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EDITORIAL

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Seeing beyond reality: considering the impact of mainstream virtual reality adoption on ocular health and the evolving role of ophthalmologists

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The unveiling of Apple's VisionPro headset on June 5, 2023 signifies a crucial transition in the realm of consumer-oriented Mixed Reality (MR) experiences. Current Virtual Reality (VR) devices are primarily tailored for single-focus time boxed experiences, predominantly in gaming. In contrast, the introduction of Apple's VisionPro and Meta's Quest 3 has showcased the vision to seamlessly incorporate Augmented Reality (AR)/VR experiences into the daily routines of the general populace. These devices have been engineered to accommodate a diverse array of activities including work, fitness, education, and leisure. Furthermore, their incorporation of a pass-through video feed of the user's environment drastically reduces the need for removal in comparison to conventional VR devices. As the adoption of these devices grows, it is essential to consider their implications for ocular health.

A WEALTH OF OPPORTUNITY

Virtual Reality (VR) devices, with their array of sensors and high-definition displays, have significant promise in the field of ophthalmology. To date, VR has significantly contributed to three key domains: therapeutics, diagnostics, and surgical aids.

One of the foremost applications of VR in ophthalmology is in therapeutics. Spatial computing capabilities allow for the creation of immersive environments tailored for vision training, assisting individuals with visual impairments in refining their visual acuity, depth perception, and hand-eye coordination. For example, VR tools can be instrumental in preventing and managing myopia by effectively mimicking outdoor environments while controlling light intensity and spectral composition [1]. By combining eye-tracking and foveated rendering, VR displays can effectively simulate the paracentral defocus state and manage ocular axis lengthening. A study examined the combination of low-dose atropine with VR-supported binocular vision function balance training in treating 136 patients with juvenile myopia [2]. Compared to standalone low-dose atropine treatment, those who received the combined therapy exhibited significantly improved unaided vision and larger pupil diameters. The study also reported a significant decrease in dioptre correction following the intervention, with no change in adverse reactions. Another study investigated the impact of autostereoscopic 3D visual training on the accommodative functions of individuals with myopia [3]. Here, 46 participants watched a video depicting a moving target alternating between a point 50 cm in front of the screen and a point 500 cm behind it, with pauses at both ends. The results indicated a reduction in accommodative lag and an enhancement in accommodative facility post-training. Furthermore, analogous research has been carried out on the use of VR in treating other ocular conditions like amblyopia [4–7]. Taken together, VR devices exhibit strong promise as a treatment modality.

Additionally, with MR becoming more commonplace, MR-capable devices can be used regularly outside the clinical setting — allowing for at-home diagnosis and monitoring of ophthalmologic conditions. Capitalizing on the capabilities of spatial computing can allow individuals to proactively manage their eye health, identify initial indicators of vision-related disorders, and consult healthcare professionals as needed. For instance, recent studies have reported the possibility of monitoring glaucoma and tracking visual field loss over time via virtual visual field testing at home [8]. Notably, all 20 participants found the VR-based visual field testing easy to use, with most favouring this method over the standard of care Humphrey Field Analyzer used in clinical settings. Preliminary studies also indicate that virtual visual field testing is comparable in performance to the conventional Humphrey visual field testing, widely recognized as the gold standard [9, 10]. These encouraging findings highlight the significant potential of VR technologies in facilitating home-based eye diagnostics.

In addition to the impact on patients, spatial computing can offer considerable benefits for surgical applications and training. VR simulators, such as Eyesi (VRmagic, Mannheim, Germany) and MicroVisTouch (ImmersiveTouch, Chicago, Illinois), have already become routine training tools for microsurgical techniques employed in numerous ophthalmology education programs [11–13]. By providing aspiring ophthalmologists with the opportunity to rehearse complex procedures in lifelike virtual environments, students can acquire practical skills in a safe and controlled setting.

A CALL FOR CAUTION

Given Apple's and Meta's extensive reach into the lives of so many, and the unstudied impact of long-term MR usage, it is imperative that the ophthalmology community provides the necessary guidance and research to confirm that this technological shift does not compromise public health. Critically, we must emphasize daily-usage guidelines.

It is crucial to understand that extended periods in virtual reality environments can have negative effects on eye health. Prolonged exposure to artificial light, particularly blue light emitted by VR headsets and displays, has been linked to a range of eye conditions, including digital eye strain, dry eye syndrome, and fatigue [14–16]. Studies also suggest that excessive blue light exposure can interfere with circadian rhythms, causing sleep disturbances and possibly increasing the risk of eye diseases such

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as age-related macular degeneration [17–20]. Many VR devices feature low resolution and limited visual fields, which could ironically hasten the onset of myopia and other accommodative and vergence issues [1]. These effects may be intensified by extended use, as users, captivated by immersive experiences, might neglect to blink as frequently as necessary. There are also several broader healthcare concerns of screentime on youth populations — such as the positive correlation between screentime and the risk of ADHD, which could be applicable to VR screentime as well [21–23].

Increased research that considers the changing user dynamics of AR/VR devices and cogent public health communication are essential to safeguard the health of users as these devices become increasingly integrated into daily life.

CONCLUSION

Ophthalmologists play a vital role in understanding and addressing the ocular health consequences of extended virtual reality experiences. It is incumbent upon us to conduct further research to better comprehend the long-term effects of VR usage and to develop evidence-based guidelines for safe and responsible integration with clinical care.

Furthermore, collaborations between ophthalmologists and VR developers can facilitate the creation of ocular-friendly VR experiences. This could involve optimizing display technologies to reduce blue light emissions and developing eye-tracking capabilities to ensure accurate and natural eye movements within the virtual environment. Such collaborations can enable the integration of ophthalmic expertise in the design and development of VR experiences, promoting ocular health while maintaining its immersive nature.

In conclusion, the increasing prevalence of MR experiences necessitates a comprehensive understanding of their impact on ocular health. By acknowledging both the positive and adverse effects, ophthalmologists can guide patients, developers, and policymakers toward safe and responsible MR/VR usage. Through continuous research, education, and collaboration, we can harness the transformative power of spatial computing while safeguarding the precious gift of sight.

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REFERENCES

1. Zhao F, Chen L, Ma H, Zhang W. Virtual reality: a possible approach to myopia prevention and control? Med Hypotheses. 2018;121:1–3.
2. Shi Y. Effect of atropine eye drops combined with VR-based binocular visual function balance training for prevention and control of juvenile myopia. Evid Based Complement Altern Med. 2022;2022:4159996.
3. Huang Y, Li M, Shen Y, Liu F, Fang Y, Xu H, et al. Study of the immediate effects of autostereoscopic 3D visual training on the accommodative functions of myopes. Invest Ophthalmol Vis Sci. 2022;63:9.
4. Herbison N, MacKeith D, Vivian A, Purdy J, Fakis A, Ash IM, et al. Randomised controlled trial of video clips and interactive games to improve vision in children with amblyopia using the I-BiT system. Br J Ophthalmol. 2016;100:1511.
5. Žiak P, Holm A, Halička J, Mojžiš P, Piñero DP. Amblyopia treatment of adults with dichoptic training using the virtual reality oculus rift head mounted display: preliminary results. BMC Ophthalmol. 2017;17:105.
6. Halička J, Sahatqija E, Krasňanský M, Kapitánová K, Fedorová M, Žiak P. Visual training in virtual reality in adult patients with anisometric amblyopia. Cesk Slov Oftalmol. 2020;76:24–8.
7. Boon MY, Asper LJ, Chik P, Alagiah P, Ryan M. Treatment and compliance with virtual reality and anaglyph-based training programs for convergence insufficiency. Clin Exp Optom. 2020;103:870–6.
8. Hu GY, Prasad J, Chen DK, Alcantara-Castillo JC, Patel VN, Al-Aswad LA. Home monitoring of glaucoma using a home tonometer and a novel virtual reality visual field device: acceptability and feasibility. Ophthalmol Glaucoma. 2023;6:121–8.
9. Phu J, Kalloniatis M. Static automated perimetry using a new head-mounted virtual reality platform, virtual field, compared with the Humphrey field analyzer in glaucoma and optic nerve disease. Invest Ophthalmol Vis Sci. 2021;62:3364.
10. Nanti NB, Lenoci J. Comparison of virtual reality visual field testing to Humphrey visual field testing in an academic ophthalmology practice. Invest Ophthalmol Vis Sci. 2021;62:3486.
11. Iskander M, Ogunsola T, Ramachandran R, McGowan R, Al-Aswad LA. Virtual reality and augmented reality in ophthalmology: a contemporary prospective. Asia Pac J Ophthalmol. 2021;10:244–52.
12. Vergmann AS, Vestergaard AH, Grauslund J. Virtual vitreoretinal surgery: validation of a training programme. Acta Ophthalmol. 2017;95:60–5.
13. Cissé C, Angioi K, Luc A, Berrod JP, Conart JB. EYESI surgical simulator: validity evidence of the vitreoretinal modules. Acta Ophthalmol. 2019;97:e277–82.
14. Pavel IA, Bogdanici CM, Donica VC, Anton N, Savu B, Chiriac CP, et al. Computer vision syndrome: an ophthalmic pathology of the modern era. Medicine. 2023;59:412.
15. Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW. Computer vision syndrome: a review. Surv Ophthalmol. 2005;50:253–62.
16. Rosenfield M. Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic Physiological Opt. 2011;31:502–15.
17. Golebiowski B, Long J, Harrison K, Lee A, Chidi-Egboka N, Asper L. Smartphone use and effects on tear film, blinking and binocular vision. Curr Eye Res. 2020;45:428–34.
18. Sheppard AL, Wolffsohn JS. Digital eye strain: prevalence, measurement and amelioration. BMJ Open Ophthalmol. 2018;3:e000146.
19. Talens-Estarelles C, Cerviño A, García-Lázaro S, Fogelton A, Sheppard A, Wolffsohn JS. The effects of breaks on digital eye strain, dry eye and binocular vision: testing the 20-20-20 rule. Contact Lens Anterior Eye. 2023;46:101744.
20. Wolffsohn JS, Lingham G, Downie LE, Huntjens B, Inomata T, Jivraj S, et al. TFOS lifestyle: impact of the digital environment on the ocular surface. Ocul Surf. 2023;28:213–52.
21. Liu H, Chen X, Huang M, Yu X, Gan Y, Wang J et al. Screen time and childhood attention deficit hyperactivity disorder: a meta-analysis. Rev Environ Health. 2023. https://doi.org/10.1515/reveh-2022-0262, Epub ahead of print.
22. Tamana SK, Ezeugwu V, Chikuma J, Lefebvre DL, Azad MB, Moraes TJ, et al. Screen-time is associated with inattention problems in preschoolers: results from the CHILD birth cohort study. PLoS One. 2019;14:e0213995.
23. Suggate SP, Martzog P. Screen-time influences children's mental imagery performance. Dev Sci. 2020;23:e12978.

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AUTHOR CONTRIBUTIONS

VSJ and BJF collaborated closely on conceptualizing and framing the scientific comment. VSJ provided insights and perspectives and analyzed relevant literature. BJF played a substantial role in guiding the overall direction of the comment, offering expertise in the field, and overseeing the writing process. Both authors actively participated in drafting and revising the manuscript.

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COMPETING INTERESTS

The authors declare no competing interests.