Advances in measuring accommodation with an objective aberrometer

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Outline

- Motivation
- Accommodative measurement approaches
  - Internal target
  - External target
    - fellow eye
    - measured eye
    - binocular vision
      - COAS – VR
      - COAS-DSA
- Conclusions
Motivation -- we need ...

- An objective, quantitative assessment of the optical / mechanical accommodation
- To excludes (or measure) effects due to multi-focal, depth of focus, pupil diameter, or neurological factors
  - (only optical-mechanical changes are measured)
- A quantitative accommodation measurement of the subject’s sphere range
- A wavefront measurement that quantifies aberrations that could reduce the benefits of an otherwise successful procedure

Improved measurements will improve corrective modalities
The eye is never still

HO-Aberrations with Soft-CL wear

Vision is a dynamic process → dynamic approaches for WS!
Measurement of accommodation requires a quantitative visual stimulus

- Known/measurable visual stimulus provided with variable magnitude
- Target must drive/motivate accommodation
- Binocular/monocular vision measurement comparison
- Natural target appearance
- Time and duration of target presentation may be important
- Patient motivation and/or training
There are still subjective factors

- The response can be highly subjective
  - Depends on experience, motivation, time-of-day and other factors
- The visual target can affect subject motivation
  - Photographs may receive better response
  - Different subjects may respond to different targets
- Binocular vision may play an important role
- Other, a priori, information may affect the process
  - Physical arrangement of target
  - Internal instrument targets may not be perceived correctly
Accommodation can be measured by moving the internal target:

- Move internal target and measure response
- Programmable steps
- Uses existing internal hardware

But how do we know if the subject is focused on the target?
External targets may provide a better subjective response

- Fellow eye
- Measured eye
- Target may be dynamically “switched”
- Adjustable target positions
Full binocular stimulation should give the best results

- COAS – VR
  - Image relayed
  - Includes IR eye tracker
    - Simultaneous wavefront and eye position
  - Full dynamic accommodation measurement
    - Static or dynamic targets
    - Frequency analysis possible
  - External or internal targets

Need “accessory” that can provide binocular stimulus
Feasibility & technical challenges binocular stimulation

Concepts for binocular stimulation designed as independent “plug-on” to COAS G210

Setup I:
- Path 1
- M1
- M2
- Correlation
- Power table height variance

Setup II:
- Electromechanical control
- M1
- M2
- Correlation
- Power table height variance

Highest demands for the mirror M2 in front of aperture!
Design

- Open frame does not give feeling of mass
- Binocular view of target
- Near and far targets
  - computer controlled sequencing
- Triggered through normal COAS acquisition
- Adjustable target positions
- Changeable target types
Realization
Measurement Process
Analysis

Zernike Coefficients (user selected) & Sphere (Zernike, all coefficients)

Plot Settings

- SCA Plot
- Coefficients Plot
- RMS Plot
- Mixed Plot

Left Ordinate
- Maximum
- Minimum
- Ticks

Right Ordinate
- Maximum
- Minimum
- Ticks

Abscissa
- Maximum
- Minimum
- Ticks

Marker

Redraw

Close
The measurement protocol is important

1. Corrected to emmetropia
   - Or set 2nd target to Spherical equivalent of base refraction

2. Near target set within 2-3 diopters of expected range

3. Target size should be adjusted for dioptric stimulus (smaller targets for younger subjects)

4. Measurement should be performed several times to “familiarize” the subject
Results

- 30 y.o. male
- Far target at 6 m distance (0.17 D)
- -6 D target change at 3 seconds
- 0 D at 6 seconds
- 30 Hz data acquisition
- 9.9 sec of data
Results

- 38 y.o. male
- Far target at 3D
- -3 D target change at 4 seconds
- 0 D at 8 seconds
- Higher orders only
- 30Hz acquisition
- 9.9 seconds of data
Normal emmetropes follow the typical accommodation trend

- All subjects emmetropic
- Measurement using far/near/far targets
- Familiar subjects – each subject measured multiple times
- 6D target used for entire set
  - Insufficient stimulus for younger subjects
- Some outliers in data
Accommodation range measurements reflect the subjects visual condition

- All subjects approximately emmetropic
- Measurement using far/near/far targets
- Unfamiliar subjects – first time use
- Clinical measurements – not all subjects had normal vision
- 6D target used for entire set
Conclusions

- Aberrometers can provide a quantitative way to accurately measure the optical accommodation, but ...
  - Subject visual stimulus is important to accurately measuring clinical accommodation
  - Complicated by subjective factors
    - Motivation, binocularity, target design, age, training
    - Well designed protocol is critical to accurate measurement
- Surprisingly little difference between internal and external targets
  - Only initial results – not a clinical study
Thank you!