Testing vision with physical and simulated multifocal corrections in an adaptive optics visual simulator

Posterboard #: B0133

Abstract Number: 3128 - B0133

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Disclosure Block: Maria Vinas, None; Carlos Dorronsoro, None; Aiswaryah Radhakrishnan, None; Edward Anthony LaVilla, None; Jim Schwiegerling, None; Susana Marcos, None

Purpose: Spatial Light Modulators (SLM) are increasingly used as active elements to simulate optical corrections,in particular multifocal presbyopic corrections,in Adaptive Optics (AO) systems.We compare visual perception with manufactured multi-zone multifocal phase plates (PP) and through similar phase maps (PM) simulated with an SLM in an AO visual simulator.

Methods: 6 multi-zone multifocal designs,2-4 zones of progressive power (0 to +3D) in either radial or angular configurations, were evaluated in the form of manufactured PP and simulated PM.A custom-developed 2-active-element AO system was used to measure and compensate for the eye's aberrations (deformable mirror) and to simulate the multifocal solutions (SLM).A supercontinuum laser was used for wavefront sensing (827nm) and to monochromatically illuminate (555nm) the visual stimulus.Multifocal PP were manufactured in a freeform lathe and characterized by profilometry.Vision with the 6 PP and PM was evaluated on 4 subjects (age:28.5±0.1yrs;sph:-1.42±0.28):(1)Perceptual score of the stimuli viewed through the different multifocal patterns (60 trials;1-6 response);(2)Visual acuity (VA),from an 8-Alternative Forced Choice procedure with tumbling E letters and a QUEST algorithm.Experiments were performed under AO-correction and for different viewing distances.

Results: Vision with manufactured PP and simulated PM followed similar trends.The perceptual score for radial designs with PP and PM was significantly correlated at all distances (far:p=0.046;int:0.005;near:p=0.005). For angular designs score correlated significantly for far (p=0.005).Perceptual scores for 3- and 4-angular designs were higher with PP than for PM for far (difference 3A:1.55;4A:2.35), but lower for near (3A:-2.07;4A:-1.37).VA was not statistically different for PP or the corresponding simulated PM for far (ANOVA,p=0.112) or near vision (ANOVA,p=0.260),and were significantly correlated across designs for far (p=0.004).PP consistently produced higher VA for far than near (p=0.004).The optimal pattern differed across subjects and distances,but was consistently lower for 4-zone radial designs.

Conclusions: Comparison of multifocal presbyopic corrections using SLM and manufactured multi-zone multifocal phase plates in an AO system allows identifying the performance of SLMs to simulate such multifocal corrections,and therefore the accuracy of SLM-based visual simulators.

Layman Abstract (optional): Provide a 50-200 word description of your work that non-scientists can understand. Describe the big picture and the implications of your findings, not the study itself and the associated details.: Spatial Light Modulators (SLM) are increasingly used as active elements to simulate optical corrections, in particular multifocal presbyopic corrections, in Adaptive Optics (AO) systems. In this study we compared visual perception with lathed-manufactured multi-zone multifocal phase plates and through the same corrections simulated with an SLM in a custom-developed two-active-elements AO visual simulator used to measure and compensate for the eye's aberrations (with a deformable mirror) and to simulate the different multifocal solutions (with an SLM), respectively. We provide insights of the limits of SLMs to simulate such multifocal corrections.