Impact of modified chromatic aberration on the depth of field using an adaptive optics visual simulator

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Purpose: The longitudinal chromatic aberration CA of the human eye is almost 2 D and its effect on the retinal image quality is significant. However, some factors are known to mitigate the impact of the CA on vision, as the spectral response of the photoreceptors, the Stiles-Crawford effect, and the monochromatic high order aberrations. In this work, we studied the impact of modified conditions of the longitudinal chromatic aberration (CA) on vision using a novel experimental approach.

Methods: We used an adaptive optics visual simulator (AOVS) with extended capabilities for chromatic aberration manipulation. The AOVS incorporated a liquid crystal on silicon spatial light modulator (LCoS-SLM) as correcting device. Dedicated phase masks were programmed on the modulator to dynamically alter the induced CA. Defocus was independently controlled by a tunable lens (TL). Two conditions of modified longitudinal CA were induced: corrected (C) and doubled (D) CA. The former consisted of the compensation of the natural CA of the eye, while the latter corresponded to the twofold enlargement of the chromatic shift, while still maintaining the sign of the natural case. Those cases were compared with the natural case (N). Through-focus visual acuity (VA) was measured in 4 subjects with paralyzed accommodation for every condition. Computational simulations of through-focus VA were also performed, using a ray-tracing software able to include the individual aberrations of each subject.

Results: The case C showed an average reduction of VA of 16 % compared to case N. Case D showed a drop of 23 %. While experimental through-focus VA for case N resembled the theoretical calculations, the predicted values for cases C and D did not match well the experimental results. Those were significantly lower than expected from simulations.

Conclusions: Through focus VA for three different conditions of CA were measured with a new method based on the generation of phase masks in an AOVS. Both the corrected and double CA cases presented a reduction in VA compared to the natural case. There was an overestimation of the through focus VA for cases C and D from simulations as compared to the experimental results. This fact might indicate that additional neural factors are present, perhaps impacting vision under modified chromatic conditions. The results can help to optimize optical corrections, as intraocular lenses and others, attempting to include CA manipulation to enhance vision.

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