2:00 PM 2.5 hour(s) Room 225 A-B
P-03 **Papers: Visual Function & Structure**
Moderators: Ronald Harwerth, OD, PhD, FAAO, William H. Swanson, PhD, FAAO

2:00 PM Keynote: **IMPROVING STRUCTURE FUNCTION RELATIONSHIPS FOR CLINICAL USE**
Ronald Harwerth OD, PhD, FAAO

2:30 PM. **BASELINE DATA FROM A MULTI-CENTER LONGITUDINAL GLAUCOMA STUDY (MLOGS)** (120158)
William H. Swanson, PhD, FAAO, Victor E. Malinovsky, OD, FAAO, Brad M. Sutton, OD, FAAO, Julie K. Torbit, OD, FAAO, Indiana University School of Optometry, Mitchell W. Dul, OD, MS, FAAO, State University of New York (SUNY) College of Optometry

**RESULTS:** For the basement of -1.5 log unit there were 9 failures of agreement: RNFL defects were not as deep as perimetric defects for all six comparisons ($Z > 7.4$); CSP defects were not as deep as CAP defects for both comparisons ($Z < -4.3$), and FDP defects were not as deep as CAP defects for IT ( $Z = 3.3$). For the basement of -0.6 log unit there were six failures of agreement: RNFL failed to agree with perimetry for all six tests ($Z > 3.4$).
**PURPOSE:** To report baseline data from a prospective multi-center longitudinal study of patients under treatment for glaucoma. MLOGS includes a new contrast sensitivity perimetry (CSP) test based on contemporary vision science, and optimized for detecting progression of glaucoma.
**METHODS:** One eye each was tested for 68 patients with glaucomatous field loss and optic nerve damage (mean 66, SD 9 yrs) and 67 age-similar controls (mean 63, SD 9 yrs). Four tests were used: conventional automated perimetry (CAP), 24-2 SITA Standard; frequency-doubling perimetry (FDP) 24-2 on Humphrey Matrix; peripapillary retinal nerve fiber layer (RNFL) Stratus OCT 3.4; contrast sensitivity perimetry (CSP) on a custom testing station (Malinovsky et al AAO 2011). Dynamic ranges were fixed with basements of -1.5 log unit and -0.6 log unit. We used Bland-Altman analysis to assess agreement between each pair of tests, for IT and ST RNFL sectors. Two tests were considered to be in agreement when the slope of the Bland-Altman fit was not significantly different from zero. To control for 24 tests on the same dataset, a Bonferonni correction was used for statistical significance ($p < 0.002$, $|Z| > 3.07$).
**CONCLUSIONS:** Baseline data from MLOGS show the same forms of agreement with clinical data as we have found in prior studies with CSP. In damaged sectors, CAP tended to score a sector as more damaged than did CSP or FDP, while RNFL tended to score the sector as less damaged than all three perimetry tests.
**ADDITIONAL COMMENTS:** Supported by NIH grants R01EY007716, 5P30EY019008

2:45 PM. **OPTIMIZING CONTRAST SENSITIVITY PERIMETRY FOR CLINICAL USE: REDUCING AGE** (120246)

Mitchell W. Dul, OD, MS, FAAO, State University of New York (SUNY) College of Optometry, William H. Swanson, PhD, FAAO, Indiana University School of Optometry, Irene A. Tran, BS, State University of New York (SUNY) College of Optometry

**RESULTS:** The expected age effect (mean ± SE) for FDP at 18 Hz was 0.42 ± 0.02 log unit, substantially greater than 0.15 ± 0.02 log unit for Gabors at 5 Hz ($t = 13$, $p < 0.0005$) and 0.04 ± 0.001 log unit for pulsed Gabors ($t = 27$, $p < 0.0005$). Dynamic range was equal for 18 Hz FDP and 5 Hz Gabors, and was 0.5 log unit lower for pulsed Gabors.
**PURPOSE:** Conventional perimetry, which uses small (0.43 degree) targets, is hampered by high test-retest variability which increases as perimetric sensitivity decreases. Matrix Frequency Doubling Perimetry (FDP) (Carl Zeiss Meditek), a form of contrast sensitivity perimetry, uses larger (5 degree), 5 c/deg targets with a rapid (18 Hz) temporal counterphase flicker and variability does not increase as a function of sensitivity. However, high temporal frequencies cause sensitivity to decline when retinal illuminance is reduced by aging effects on the lens and pupil diameter (Graham and Hood, Vis Res 1992). Our goal is to develop alternative perimetric grating stimuli with relative immunity to age effects
**METHODS:** We produced Gabor grating patches, 0.14-0.5 c/deg, with a 200 msec rectangular pulse presentation and 1.0 c/deg patches presented for 600 msec with 3 cycles of 5 Hz counterphase squarewave flicker, using a 2-dimensional Gaussian window. We simulated reductions of retinal illuminance expected in normal aging by placing neutral density filters of 0.6, 1.2, and 1.6 log attenuation in front of 12 cyclopleged eyes of young healthy subjects. For each of 3 types of tests (FDP and 2 versions of Gabors), mean sensitivity vs. retinal illuminance data were fit with a standard adaptation model to predict the expected effect of age (Swanson et al, IOVS, 2005).
**CONCLUSIONS:** There is less of an effect of reduced retinal illuminance with slow temporal presentation Gabor patches when compared to FDP. Introducing moderate (5 Hz) flicker improved the dynamic range for the Gabor patches, while retaining relative immunity to aging effects on lens and pupil.
**ADDITIONAL COMMENTS:** Supported by NIH grants EY007716, P30EY019008, and T35EY020481

3:00 PM. **OLDER EYES SHOW LARGER INCREASES IN FLICKER-INDUCED DENSITY THAN YOUNGER EYES** (120339)

John V. Lovasik, OD, PhD, FAAO, Helene Kergoat, OD, PhD, FAAO, Mireille Parent, MSc, University of Montreal School of Optometry

**RESULTS:** Pre-Flicker recordings of ONH density revealed small spontaneous oscillations that matched the heart rate of subjects. Each flicker interval caused a biphasic increase in ONH density that peaked within ~30sec. When flicker stopped, the density of the ONH decreased monotonically to regain baseline within 20 sec. The same response pattern was seen for the second and third flicker intervals. The maximum increase in ONH density increased systematically with subject age ($p = 0.04$).
**PURPOSE:** Abnormal ocular blood flow appears to be involved in sight threatening diseases like glaucoma. Studies using Laser Doppler flowmeters (LDF) have reported

that blood flow in the optic nerve head (ONH) in response to flicker is greater in normal eyes than in eyes with ocular hypertension or POAG. In this study we used digital imaging to measure changes in ONH density caused by flicker. Our objective was to determine if such changes in the ONH density paralleled known changes in blood flow and if they changed with age.
**METHODS:** An Imedos Retinal Vessel Analyzer typically used to measure flicker-induced changes in vessel caliber was modified to record real-time changes in the optical density of target sites on the ONH in 97 healthy adults between 20 and 80 yrs of age. An inbuilt eye tracker insured constancy of test site on the ONH that was recorded at 25 fps before, during, and after 3 consecutive 60sec flicker (12.5Hz) and three 60sec recovery intervals. Flicker related changes in the ONH density were expressed as percent change from a steady-state recording prior to flicker. Linear regressions for an alpha= 0.05 were used for statistics.
**CONCLUSIONS:** The systematic increase in ONH density during flicker paralleled published LDF recordings of ONH blood flow to flicker. The progressively larger flicker-induced increase in ONH density with age suggests that older eyes require more blood flow to sustain normal vision and thus may be at increased risk for ischemic neuropathy.
**ADDITIONAL COMMENTS:** Grant: Canadian Foundation for Innovation; Natural Sciences and Engineering Research Council of Canada

3:15 PM. **DIFFERENCES IN NON-NEURAL COMPONENT OF SUPERIOR TEMPORAL AND INFERIOR TEMPORAL SECTORS OF RETINAL NERVE FIBER LAYER** (120201)
Nicole Stiles, OD, Andrew Kerns, William H. Swanson, PhD, FAAO, Victor E. Malinovsky, OD, FAAO, Indiana University School of Optometry, Mitchell W. Dul, OD, MS, FAAO, State University of New York College of Optometry

**RESULTS:** When data from both the IT and ST sectors were combined, the non-neural component was estimated as 23+/-4% (mean+/-SE). However, when the non-neural components were estimated separately, the ST non-neural component was found to be 29+/-4% and the IT non-neural component 17+/-5%.
**PURPOSE:** The retinal nerve fiber layer (RNFL) is composed of a neural component, which can decline with disease, as well as a non-neural component that remains even if the eye is blind from glaucoma or optic neuropathy. The percentage of total RNFL thickness attributed to the non-neural component has been estimated as 33% (Hood et al., 2007, Prog Retin Eye Res 26:688). However, this estimate pooled data from both the superior temporal (ST) and inferior temporal (IT) sectors. Our study assessed the non-neural component in the ST and IT sectors separately.
**METHODS:** One eye each of 67 controls and 68 patients with glaucoma was tested using Stratus Ocular Coherence Tomography and 24-2 SITA Standard. Fraction of mean normal was computed for the patients with glaucoma, then arithmetic averages were computed for the IT and ST sectors. Bland Altman analyses of patient data were used to estimate the non-neural component as a fraction of total RNFL thickness for ST and IT sectors combined and individually.
**CONCLUSIONS:** In this sample of patients, the estimated non-neural percentage of RNFL was lower for IT than for ST. If confirmed in a larger sample of patients, these

results imply that use of 33% for the non-neural component of RNFL may lead to overestimates of neural damage for the IT sector. An additional consideration for the analysis of these results is the possible increase in the non-neural component with age or disease (Harwerth et al., 2010, Prog Retin Eye Res 29:249). Improved estimates of the non-neural component may help more accurately track ganglion cell loss from glaucoma and may yield better agreement between imaging and perimetry data.
**ADDITIONAL COMMENTS:** Supported by NIH grants T35EY013937 and R01EY007716

3:30 PM. **ABSOLUTE SCALING OF IN VIVO MEASUREMENTS OF RETINAL STRUCTURE** (120400)
Nimesh Patel, OD, FAAO, Ronald S. Harwerth, OD, PhD, FAAO, University of Houston, College of Optometry

**RESULTS:** 1) During eye growth, the retinal region imaged increased with an increase in axial length (0.011mm/mm, R2=0.85, p<0.01). Overall there was good correspondence between the change in retinal scaling determined by schematic eye calculations and image registration (R2=0.88, p<0.01, mean diff=0.0023mm/deg, 95% LOA=12.56, -10.13). 2) The increase in the retinal region scanned resulting from an increase in the power of the cornea, via soft contact lenses (R2=0.94, p<0.01), was also accurately modeled by the schematic eye (R2=0.97, p<0.01, mean diff = -0.00001mm/deg, 95% LOA=5.089, -5.096).
**PURPOSE:** In vivo retinal imaging is often used to quantify structures of the posterior segment. Absolute measures require accurate transverse scaling to compensate for variations in the optics of the eye, including both anterior segment power and axial length. The purpose of this study was to validate a method based on schematic eye calculations to produce accurate scaling across changes in optical power and ocular biometry.
**METHODS:** 1) To investigate changes in retinal scaling as a function of axial length, 16 infant rhesus monkeys were imaged during the period of rapid eye growth (1.5 years) starting at 30 days of age. The scans used for data analysis included 30 degree infrared scanning laser ophthalmoscope (IR-SLO) images centered on the optic nerve and the fovea. 2) To investigate changes in retinal image size as a function of anterior segment power, 15 human subjects were imaged (IR-SLO) with soft contact lenses ranging in power from -12 to +8D. For both studies, the changes in retinal image size were compared for calculations using a three surface schematic eye and the adjustments required for image registration.
**CONCLUSIONS:** Calculations based on a model eye will accurately determine transverse scaling to obtain absolute measures of retinal structure with in vivo imaging. These procedures should reduce the population variance in morphological parameters, as well as provide data for accurate modeling of structure-function relationships of individual patients.
**ADDITIONAL COMMENTS:** R01 EY001139, K23 EY021761, P30 EY007551

3:45 PM. **ISOLATION OF IPRGC CONTRIBUTION TO THE HUMAN PUPILLARY LIGHT REFLEX** (120153)

Phillip Yuhas, Holly E. Moose, PhD, Andrew T.E. Hartwick, OD, PhD, FAAO, The Ohio State University College of Optometry

**RESULTS:** In response to a slowly flickering (0.1 Hz) stimulus, there was a significant reduction in magnitude of pupil flicker elicted by the blue versus red light as the intensity increased to $10^{14}$ phots/s/cm$^2$ (14.0% vs 21.7%; p<0.01). For flickering stimuli at $10^{14}$ phots/s/cm$^2$, there was a significant difference (P<0.05) in the pupil response elicited by the two stimuli (blue vs. red) when presented at 0.2, 0.1 and 0.05 Hz, but not at 0.5 or 1.0 Hz, flicker frequencies. Unexpectedly, the flicker in the pupil response to flashing (0.1 Hz) bright ($10^{14}$ phots/s/cm$^2$) red light significantly decreased when the red light was alternated with flashes of blue light (16.1% ± 1.9 SEM) as compared to the flickering stimuli of red light alone (22.2% ± 1.4 SEM).
**PURPOSE:** Intrinsically photosensitive retinal ganglion cells (ipRGCs), which express melanopsin photopigment, respond sluggishly to light and are thought to contribute to the sustained pupillary constriction that occurs after the offset of a bright stimulus. Due to the unique temporal properties of these ganglion cell photoreceptors, our aim was to utilize flickering light stimuli to isolate an ipRGC component to the human pupillary light reflex (PLR).
**METHODS:** A flickering LED light stimulus was presented to the dilated left eye of 18 healthy subjects (age: 23 to 27). The consensual pupil response was recorded in the right eye under infrared illumination. The amplitude of the flicker in the pupil response (% of maximum pupil constriction) was determined using Fourier analysis. The effect of stimulus frequency (range: 0.05 to 1.00 Hz), intensity (range: $10^{12}$ to $10^{15}$ phots/s/cm$^2$), and prior light exposure on the pupil response to flickering red (625 nm) and blue (470 nm) light was determined.
**CONCLUSIONS:** The ipRGC input to the PLR can be best isolated with a bright, slowly flickering, stimulus that alternates between long and short wavelengths.
**ADDITIONAL COMMENTS:** Funded by NIH T35 Grant EY007151, Optometric Educators Inc., Ohio Lions Eye Research Fund.

4:00 PM. **EFFECT OF CONSTANT LIGHT ON PHYSIOLOGICAL CIRCADIAN RHYTHMS OF THE ADULT BROWN NORWAY RAT** (120705)
Diana C. Lozano, BS, University of Houston, College of Optometry, Jessica Lee, Southern California College of Optometry, Andrew T.E. Hartwick, OD, PhD, FAAO, The Ohio State University College of Optometry, Michael D. Twa, OD, PhD, FAAO, University of Houston College of Optometry

**RESULTS:** All physiological parameters were described well with a sinusoidal function (mean $r^2$ for: IOP=0.79 ± 0.10; Temperature=0.53 ± 0.16; MAP=0.65 ± 0.25). Temperature periods significantly increased between LD (24.05 ± 0.22h) and LL (24.92 ± 0.22h; *P*=.01). Temperature amplitude under LD (0.23 ± 0.08°C) significantly dampened under LL (0.06 ± 0.02°C; *P*=.03). IOP mesor under LD (19.7 ± 2.0 mm Hg) was significantly lower than under LL (21.5 ± 2.5 mm Hg; *P* =.04). MAP amplitude (11.5 ± 5.4 vs. 15.5 ± 10.3 mm Hg; *P* =.20) and mesor (97.8 ± 9.0 vs. 95.9 ± 6.5 mm Hg; *P* =.29) did not significantly change between LD and LL. The mean differences in temperature and IOP acrophases were 1.4 ± 1.0 h(LD) and -5.2 ± 1.6 h(LL).

**PURPOSE:** The purpose of this study was to quantify the circadian rhythm of intraocular pressure(IOP), temperature, and mean arterial pressure(MAP) in the adult brown Norway rat under normal light-dark(LD) and continuous dim light(LL) conditions.
**METHODS:** IOP (n=10 rats) and MAP (n=4 rats) were measured every two hours over 24-hours, while temperature (n=4 rats) was telemetrically recorded every 5 minutes. Measurements were acquired under LD and 28-days (LL) of continuous dim light (48±11 lux) exposure. The Lomb-Scargle periodogram was used to calculate the period length of temperature while the least-squared cosine regression was used to calculate the mesor (average value), amplitude, and acrophase (time at which the peak of a rhythm occurs) of all physiological parameters. The difference between temperature and IOP acrophases were used to calibrate each rat to their internal clock. Statistical comparisons of period lengths and regression analysis parameters between LD and LL were assessed using paired t-tests.
**CONCLUSIONS:** IOP, core body temperature, and MAP in the rat varied in a sinusoidal fashion and their phase relationships were altered by changing the environmental lighting conditions. A single IOP measurement during the day is insufficient to describe IOP dynamics under LD and LL conditions.
**ADDITIONAL COMMENTS:** NEI T35(EY07088)

4:15 PM. **SCATTERED LIGHT IMAGING WITH PATTERNED ILLUMINATION** (120434)
Ann E. Elsner, PhD, FAAO, Stuart Young, BS, Colleen McIntyre, BA, Andrea Walker, BS, Indiana University School of Optometry, Matthew Muller, MS, MBA, Aeon Imaging

**RESULTS:** Images were obtained in all subjects without mydriasis, even with green light, but the wider confocal aperture provided brighter images in subjects with small pupils. As hypothesized, the appearance of retinal features varied with color, illumination condition, and aperture width, e.g. blood vessels ($p < .0001$ for shutter width and color) and the disc of some high myopes, with dual line illumination sometimes improving contrast.
**PURPOSE:** To minimize unwanted color variations in fundus images that can mask key retinal features, to maximize the contrast of retinal features, and to investigate multiply scattered light in red/green retinal imaging with emmetropes and high myopes. Using a new, non-mydriatic color camera that has confocal imaging, the DLP-Cam (Aeon Imaging), we investigated varying the illumination pattern, along with varying the width of the confocal aperture. We hypothesized that an illumination pattern with dual, separated slits would produce images with more scattered light than a single, narrow scanned slit. Similarly, detection with a wider confocal aperture slit width should allow more scattered light into the image than a narrow confocal aperture, particularly for red illumination.
**METHODS:** We compared the fundus images of the disc and surrounding vessels in 8 subjects, 23 to 61 yr, with refractions from 0 to -9.5D. We acquired 33 x 21 deg, disc-centered images at 11.8 Hz, using either a 78 micron illumination slit moving across the retina or dual 78 micron slits with a gap of 234 microns between them. Two confocal aperture slit widths were set electronically to 309 or 599 microns. Monochromatic images from red or green LED illumination were collected and analyzed separately or as

a red/green image, with a digital resolution of 1024 x 768 pixels. Maximum power was < 80 microwatts at the cornea, with a 1.6 mm pupil.
**CONCLUSIONS:** The appearance of color images from confocal scanning devices is altered by selection of illumination pattern and color, and aperture width.
**ADDITIONAL COMMENTS:** Supported by NIDDK EY020017, NIBIB EB014805, and NEI EY007624.