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## ARTICLE

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# Dynamic Visual Stimulus Presentation in an Adaptive Optics Scanning Laser Ophthalmoscope

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### ABSTRACT

**PURPOSE:** To demonstrate the technology and application of synchronized laser modulation in the adaptive optics scanning laser ophthalmoscope (AOSLO), which makes it possible to deliver adaptive optics (AO) corrected stimuli to the retina of a living eye and to record the precise retinal location where the stimulus has landed.

**METHODS:** The modification involves the development of custom software to control a high frequency pixel clock and a waveform generator board in synchrony with the scanning mirrors. The experiment involves a measurement of visual acuity with and without aberrations correction with AO.

**RESULTS:** The system can project stimuli at a frame rate of 30 Hz with high sampling resolution (7.5 seconds of arc), thereby limiting the quality of the retinal image to the level of AO correction. Visual acuity in six subjects is improved on average by 33% after aberration correction across a 5.89-mm pupil.

**CONCLUSIONS:** Dynamic visual stimulus presentation in an AOSLO works effectively and expands the scope of AOSLO applications. [*J Refract Surg.* 2005;21:S575-S580.]

**T**he use of laser modulation to write patterns directly onto the retina while simultaneously recording them as part of the retinal image in a scanning laser ophthalmoscope was conceived at the time of its invention by Webb et al.<sup>1,2</sup> Since that time many of the proposed applications have been demonstrated,<sup>3</sup> such as the ability to locate scotomas with microperimetry,<sup>4</sup> find the preferred retinal locus in eyes with central scotomas,<sup>5,6</sup> measure visual acuity<sup>3</sup> and other functional tests,<sup>7</sup> measure fixation dynamics during reading tasks,<sup>8</sup> and investigate fixation in patients with retinal pathology<sup>9</sup> or reading disabilities.<sup>10</sup>

Although the effectiveness of these applications is evident, the scope of the applications to date has been limited by the resolution of the eye, size of the scan, and sampling (pixel) density. For example, at best, a commercial scanning laser ophthalmoscope operates with 512 pixels over a 5-degree field. Under these conditions each pixel spans approximately 0.6 minutes of arc, making it difficult to generate high fidelity letters that are 20/20 (5 minutes of arc) or smaller. Furthermore, coarse pixel sampling, distortion of frames due to eye movements,<sup>11</sup> and compromised image quality (either from diffraction or aberrations) result in uncertainties in the ability to localize the position of the stimuli on the mosaic to finer than the dimension of a cone.

The adaptive optics scanning laser ophthalmoscope (AOSLO) was designed to overcome some of these limitations.<sup>12</sup> The AOSLO uses adaptive optics (AO) to compensate the aberrations that cause blur in the retinal image. In

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