Non-Immersive Virtual Reality as a Safer Alternative for Cognitive Training in Older Adults: Investigating the Effect of Age on Cybersickness

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***Abstract*— Virtual reality (VR) has emerged as a promising tool for cognitive training in older adults, yet cybersickness remains a significant barrier to its widespread adoption. This study investigates the effects of age and sex on cybersickness in immersive and non-immersive VR environments using data from 629 participants collected over 14 years. Participants played spatial navigation games in either an immersive (head-mounted display) or non-immersive (laptop screen) setting, and cybersickness occurrence was recorded. Logistic regression analysis revealed that in immersive VR, older age was associated with an increased likelihood of experiencing cybersickness, and females were significantly more susceptible than males. In contrast, neither age nor sex significantly influenced cybersickness occurrence in non-immersive VR, where overall cybersickness prevalence was substantially lower (6.9% vs. 24.0% in immersive VR). These findings highlight the potential of non-immersive VR as a safer and more accessible alternative for cognitive training in aging populations, mitigating the challenges posed by cybersickness in immersive VR environments.**

Keywords- virtual reality; cybersickness; age.

I. INTRODUCTION

Virtual reality (VR) has gained increasing attention as a tool for cognitive training in older adults due to its ability to provide engaging, interactive experiences that may enhance cognitive function [1–3]. However, cybersickness—a condition that presents with symptoms such as nausea, dizziness, eye fatigue, and disorientation [4]—remains a significant barrier to the widespread adoption of VR-based interventions. Cybersickness arises due to sensory mismatches between visual, vestibular, and proprioceptive inputs [5], leading to discomfort that can limit user engagement and reduce the feasibility of VR applications, particularly among older individuals.

Age has been found to influence cybersickness susceptibility [6], particularly in immersive VR environments, where users experience a greater sense of presence and motion perception. However, the directionality of the age effect remains controversial. Some studies suggest that older adults experience significantly less cybersickness than younger adults [7–9], while others report the opposite, with older individuals being more vulnerable [10, 11]. Most existing studies have been limited by small sample sizes, making it difficult to draw definitive conclusions. Additionally, while the impact of age on cybersickness has been explored in immersive VR environments, there is a lack of research on non-immersive VR systems, such as those using conventional screens (e.g., laptops or desktop monitors), which are widely available and often more accessible for older adults. Understanding how cybersickness manifests in non-immersive VR settings is critical, especially since these systems could serve as a safer and more practical alternative for cognitive training in aging populations. To address this gap, we conducted a large-scale analysis using data collected over 14 years from 629 participants, evaluating the effect of age and sex on cybersickness in both immersive and non-immersive VR environments.

II. METHOD

Participants played one of three VR-based spatial navigation games: VRNHouse, Virtual Hallway, or Barn Ruins. These games involved maze-like route-finding tasks designed for spatial navigation studies and had been tested and validated in previous research. Participants played either immersive games using a head-mounted display (HMD) or non-immersive games on a laptop screen using a gaming controller. Their age, sex, and cybersickness occurrence (binary: present/absent) were recorded. As shown in Table I, the immersive VR group consisted of 179 participants (mean age: 55.84 ± 19.65 years, 70 males), while the non-immersive VR group included 450 participants (mean age: 56.56 ± 17.85 years, 159 males). Given that cybersickness is influenced by the level of immersion, we conducted separate logistic regression analyses for the immersive and non-immersive datasets to examine the effects of age and sex on the likelihood of experiencing cybersickness. Logistic regression was used as the outcome measure- cybersickness occurrence- was binary.

III. RESULTS

The logistic regression analysis for the immersive group ($n = 179$) showed that both age and sex significantly influenced cybersickness occurrence. Among the 179 participants, 43 (24.0%) reported experiencing cybersickness, while 136 (76.0%) did not, as outlined in Table I. Sex had a significant effect (OR = 0.17, 95% CI [0.06, 0.41], $p < 0.001$), indicating that males were significantly less likely to experience cybersickness than

females. Additionally, for every 10-year increase in age, the odds of experiencing cybersickness increased by 1.28 times (OR = 1.28, 95% CI [1.04, 1.61], p = 0.024).

Conversely, in the non-immersive VR group (n = 450), only 31 participants (6.9%) reported cybersickness, while 419 (93.1%) did not. Logistic regression revealed that neither age nor sex had a significant effect on cybersickness susceptibility in non-immersive VR.

TABLE I. DESCRIPTIVE STATISTICS FOR FACTORS IMPACTING CYBERSICKNESS SUSCEPTIBILITY IN VERBAL IMMERSIVE AND NON-IMMERSIVE DATA (MEANS ± SD)

	Verbal-immersive full dataset	***Verbal-nonimmersive subset***
N	179	450
CS (present/ absent)	43/136	31/419
Age	55.84 ± 19.65	56.56 ± 17.85
Sex (Male/Female)	70/109	159/291

IV. CONCLUSION

Our findings suggest that older adults face a higher risk of cybersickness in immersive VR environments, congruent with the results in the studies [10, 11]. This increased risk could limit their ability to comfortably engage with immersive VR-based cognitive training programs. Our study did not find this increased risk of cybersickness in older adults while using non-immersive VR, making it a safer and more viable alternative for prolonged cognitive training sessions.

These findings have important implications for the design of VR-based cognitive training programs for older adults. While immersive VR is engaging and realistic, older adults are more likely to experience cybersickness while using immersive technology. This may make it harder for them to use VR headsets for long periods, reducing their ability to stick with VR-based cognitive training programs. In contrast, non-immersive VR had a significantly lower incidence of cybersickness (6.9%), reinforcing its potential as a more comfortable and accessible alternative for older users.

By prioritizing non-immersive VR solutions, cognitive training programs can maximize engagement and accessibility while minimizing the discomfort associated with cybersickness, ultimately improving the overall effectiveness of VR-based cognitive rehabilitation for older adults.

V. STUDY LIMITATIONS AND FUTURE WORK

This study is limited by the specific VR games used, the lack of a control group, and the exclusion of factors such as prior VR experience, motion sickness susceptibility, and personality traits. Future research should investigate a wider range of VR applications, examine individual differences in cybersickness susceptibility, and explore adaptive strategies to reduce discomfort in immersive VR. Additionally, long-term studies are needed to evaluate the effectiveness, engagement, and feasibility of non-immersive VR for cognitive training in older adults, particularly in real-world and clinical settings.

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