Adaptive optics: the future of visual testing

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Abstract - Adaptive optics allows to manipulate optical wavefronts reaching the eye and perform non invasive visual testing. A revision of the history of this emerging field and the current state of the art will be presented.

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Different laboratories in the world developed adaptive optics (AO) instruments for use in Ophthalmology. The main application in the early days of AO for the eye was to improve the resolution and quality of retinal images recorded through the corrected eye's optics in ophthalmoscopes. However, once AO instruments were operative for the eye, we soon realized that not only ocular aberrations could be corrected, but also any desired aberration pattern could be added to the eye in a controlled manner. By using an additional optical path, visual stimuli were projected to the eye’s subject to perform visual testing for a variety of optical conditions. This is the basis of the concept of the adaptive optics vision analyzer. This instrument consists of a wavefront sensor to measure the eye’s aberrations and a correcting device to modify the eye’s optics. The correcting/manipulating device is placed in the system conjugated both with the subject's pupil plane and the wavefront sensor, by using appropriate sets of lenses in a telescope configuration. Subjects view a stimulus (letters or any visual scene) produced by a micro-display. The potential applications of this type of AO instruments in Ophthalmology can be enormous. Perhaps the most obvious is the progressive substitutions of phoropters, those old-fashion systems that you find in any ophthalmic clinic, containing wheels with different lenses used during visual testing to determine the required optical prescription. With AO, standard lenses will be replaced with opto-electronics devices and moreover, not only defocus and astigmatism, but all optical aberrations could be induced. This will allow optimizing the optical correction for different visual tasks. For example, in some cases, some residual customized amount of spherical aberration could provide some extra depth of focus in presbyopic eyes. Another powerful application will be the pre-testing of different optical solutions. In invasive procedures, such as laser refractive surgery, before a definitive ablation of the cornea is performed, the optical profile to be induced could be optimized for each patient. This will open the door to an era of true customized eye treatments. The future of this technology looks promising and I expect a rapid transition from the laboratories to the clinics. However, there are challenges that still need substantial work. Although we have already proposed binocular AO systems, they are still limited to the laboratory. An additional advance for this field will be the reduction of the associated costs of the key correcting elements. The high costs of these technologies today lay at the limit of what is commercially viable for clinical instruments. I am convinced that these tools will revolutionize the way vision is tested and corrected today. A revision of the history of the field and the current state of the art will be presented.