LSC)*, pp. 37-30. IEEE, 2017.