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INVESTIGATING THE RELATIONSHIP BETWEEN ATTENTIONAL FILTERING AND MEMORY PERFORMANCE IN VIRTUAL REALITY ENVIRONMENT

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Abstract

Experimental research on cognition needs more realistic paradigms to achieve ecological validity as well as to transfer and eventually generalize the results to clinical practice. Selective attention was found to be highly related to memory and training of attentional filtering enhanced memory performance. Moreover, a real memory room might provide a more interesting environment for cognitive training, even though it is very demanding for the examiner to arrange the set-up. Therefore, we developed a change detection task using a virtual reality (VR) environment and compared it with one in a real environment (RE) room. Data of healthy younger and older adults were analyzed regarding their memory and distractor inhibition performance. The results indicate that both test set-ups reveal age effects but only RE in younger adults produces a distractor effect. For younger adults, VR was found to be more challenging as compared to the real room whereas OA performed similar in VR and RE. Technical development like VR becomes more and more attractive to create interesting experimental test settings but their additional value needs to be further investigated.

Keywords: *Distractor inhibition, memory, virtual reality, aging, selective attention.*

1. Introduction

Neuropsychological and experimental assessments make use of conventional methods (e.g. paper-pencil or computerized tasks) in order to measure psychological constructs, such as attention and memory. As these tests lack generalization to everyday performance, realistic test settings are discussed to measure cognitive performance in a more ecologically valid way. However, realistic testing, in which the examiner has a highly interactive role, is difficult to control, and conducting experiments objectively as well as standardized is thus challenging. A promising tool to combine ecological validity of realistic testing and high standardization of test procedures seems to be virtual reality. Some studies using virtual reality already replicated clinical test results with good construct validity (Corriveau Lecavalier et al., 2020; Diaz-Orueta et al., 2012; Parsons et al., 2017; Parsons & Barnett, 2018) but further implications for cognitive research such as age-related effects of technical assessment or motivation of subjects doing the task is insufficient, especially for functions of memory and attention.

Memory performance, selective attention and their interactions are well-investigated (Schmicker et al., 2016, 2017, 2021; Vogel et al., 2005). Subjects, who can ignore irrelevant distractors while encoding relevant items more effectively also have a higher memory capacity compared to subjects with a lower memory capacity, who seemingly store irrelevant information unnecessarily (Vogel et al., 2005). However, the respective research is mainly based on computerized tasks and is thus hardly suitable for generalization to everyday performance or for use in applied cognitive trainings. Hence, more realistic test settings have to become focus of respective research. Considering ecological validity, a previous study used a real environment assessing age differences in memory performance and distractor inhibition in a change-detection paradigm (Rumpf et al., 2019). Based on this paradigm, we adapted a virtual reality paradigm and compared the results of younger and older adults to those of the realistic environment by Rumpf et al. (2019).

2. Objectives

This study investigated whether a virtual reality (VR) change-detection test can replicate the findings of a realistic environment (RE). Performance of younger and older adults was compared concerning memory and distractor inhibition effects. We expected to see age-differences in total memory performance and lower performance in conditions containing distractors compared to those without distractors, independent from age.

3. Methods

Memory performance of younger (YA, 19-33 years old) and older adults (OA, 60-77 years old) in a VR paradigm (n_{YA}= 33, n_{OA} = 12) was compared to the results of a previous study that used a similar memory room in a real environment (n_{YA}=28, n_{OA}=22). The VR change-detection paradigm was based on the method created by Rumpf et al. (2019). Participants entered a room in which they had 15s time to memorize the orientation and position of color-marked targets. The experiment encompassed a condition without distractors (6 target objects) and a distractor condition (6 target object and 6 distractor objects). Objects were 12 items that can normally be found in an ordinary office (folder, calculator, scissors, pencil holder, stapler, calendar, notebook, pen, watering can, alarm clock, lunch box, mug). Before each trial, participants were told the crucial target color. In case of the distractor condition, they were instructed to only memorize the red or green marked objects, while distractors of the other color were present. In the no-distractor condition they had to memorize all objects, which were marked with the same color, namely either red or green. After a retention interval of 1 min, participants entered the room again and put the changed objects back to their former positions. Objects could change their position in the room as well as their rotation. Performance was measured as the correctly recognized changes (hits) and correct rejections, independent from dimensions, i.e. position or rotation (max. 6 hits/CR, i.e. 100% accuracy). Data were analyzed using R version 4.1.2 (2021-11-01). Two-way ANOVAs for the factors group (YA, OA) and condition (RE, VR) and repeated-measures ANOVAs for DIS (ND, D) separately for both conditions as well as the post-hoc tests were calculated.

4. Results

Data analysis revealed that both RE and VR reflect age-related differences in memory performance ($F(1,91) = 63.10$, $p < .001$, $\eta^2=0.41$), although performance in VR was generally lower than in RE (total memory performance: $F(1,91) = 7.95$,$p < .01$, $\eta^2=0.08$; figure 1). Whereas performance of OA did not differ significantly between RE and VR ($p = .85$), younger participants performed significantly worse in VR ($p<.001$).

Trials containing distractors descriptively worsened the performance of all participants independent from age (figure 2). While VR measures produced smaller distractor effects (difference between no distractor and distractor condition) than RE ($F_{VR}(1,43)=2.71$, $p = .107$, $\eta^2= 0.15$; $F_{RE}(1,48)=5.89$, $p < .05$, $\eta^2=0.053$). Only YA showed a post hoc significant distractor effect in RE ($p < .05$).

Figure 1. Memory performance (total in %correct answers) measured in the real environment (RE) and in the virtual reality (VR) in younger adults (YA) and older adults (OA).

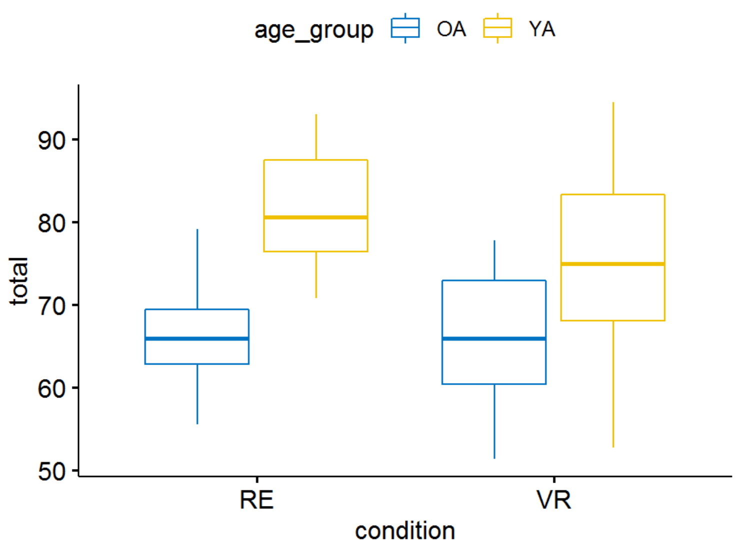
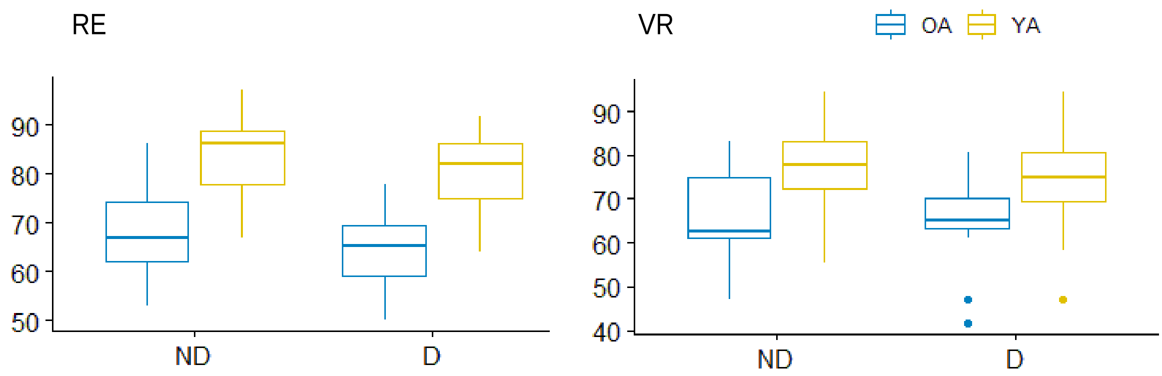


Figure 2. Memory performance in no distractor (ND) and distractor (D) condition measured in the real environment (RE) and in the virtual reality (VR) in younger adults (YA) and older adults (OA).



5. Discussion

The VR change detection paradigm was able to replicate age effects of total memory performance as younger adults outperformed older participants in RE as well as VR setting. Yet, VR might be generally more challenging compared to the real room. There is additional demand due to orienting with the VR, handling technical hardware, e.g. using the head-mounted display, and getting familiar within the virtual environment. All these factors might influence performance by additional distracting information and hence could result in less distractor interference as performance occurs to be generally worse. However, the results are promising in terms of VR feasibility. Finally, its potential to combine ecological validity and objective standardized assessment should lead to future research and a deeper understanding of VR effects in cognitive fields.

References

Corriveau Lecavalier, N., Ouellet, É., Boller, B., & Belleville, S. (2020). Use of immersive virtual reality to assess episodic memory: A validation study in older adults. *Neuropsychological Rehabilitation*, *30*(3), 462–480.

Diaz-Orueta, U., Iriarte, Y., Climent, G., & Banterla, F. (2012). AULA: An ecological virtual reality test with distractors for evaluating attention in children and adolescents. *Virtual Reality and Scientific Visualization Journal*, *5*(2), 1–20.

Parsons, T. D., Carlew, A. R., Magtoto, J., & Stonecipher, K. (2017). The potential of function-led virtual environments for ecologically valid measures of executive function in experimental and clinical neuropsychology. *Neuropsychological Rehabilitation*, *27*(5), 777–807.

Parsons, T. D., & Barnett, M. D. (2018). Virtual apartment stroop task: Comparison with computerized and traditional stroop tasks. *Journal of Neuroscience Methods*, *309*, 35–40.

Rumpf, U., Menze, I., Müller, N. G., & Schmicker, M. (2019). Investigating the Potential Role of Ecological Validity on Change-Detection Memory Tasks and Distractor Processing in Younger and Older Adults. *Frontiers in Psychology*, 1–12.

Schmicker, M., Müller, P., Schwefel, M., & Müller, N. G. (2017). Attentional Filter Training but Not Memory Training Improves Decision-Making. *Frontiers in Human Neuroscience*, 11(March), 1–7.

Schmicker, M., Schwefel, M., Vellage, A.-K., & Müller, N. G. (2016). Training of Attentional Filtering, but Not of Memory Storage, Enhances Working Memory Efficiency by Strengthening the Neuronal Gatekeeper Network. *Journal of Cognitive Neuroscience*, *28*(4), 636–642.

Vogel, E. K., McCollough, A. W., & Machizawa, M. G. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature*, *438*(7067), 500–503.