

Accommodation in two-photon vision – application in Augmented Reality technology

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1. Main Text

The two-photon vision phenomenon is based on the visual perception of pulsed infrared lasers (800-1300 nm) due to the isomerization of visual pigments caused by two-photon absorption¹. Two-photon vision is a phenomenon with promising potential for AR applications: the spectral band for two-photon visual perception differs from normal vision and two-photon visual stimuli are subjectively perceived as highly clear and sharp due to quadratic dependence of two-photon brightness on the power of the stimulating laser. The quality of the image formed on the retina is strongly conditioned by the accommodation parameters of the eye. Accommodation response is also important for managing vergence-accommodation conflict in AR/VR technology². This study aimed to assess the accommodation amplitude of the eye for two-photon vision and evaluate the impact of defocus on the perceived image.

2. Methods and results

Twelve healthy volunteers with no diagnosed visual system pathologies participated in the study. To measure accommodation amplitude, a letter stimulus “E” of 0.2° size was displayed through fast scanning of the retina with a pulsed laser beam at a wavelength of 1040 nm for two-photon vision and 520 nm for one-photon vision, with both stimuli perceived as green. Both beams were generated by a femtosecond laser ($\tau_p=250$ fs, $F_{rep}=63$ MHz). Using a brightness matching method, both stimuli were adjusted to have the same subjective brightness³. The measurement involved increasing the stimulus for accommodation by adjusting defocus in 0.5 D steps until the participant observed subjective blurring of the stimulus.

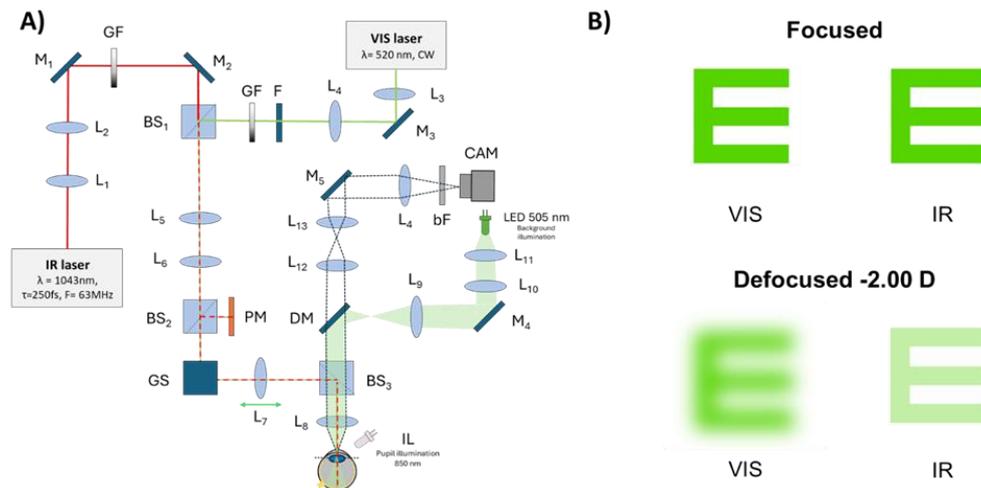


Fig. 1. **A)** Optical system. The infrared (IR) and visible (VIS) beams were generated by a femtosecond laser ($\lambda = 1043$ nm, $\tau = 250$ fs, $F = 63$ MHz) and continuous wave laser ($\lambda = 520$ nm), respectively. LED, green light emitting diode; F, neutral density filter; GF, neutral density gradient filter; Li, lens; Mi, mirror; Bsi, beamsplitter; GS, scanner; DM, dichroic mirror; bF, bandpass filter; PM, power meter; IL, pupil illuminator; CAM, camera.

B) Schematic representation of the effect of defocus on perceived stimuli in one-photon (VIS) and two-photon (IR) vision.

The accommodation amplitudes determined on the subjective blurring were higher for two-photon vision: 4.0 ± 0.6 D compared to one-photon vision: 2.7 ± 0.6 D. The results show that two-photon vision is characterized by a higher accommodation amplitude, allowing for maintaining a high-quality image over a wider range of defocus than one-photon vision. The findings confirm the potential for applying the phenomenon of two-photon vision in retinal displays and AR technology. The objective confirmation of these findings is planned with adaptive optics system measurements. It will provide deeper insights into the dynamic behavior of accommodation and support the development of AR technologies with two-photon vision.

3. Acknowledgements

The International Centre for Translational Eye Research (FENG.02.01-IP.05-T005/23) project is carried out within the International Research Agendas programme of the Foundation for Polish Science co-financed by the European Union under the European Funds for Smart Economy 2021-2027 (FENG).

The “Retinal display based on two-photon vision for Augmented Reality” (FENG.02.07-IP.05-0233/23) project is carried out within the Proof of Concept programme of the Foundation for Polish Science co-financed by the European Union under the European Funds for Smart Economy 2021-2027 (FENG).

4. References

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