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Adaptive-Optics Correction of Asymmetric Aberrations Degrades Accommodation Responses

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Abstract

Purpose: The exact role of the monochromatic aberrations present in the normal eye on the performance of the accommodation mechanism is unknown. We carried out experiments with adaptive-optics to explore the impact of asymmetric aberration on accommodation responses in absence of other possible cues.

Methods: The aberration pattern of the eye was controlled in real-time with a closed-loop adaptive-optics system while the subject performed a variety of accommodation tests. The apparatus measure the wave-front aberration in infrared light with a Hartmann-Shack wave-front sensor (Fernández, Iglesias & Artal, Opt. Lett., 26, 746, 2001). Astigmatism, coma and trefoil are partially corrected in real-time with a membrane deformable mirror, while the subject uses an additional channel for vision through the device. A monochromatic (540 nm) high contrast letter, subtending 25 minutes of arc, acts as the accommodation stimulus. The vergence of the stimulus is computer-controlled by a motorized optometer. The accuracy and speed of the accommodation responses for different situations were measured in subjects both with their normal aberrations and with their asymmetric aberrations partially corrected.

Results: During accommodation from far to near stimulus (2 diopters), the total amount of high-order aberrations significantly decreases. Several aberration terms are highly correlated with defocus during accommodation. We achieved a closed-loop partial correction (around 70%) of the asymmetric terms during accommodation. This correction disrupted the correlation between different aberration terms found in normal conditions. Accommodation response time increases by a factor of two when the experiment was performed with the aberrations corrected. However, the final precision was similar in the two cases. The gain of the accommodation system to a dynamic changing stimulus was also lower when the aberrations were corrected.

Conclusion: We demonstrated the potential of an adaptive-optics apparatus to explore the role of aberrations during accommodation. By partially removing asymmetric aberrations, we found a systematic reduction on the performance of accommodation. This may indicate the use of asymmetric aberrations to

determine the direction of focus during accommodation. As a related conclusion, these results suggest that an hypothetical perfect real-time correction of normal aberrations could induce a collateral reduction in the accommodation performance.

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