**Purpose:** Visual acuity is an essential clinical endpoint to assess the effectiveness of intraocular lenses (IOLs) in clinical trials. Recent innovative trifocal IOLs have been shown to provide patients with great visual acuity at distance, intermediate and near. Population-based simulation of visual acuity at a range of defocuses (i.e., defocus curve) can help to optimize IOL optical design and guide clinical study design.

**Methods:** One-hundred virtual eyes have been generated using two-surface reduced eye model. Monte-Carlo approach was adopted by iterating different corneal power and aberration, anterior chamber depth and pupil size. The IOL surface was extracted from normative lens design in grid-sag format. Two major metrics, MTF area from 0 to 50 c/mm (MTFa50) and light-in-the-bucket (LIB), were calculated at varied defocuses from -3.5 D to +1.0D. The metric-visual acuity correlation was established using existing clinical data of a bifocal IOL. The correlation functions (MTFa50: a*x^b+c; LIB: a*logLIB+b) were applied to the new trifocal IOL to simulate its visual acuity and defocus curve.

**Results:** The LIB has shown better correlation with clinical binocular visual acuity than MTFa50 (R²=0.92 vs 0.64). The correlation functions were 6.7*x^(-0.047)-5.2 for the MTFa50 and -0.24*logLIB-0.20 for the LIB. Similar to the clinical binocular visual acuity, both MTFa50 and LIB metrics predicted the trifocal lens could provide visual acuity better than 0.12 logMAR from 0D (distance) to -2.5D (near) (Figure 1). Simulated difference (MTFa50-LIB) ranged from -0.07 to 0.03 logMAR, all within 1 line. MTFa50 predicted defocus curve was more smooth and monotonic without a distinct secondary peak. Bland-Altman analysis suggested that MTFa50 tended to predict worse visual acuity than LIB when the visual acuity was good and to predict better visual acuity when the visual acuity was poor (Figure 2).

**Conclusions:** The predicted visual acuity using population-based MTFa50 and LIB metrics have been generally consistent with each other. Calculating MTF area metric only up to 50 c/mm rather than traditional 100c/mm may act as a low-pass filter in predicting visual acuity and defocus curve.
which suggests that the finite length of the waveguides may still not suffice to effectively decouple radiative modes.

**Conclusions:** Arrays of cylindrical waveguides were realized in photoreceptors that resemble the angular sensitivity to light of retinal photoreceptor cones. With further development this may prove an essential add-on for refractive eye models and next-generation retinal implants to reduce the impact of intraocular scattered light by angular filtering.

**Commercial Relationships:** Denise Valente, University College Dublin (P); Brian Vohsen, University College Dublin (P)

**Support:** Science without borders - Scholarship, CAPES foundation, Brazil

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**Program Number:** 4211 **Poster Board Number:** B0672  
**Presentation Time:** 8:30 AM–10:15 AM  
**Relative influence of blur, contrast and ghosting on perceived image quality and visual acuity**  
Julia S. Benoit1,2, Ayeswarya Ravikumar1, Jason D. Marsack1, Heather A. Anderson1, 1Department of Basic Vision Sciences, University of Houston College of Optometry, Houston, TX; 2Texas Institute for Measurement, Evaluation, and Statistics, University of Houston, Houston, TX; 3Clinical Sciences, University of Houston, Houston, TX.

**Purpose:** Objective refraction optimizes aspects of image quality, but may do so at the cost of one versus another and thus may not correspond to patients’ perceived optimal visual quality despite improved acuity. The purpose of this study was to determine the relative impact of 3 features (blur, contrast, ghosting) on perceived overall image quality and to evaluate which features were related to measured visual acuity.

**Methods:** 14 cycloplegged adult observers viewed logMAR acuity charts displayed on an LCD monitor monocularly through a unit magnification telescope with a 3mm aperture. Acuity charts were created from wavefront measures of 30 adult subjects with Down syndrome (DS). For each DS eye, a series of acuity charts were produced to simulate retinal image quality when applying various metric-derived spherio-cylindrical refractions. 10 unique chart sets, comprised of ~65 aberrated and one clear chart, were each viewed by 5 of 14 observers. Observers rated blur, ghosting, and contrast on a 10 point scale (10=poorest), overall image quality on a 0-100 point scale (100=best) and read each chart until 5 total letters were missed (logMAR technique). Multilevel modeling was used to estimate each feature’s influence on overall perceived image quality and letters lost (acuity relative to clear chart).

**Results:** Mean clear chart acuity was -0.1±0.6 logMAR. Among all charts read with measured acuity < 0.7 logMAR, perceived image quality spanned the entire scale (mean=59±22) and average letters lost was 2 lines (-0.2±1.4 logMAR). Perceived blur, ghosting, and contrast were individually correlated with overall perceived image quality and letters lost (r<0.001). In an adjusted analysis for all features, blur, contrast, and ghosting have unique effects on overall perceived image quality (p<0.05) whereas for letters lost, contrast did not exert an effect over and above the other two (p=.8223). Finally, blur (b=-.009, p<0.001) and ghosting (b=-.003, p<0.001) influence letters lost over and beyond their effects on image quality (b=-.001, p<.0001).

**Conclusions:** Refractions that are objectively identified would ideally have high contrast and low blur and ghosting, but in individuals with elevated aberrations (e.g., individual with DS) compromises may be needed. These data suggest that blur and ghosting may be given priority over contrast when the goal is to improve acuity.

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**Commercial Relationships:** Julia S. Benoit, None; Ayeswarya Ravikumar, None; Jason D. Marsack, None; Heather A. Anderson, None

**Support:** NIH EY024590

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**Program Number:** 4212 **Poster Board Number:** B0673  
**Presentation Time:** 8:30 AM–10:15 AM

**A simulation study in control observers demonstrates objectively optimized refractions outperform habitual refraction acuity for Down syndrome eyes**

Ayeswarya Ravikumar, Jason D. Marsack, Julia S. Benoit, Heather A. Anderson, College of Optometry, University of Houston, Houston, TX.

**Purpose:** Refractions identified through optimization of image quality metrics (IQM) may bypass some of the challenges of current refracting techniques for patients with Down syndrome (DS). The purpose of this study is to determine which optimized IQM identified spherio-cylindrical refractions that provided best predicted visual acuity (VA).

**Methods:** Autorefraction, habitual refraction (spectacles: n=23, unaided: n=7), and dilated wavefront error (WFE) were obtained for 30 subjects with DS. For each eye, the resultant metric value for 16 IQM was calculated after >25000 spherio-cylindrical combinations of refraction were added to the measured WFE to generate residual WFE in the presence of each refraction. The single refraction corresponding to each of 16 optimized IQM value per eye was selected and used to generate acuity charts. Charts were also created for autorefraction, habitual refraction, and a theoretical zeroing of all lower-order aberrations. The resultant charts were grouped in 10 sets with a clear chart randomly inserted in each set. 5 dilated controls (20/10/20 acuity) viewed each set on a high contrast monitor through a unit magnification telescope with a 3mm pupil aperture. Observers read each chart until 5 letters were missed (logMAR scoring). Letters lost was calculated as the difference in acuity from the clear chart. Average letters lost for the 5 observers for each chart was used to rank the IQMs for each DS eye.

**Results:** Average acuity for the best performing refraction for all DS eyes was within 5 letters (0.11±0.05 logMAR) of the clear chart acuity. Optimized IQM refractions had ~3.5 lines mean improvement from the habitual refraction (0.37±0.22 logMAR, p<0.001). 6 metrics (VSMFT, VSX, SRX, LIF, AreaMTF and STD) identified refractions that were ranked first, or within 0.06 logMAR of first, in >90% of eyes. Habitual refraction and autorefraction were ranked among the 3 worst performing refractions in 90% and 82% of the eyes, respectively.

**Conclusions:** 6 IQMs, when optimized, most consistently provided refractions with resultant acuity closest to a perfect chart, while habitual corrections and autorefraction performed among the worst, indicating that the utilization of spectacle prescriptions identified from IQM optimization techniques may be a useful tool to improve VA in this population.

**Commercial Relationships:** Ayeswarya Ravikumar, None; Jason D. Marsack, None; Julia S. Benoit, None; Heather A. Anderson, None

**Support:** NIH EY024590

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**Program Number:** 4213 **Poster Board Number:** B0674  
**Presentation Time:** 8:30 AM–10:15 AM

**Optimizing Spectacle Prescriptions for Patients with Keratoconus**

Elizabeth Shumard, Gareth D. Hastings, Raymond A. Applegate, Lan C. Nguyen, Roxana T. Hemmati, Jason D. Marsack, University of Houston College of Optometry, Houston, TX.

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Purpose: To compare visual performance obtained with spectacle lenses determined using the clinically standard subjective refraction to a refraction objectively determined based on visual image quality and wavefront data from subjects with keratoconus.

Methods: Ten subjects (n = 19 eyes) with keratoconus underwent a subjective refraction starting from an autorefractor measurement. An optimized objective refraction was also determined by first measuring the total wavefront aberrations of the eye, mathematically applying every possible spectacle correction in the phoropter (at 2° axis steps), and identifying the refraction that provided the best visual image quality determined from the visual Strehl ratio (VSR). Two trial frames were prepared (double blind): one containing the subjective and one containing the objective refraction. High contrast acuity tasks were recorded monocularly for each prescription in a randomized order.

Results: While on average, the mean objective prescription changed visual acuity by $-0.04 \pm 0.17$ logMAR over the subjective refraction, the average change was not statistically significant at the p=0.05 level. When examined by subject, 1 eye gained more than 2 lines, 6 eyes gained between 1 and 2 lines while 4 eyes lost more than 1 line. When asked which of the prescriptions the subjects preferred, subjects chose the objective refraction 73% of the time. When asked to give a free response about their preference of the objective prescription, subjects used words such as “clearer”, “less doubling”, or “less distorted”.

Conclusions: Seventy-nine percent of eyes were either equivalent or gained at least one line in VA with the objective prescription over the subjective refraction, suggesting an optimized objective refractions based on wavefront data would be a useful starting point of spectacle refraction for keratoconus patients.

Commercial Relationships: Elizabeth Shumard, None; Gareth D. Hastings, None; Raymond A. Applegate, University of Houston (P); Lan C. Nguyen, None; Roxana T. Hemmati, None; Jason D. Marsack, University of Houston (P)

Support: NIH EY019105

Program Number: 4214 Poster Board Number: B0675

Deficient Contrast Sensitivity Function in Regular Astigmatic Eyes with Normal or Corrected-to-Normal Visual Acuity


1State Key Laboratory of Ophthalmology, Guangdong Provincial Key Lab of Ophthalmology and Visual Science, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China; 2School of Ophthalmology & Optometry and Eye Hospital, Wenzhou Medical University, Wenzhou, Zhejiang, China; 3Technical University of Munich, Munich, Germany; 4Ohio State University, Columbus, OH.

Purpose: The contrast sensitivity function (CSF) provides a more comprehensive measure in functional vision compared to visual acuity. This study investigates the visual quality of regular astigmatic subjects with normal or corrected-to-normal visual acuity by evaluating their CSF and ocular optical performance.

Methods: A total of 40 eyes of patients (ages 15-29 years old) with regular astigmatism either with normal acuity or corrected-to-normal acuity with their full spectacle corrections, and 34 healthy eyes of individuals (ages 22-30 years old) without astigmatism participated in this study. The cutoff spatial frequency (cutoff SF) and the area under log CSF (AULCSF) in CSF were derived with the quick CSF method (Lemes, et al, 2010; Hou, et al, 2015). The MTF cutoff frequency (MTFcutoff), Strehl20 ratio, OQAS values (OVs) at 100%, 20%, and 9% contrasts, and objective scatter index (OSI) were used to assess the optical quality of the studied eyes by the Optical Quality Analysis System (OQAS).

Results: The average astigmatism was 2.56±0.84 D (1.50-4.50 D) in the astigmatic eyes. The MTFcutoff (29.28±15.55 c/d) of the astigmatic eyes was significantly lower than that of the normal eyes (40.48±11.68 c/d) (p<0.001). The Strehl20 ratio was less in astigmatic eyes (0.18±0.09) than that of the normal eyes (0.23±0.08) (p<0.01). OVs (100%, 20%, and 9%) and OSI were significantly smaller in the astigmatic eyes compared to normal (all p<0.05). Moreover, the cutoff SF in the astigmatic eyes was significantly lower (14.36±4.32 c/d) than that in the normal eyes (17.82±5.48 c/d) (p < 0.001). The AULCSF was reduced in astigmatic (1.15±0.28) versus normal eyes (1.35±0.17) (p<0.01). Most importantly, for patients with regular astigmatism, although visual acuity was not correlated with any optical performance measure, the AULCSF negatively correlated with the degree of astigmatism and the Strehl20 ratio (r=−0.3223 and -0.3745; p<0.05), and the cutoff SF correlated with the degree of astigmatism (r=0.3553; p<0.05).

Conclusions: Astigmatic eyes exhibited deficient contrast sensitivity function and optical transmission, even under full optical correction. The contrast sensitivity function is an important clinical management factor in assessing astigmatism correction in addition to visual acuity, even for individuals with normal uncorrected visual acuity.

Commercial Relationships: Jinrong Li, None; Jin Yuan, None; Fang Hou, None; Michael Dorr, Adaptive Sensory Technology (P); Zhong-lin Lu, Adaptive Sensory Technology (I), Adaptive Sensory Technology (P)

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Program Number: 4215 Poster Board Number: B0676

Presentation Time: 8:30 AM–10:15 AM

Thin luminance gaps can eliminate contrast-mediated perceptual asynchronies

Laysa Hedjar1, Arthur Shapiro2. 1Behavior, Cognition, and Neuroscience Program, American University, Washington, DC; 2Schools of Psychology and Computer Science, American University, Washington, DC.

Purpose: Contrast asynchrony (CA) configurations can separate the visual response to color from the visual response to color contrast (Shapiro, 2008). Recent variations of the basic CA configuration have demonstrated powerful spatial interactions that may be useful for the assessment of visual function. Here we empirically investigate these spatial interactions and attempt to account for the results with a model based on difference of gaussian (DoG) spatial filters.

Methods: The stimulus consisted of two identical bars (.5x1.0 deg) each modulating in luminance at 2 Hz (for demo see: illusionoftheyear.com/2016/06/remote-controls). One bar was placed on a bright field; the other on a dark field. The bars appear to modulate in antiphase—a perceptual response to the contrast between the bars and their surrounds, not to the luminance modulation of the bars. The asynchrony is maintained when bright rectangular flankers (.5x1.0 deg) are placed adjacent to the bar on the dark field, and dark flankers are placed adjacent to the bar on the bright field. We parametrically manipulated the length of the flankers and the width of the gap between the flankers and the modulating bars. Observers viewed the conditions in random order (20x each condition) and were asked whether the bars appear in-phase or antiphase. The observers (n=5) were college-aged with normal or corrected visual acuity.

Results: The results are plotted as psychometric functions: number of trials perceived as asynchronous vs. distance between bars and...
flankers (gap). When the flankers are the same height as the bars and the gap is zero (i.e., the bars are adjacent to flankers) or greater than 12°, observers perceive antiphase modulation. However, when the gap is between 1° and 12°, observers perceive in-phase modulation. When the flankers are longer than the modulating bars, the effect is reversed: in-phase appearance occurs for gaps of 0 and antiphase appearance for larger gaps. We model the results with a bank of contrast-driven DoG filters.

Conclusions: The asynchronous appearance switches when the gap is between 1° and 12°. The results suggest an interaction between two spatial contrast responses each with different temporal phases. A DoG model can capture most, but not all, of the results. The failure to account for all results suggests the possibility of higher-order contextual segmentation.

Commercial Relationships: Laysa Hedjar, None; Arthur Shapiro, None

Program Number: 4216 Poster Board Number: B0677
Presentation Time: 8:30 AM–10:15 AM
THEY CAN DISAPPEAR - Can the panda illusion be used to test visual acuity?
Torsten Strasser1, Hana Langrová2, Laura Kuehlewein3, Annette Werner1, Anne Kurtenbach1, Eberhart Zrenner2. 1Centre for Ophthalmology, University of Tuebingen, Tuebingen, Germany; 2University Eye Hospital, Hradec Králové, Czech Republic.
Purpose: In 2016, the artist Ilja Klemencov revealed the artwork “They can disappear” (Fig. 1), pointing out the danger of extinction of the panda bear. The illustration shows the WWF logo, a panda, hidden behind black-and-white zigzagged lines. Many people struggle to spot the bear at a first glance. However, stepping back or taking off the glasses unveils the panda. This lead us to the question if the ability to see the panda is related to the observer’s VA and if therefore, the panda illusion can be used to test visual acuity.

Methods: Images were dynamically created using silhouettes of 6 animals and presented in random order on a high-resolution screen using PsychoPy. For each presentation, the spatial frequency of the zigzag pattern was adapted based on the subjects’ response using an adaptive staircase method (Kaernbach 1991). The test ended when the limiting spatial frequency, that allows for correct identification of the animals, was determined. 23 subjects (16 ♂, 7 ♀, 38±16 yrs.) with normal ophthalmic exam (BCVA ≥ 1.0), were recruited. All subjects underwent the test with BCVA and with artificially degraded VA using plus lenses (+1D, +2D) and Bangerter occlusion foils (0.6, 0.2). Additionally, VA was determined for each condition using the Landolt C-FrACT test.

Results: Simple linear regressions were calculated to predict VA based on the limiting spatial frequency for BCVA and artificially degraded VA. Significant regression equations were found for both, plus lenses (F(1, 63) = 78.44, p < .0001, R² = .555), and Bangerter foils (F(1, 63) = 44.53, p < .0001, R² = .414). VA increased 0.32 (plus lenses) and 0.27 (Bangerter), respectively, for each cycle of degree of the limiting spatial frequency.

Conclusions: We found a significant correlation between the limiting spatial frequency and the visual acuity. However, the variability of the predicted VA is rather wide. The illusion may not be completely explained by the VA alone. Other contributing factors may be the point spread function or visual crowding. Nevertheless, the counterintuitive application of this illusion and the simplicity of the test may render it useful for estimating the visual acuity.
To determine how the spatial contrast sensitivity function (r, c) is altered in patients with mild traumatic brain injury (mTBI).

**Methods:** sCSF was measured in 10 patients with a diagnosis of mTBI (22-53 years age) and 17 control subjects (22-71 years age) using a Metropsis visual function assessment system (Cambridge Research Systems Ltd.) employing the Psykinematix software. The stimulus consisted of a 3 degree circular patch and sinusoidal gratings (0.5–32 cd/m) combined with a circular Gaussian envelope (sigma=0.5 and AR=1). The mean luminance was 87 cd/m² and stimulus duration was 500ms. A two alternate forced choice test paradigm (90/180 degree orientation) was used with thresholds determined by the average of the last 4 response reversals. The data was fitted with the equation y=(a-xb)^(c-d). The CSF parameters of S_max; peak contrast sensitivity, F_max; spatial frequency with peak contrast sensitivity, b; bandwidth at half the peak contrast sensitivity and F_0 : high-spatial frequency cutoff were derived from the fits and compared between mTBI patients and age matched controls.

**Results:** Significant reduction with age was observed for the control subject group for S_max (r=0.49, slope=-0.012, p=0.001), F_max (r=0.27, slope=-0.032, p=0.018), and F_0 (r=0.36, slope=-0.314, p=0.006). None of the parameters were significantly altered by age in the mTBI patient group. sCSF parameters of mTBI patients were compared to a subset of control subjects in the same age range (Mean age of 36+11.6 years for mTBI and 38+11.4 years for controls, p=0.71 for age difference between groups). S_max was the only CSF parameter that was significantly different (p=0.02) between mTBI patients (0.69+0.29) and age-matched control subjects (0.96+0.24). Snellen visual acuity was not significantly different between the mTBI patients and age-matched controls and the F_0 of the two groups were not significantly different from the Snellen visual acuity of the respective groups converted to cpd.

**Conclusions:** sCSF is likely to be reduced in mTBI patients when Snellen visual acuity is normal. CSF testing at the peak spatial frequency is likely to be most sensitive in detecting CSF deficits in mTBI patients. This finding may assist in the evaluation of vision in mTBI.

**Commercial Relationships:** Jennifer Nguyen, None; Roa Al-Abdalla, None; Nabin Joshi, None; Kenneth J. Ciuffreda, None; Suresh Viswanathan, None

**Support:** T35EY020481 SUNY COLLEGE OF OPTOMETRY
Eccentricity dependency of centre-surround orientation interactions on suppression of contrast detection
Menaka S. Malavita, Trichur Vidyasagar, Allison M. McKendrick, Optometry and Vision Sciences, University of Melbourne, Parkville, VIC, Australia.

Purpose: Perceptual surround suppression has been extensively studied as an analogue of cortical excitatory and inhibitory mechanisms in humans. Contrast detection thresholds of a central target can be either facilitated or suppressed depending on the contrast, orientation and spatial frequency of the surround. However, such effects on surround suppression have been rarely studied in the visual periphery. The specific purpose of this study was to study the orientation dependency of centre-surround interactions outside of the fovea. Specifically, we hypothesised that centre-surround orientation interactions in peripheral vision depend not only on the relationship of the orientation between the centre and surround but also on the retinotopic location of the centre-surround stimulus.

Methods: Contrast detection thresholds were estimated for radially and tangentially oriented centre targets with parallel, oblique (45°) and orthogonal surrounding annuli in nasal, inferior and infero-temporal visual field locations at 6° and 15° eccentricities. Two experienced and one naïve (mean age= 27.3 years) psychophysical observers participated in the study. Suppression ratio was calculated as the ratio between the detection threshold with a surround and without a surround.

Results: We find that at 6° and for the parallel centre-surround orientation, greatest suppression is seen for the horizontal compared to vertical configuration (RM-ANOVA; df = 1, p=0.006) and this effect disappears at 15° (RM-ANOVA; df = 1, p=0.29). There was no bias for orientation at 15° (RM-ANOVA; df = 1, p=0.19). Further, the magnitude of suppression was dramatically reduced with 45° centre-surround orientation difference on a radially oriented centre but not for a tangentially oriented centre, indicating a difference in the orientation tuning bandwidth between these conditions.

Conclusions: We suggest this change in the orientation anisotropy with eccentricity reflects a link between surround suppression and visual field retinotopy. Orientation tuning properties may be different for centre-surround orientations with respect to visual field location and eccentricity.

Commercial Relationships: Menaka S. Malavita, None; Trichur Vidyasagar, None; Allison M. McKendrick, None
Support: ARC Discovery Project 140100157

Predicting the Contrast Sensitivity Function in Different Luminance Conditions
Fang Hou1, Luis A. Lesmes2, 3, Edward D. Ng1, 2, My Diep1, 3, Aaron Seitz4, Pinakin G. Davey5, 1. 1Graduate College of Biomedical Science, Western University of Health Sciences, Pomona, CA; 2College of Optometry, Western University of Health Sciences, Pomona, CA; 3Psychology, University of California Riverside, Riverside, CA.

Purpose: Measurement of contrast sensitivity function (CSF) can reveal subtle defects of vision that are often missed by standardized testing using charts with 100% contrast optotypes. Clinically, CSF measures are performed with a bright background nearing photopic light levels. Given that CSF may aid in identifying night vision difficulty, we sought to compare the CSF functions in photopic and mesopic light levels.

Methods: Twenty-five individuals (26.7 mean age 4.6 SD) underwent ophthalmic evaluation including refraction and slitlamp examination. All individuals had a visual acuity of 20/20 or better on an ETDRS 100% contrast chart. Subjects underwent CSF measurement using CSV-1000E under binocular viewing conditions at a distance of 8 feet in both photopic and mesopic light levels in a randomized fashion. The light levels of CSV-1000E chart were 100% contrast chart. Subjects underwent CSF measurement using CSV-1000E under binocular viewing conditions at a distance of 8 feet in both photopic and mesopic light levels in a randomized fashion. The light levels of CSV-1000E chart were 85 cd/m². The mesopic condition was simulated using 1.5 neutral density filter. The CSF is modeled by a truncated log parabola with four parameters: peak gain, peak frequency, bandwidth, and truncation level (Watson & Ahumada, 2005).

Results: Using a maximum likelihood procedure, we found that (1) For 89.3% of the observers, the shape of the CSF, determined by its bandwidth and truncation level, was invariant across luminance conditions, although the peak gain and peak spatial frequency varied across conditions; and (2) the shape of the CSF significantly varied across observers (p < 0.001). Further examination of the fits showed that the peak gain, peak spatial frequency and log luminance fell on a straight line in the three-dimensional space. Using the average slope of the straight line from 112 observers, we were able to accurately predict the CSF in 2.65 and 20.2 cd/m² with the CSF measured in 95.4 cd/m² for each individual observer, with mean r = 0.98.

Conclusions: The results suggest that the shape of the CSF is invariant under different light conditions, and we can predict CSF in a range of luminance conditions based on the CSF measured in the standard luminance condition.
Purpose: The objective of this study is to introduce a model which uses the measured contrast sensitivity function (CSF) without a glare source to predict the CSF in the presence of a glare source.

Methods: The CSF was measured in 100 trials with the quick CSF method at three different mean luminance levels (48, 42 and 33.6 cd/m²) with and without a glare source on five healthy subjects. The different luminance levels were obtained using calibrated photographic filters. The position of the glare source was 2.5 degrees away from the contrast stimuli and the illuminance of the glare source was 12 lux at pupil of the eye. The area under the CSF curve (AULCSF) was used as outcome parameter. Furthermore, the stray light parameter at an angle of 2.5 degrees was measured. The reduction of CSF with a glare source was predicted from the measured CSF without a glare source through the calculation of a factor defined as the mean luminance of the contrast test divided by the sum of the mean luminance of the contrast test and the veiling luminance induced by the glare source. The veiling luminance was determined by the stray light parameter of the subjects at 2.5 degrees, the strength of the glare source and the angular position of the glare source with respect to the contrast test. The predicted AULCSF with glare source was compared to the measured AULCSF with a glare source. The found difference in AULCSF was compared to the precision of the CSF test (0.1 AULCSF units) to assess the quality of the prediction.

Results: The average measured stray light parameter of the subjects was 1.1 log(s). The measured AULCSF ranged from 2.0 to 2.4 and from 1.8 to 2.1 AULCSF units for the measurements without and with a glare source, respectively. The differences between the model prediction and measured AULCSF for the luminance levels 48, 42 and 33.6 cd/m² were 0.05, 0.05 and 0.03 AULCSF units respectively. The prediction error was within the precision of an individual contrast sensitivity measurement using 100 trials.

Conclusions: The described prediction model is capable of estimating the CSF with glare based on the measured contrast sensitivity function without glare for the given subset of five healthy subjects.

Commercial Relationships: Marrie Van der Moorren, Abbott Medical Optics (E); Robert Rosen, Abbott Medical Optics (E); Luuk Franssen, Abbott Medical Optics (E); Linda Lundstrom, None; Patricia A. Piers, Abbott Medical Optics (E)

Support: Swedish Research Council (621-2011-4094), and EUREKA grant INT 111017
Impact of induced intraocular scatter in visual performance in the near periphery

**Support:** Grant NIH 1 R01EY023582

**Program Number:** 4225

**Presentation Time:** 8:30 AM–10:15 AM

**Straylight angular dependency**

**Thomas J. Van Den Berg**, Luuk Franssen1, 2, Joris Coppens3.

1Netherlands Institute for Neuroscience, Royal Netherlands Academy of Arts and Sciences, Amsterdam, Netherlands; 2presently at AMO Groningen B.V., Groningen, Netherlands.

**Purpose:** Ocular straylight is defined as the visual effect of light spreading around bright point light sources. It is the result of light scattering in the eye. It is the outer part of the PSF. Its intensity declines with angle approximately according angle2 between 1 and 30 degrees. Straylight is specified by means of the straylight parameter, defined as PSF x angle2, which is more or less constant as function of angle for normal eyes. The angular dependency is important for quality of vision, and because it follows the physical characteristics of the significant scatterers in the eye.

**Methods:** Straylight measurements were performed with the C-Quant instrument from Oculus. This instrument measures at 7 degrees. We made adaptations to measure also at 2.5 and 3.5 degrees, by changing the length of the shaft of this instrument. Moreover a previous version of straylight meter was used, enabling measurements at 3.5, 10 and 28 degrees. Isolated clinical cases of media turbidity were studied and compared to large groups of normal controls. Straylight will be reported with the straylight parameter s, given logarithmically.

**Results:** On average log(s) was higher by 0.100±0.023 (s.e.) for 3.5 degrees as compared to 1.5 degrees in controls (33 eyes, 30 subjects). Log(s) was higher by 0.194±0.014 (s.e.) for 2.5 degrees as compared to 7 degrees in another control study (118 eyes, 84 subjects). As these groups also included older individuals, and individuals with cataracts, the results were analysed with age and the average straylight value as independent variables. No significant difference was found as function of either. The 28 degree control value is larger by 0.18 log as compared to 7 degrees, according a study by De Waard et al. (n=34).

Isolated clinical cases included patients with excessive amounts of straylight, yet (near) normal visual acuity, viz. 3 patients with pulverent congenital cataract and 2 patients with fish eye disease, which is a cornea condition. The angular dependencies were clearly different: For the congenital cataract straylight was relatively weak at small angles, with a relative difference of 0.16 to 0.40 at 2.5 degrees. For the fish eye patients straylight was relatively weak at large angles, with a relative difference of around 0.50.

**Conclusions:** In case of normal aging and early cataract formation the angular dependence of straylight is relatively stable. In case of special scatterers, one must be aware that the angular dependency may change.

**Commercial Relationships:** Thomas J. Van Den Berg, Oculus (P); Luuk Franssen, AMO Groningen B.V. (E); Joris Coppens, None

**Clinical Trial:** www.ccmo.nl, NL40857.018.15

Program Number: 4226

**Presentation Time:** 8:30 AM–10:15 AM

**Impact of induced intraocular scatter in visual performance in the near periphery**

**Augusto Arias Gallego**, Diego MontagudF, Enrique-Josua Fernandez, Pablo Artal.1, Laboratorio de Optica, Universidad de Murcia, Murcia, Spain; 2Diffractive Optics Group, Universitat de València, Burjassot, Spain.

**Purpose:** Both the increase of intraocular scattering due to cataracts and the reduction of central foveal vision associated with age-related macular degeneration (AMD) may occur with aging and are often developed simultaneously. We performed a study to better characterize the impact of induced scatter on the quality of vision in the near periphery, where functional areas of the retina are usually still present in patients with AMD.

**Methods:** We used a realistic cataract simulator based in projecting at the eye’s pupil plane phase masks with controlled spatial properties generated with a liquid crystal on silicon spatial light modulator. The phase wavefronts were designed to accurately replicate the angular distribution of light intensity in the retina found in cataractous eyes with different severities. The induced amount of scatter ranged from values of straylight (S) from 10 to 85 degree2/sr, that corresponds from normal aging eye to advanced cataract stages. The field of view of the instrument was 27 degrees that allowed peripheral testing. Visual Acuity (VA) and Contrast Sensitivity (CS) at 3 cycles per degree were measured at the fovea and two retinal eccentricities (5 and 10 degrees in the nasal visual field). The measurements were performed in the dominant eye of a group of ten normal subjects (32±8 years old). An effective artificial pupil of 1.33 mm diameter was used with subjects under their best focus correction.

**Results:** We found a linear decrease of the VA (expressed in LogMAR) for increasing amounts of induced scatter (values of straylight parameter S) both at the fovea and periphery. There was an average VA reduction of 0.18 (LogMAR) at the fovea for each S increment of 25 degree2/sr, while at 10 degrees this value was reduced to 0.06 (LogMAR). A similar qualitative behaviour was found for the CS.

**Conclusions:** The effect of induced scattering on VA and CS at the fovea and the near periphery was successfully evaluated. We found a relatively lower impact of scatter in the periphery. That may explain the modest improvement in vision often found after cataract surgery in patients with AMD.

**Commercial Relationships:** Augusto Arias Gallego, None; Diego Montagud, None; Enrique-Josua Fernandez, None; Pablo Artal, None

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Program Number: 4227

**Presentation Time:** 8:30 AM–10:15 AM

**Iris Characteristics Affecting Far Peripheral Vision and Negative Dysphotopsia**

**Michael Simpson**,1 Maria Muzyka-Wozniak,2 Simpson Optics LLC, Arlington, TX; 2Spektrum Eye Clinic, Wroclaw, Poland.

**Purpose:** Recent theoretical evaluations have found that negative dysphotopsia with intraocular lenses (IOLs) is related to a double image in the far periphery, and that there can also be a constricted total visual field (eg Holladay, Simpson, J Cat Refract Surg (in press)). Eye images are evaluated to characterize the iris surfaces that limit peripheral rays, and modeling is used to estimate limiting visual angles.

**Methods:** Anterior segment optical coherence tomography (OCT) preop and postop images were exported from Visante for 21 normal eyes evaluated previously (Muzyka-Wozniak J Cat Refr Surg 2016;42:563-8). Imagej was used to manually identify features, and Matlab was used to calculate the maximum iris thickness and its distance from the pupil, the gap between the iris and IOL, etc. The average eye was modeled in Zemax to estimate limiting visual angles.

**Results:** Preop and postop iris dimensions were similar, with a mean maximum thickness of 0.48±0.08 mm at 0.92 ±0.18 mm from the pupil, which did not vary systematically with pupil diameter (range 2.5-3.7mm (3.18±0.35 mm) for postop eyes). The axial pupil location (min clear iris diameter) was found to be very close to the posterior field of view, with a modest improvement in vision often found after cataract surgery in patients with AMD.
iris plane on average, and a simple wedge was used to simulate the iris shape. Mean postop values are overlaid on an example eye in Fig 1. The posterior iris surface moved from 3.32±0.31 mm preop to 4.10±0.19 mm postop, with an iris-to-IOL gap of 0.51±0.16 mm, and pupil decentration of 0.23±0.16 mm nasally. The iris was implemented in Zemax as two opaque apertures (Fig 2), and raytracing the average eye with a 3.5 mm pupil, visual angles up to 93° could be focused by the IOL, but an additional peripheral image was created for visual angles above 73°.

**Conclusions:** A simple approximation for the inner iris profile is a triangle, and rays at very large angles are obstructed by the anterior iris (eg Fig 2). Raytracing with a 3.5 mm pupil shows that light from 73° that misses the IOL hits the retina more posterior than focused light from 93°. This overlap makes negative dysphotopsia unlikely (though possible for small pupils), but peripheral illumination comes from visual angles that are also imaged by the IOL. The maximum visual angle is determined by the limit of the sensitive retina, which can’t be identified in the images (and which has no measurement method).

**Fig 1. OCT negative marked with average distances**

**Fig 2. Eye model with 3.5 mm pupil**

**Commercial Relationships:** Michael Simpson, None; Maria Muzyka-Wozniak, None

**Program Number:** 4228 **Poster Board Number:** B0689

**Presentation Time:** 8:30 AM–10:15 AM

**The effect of practice on sensitivity to global motion in subjects with and without visual discomfort**

**Purpose:** Visual discomfort (VD) refers to the perceptual difficulties experienced by individuals when exposed to bright light and the repetitive striped patterns. People with VD have been reported having reduced sensitivity to global motion. However, other studies suggested that the difference only existed at baseline test and disappeared when a second estimate was obtained. The aim of the present study is to investigate the effect of practice on sensitivity to global motion in adults with and without VD.

**Methods:** A total of 103 subjects participated in the study. The degree of VD was determined with the Wilkins & Evans Pattern Glare Test. Subjects looked at square waves patterns with spatial frequencies of 0.5, 3, or 12 cpd for 5 seconds and reported distortions perceived. A subject with a score of >3 on the 3 cpd pattern or a score of >1 on the 3-12 cpd difference was considered as having visual discomfort. The threshold of detecting the global motion was measured with random dot kinematogram. In each trial, the subjects needed to decide if the direction of the perceived global motion was up or down. The coherence of the moving dots was adjusted according to a 3-down-1-up staircase, and threshold was estimated from the mean of the last 6 reversals with an average of 80 trials per test. The test was repeated for 5 times and the improvement rate (IR) was calculated as the log ratio of threshold obtained from the initial to the last test. The comparison between subjects with and without VD was done with Wilcoxon test. Logistic regression was applied to estimate the risk of a subject having VD based on the value of IR.

**Results:** Based on the pattern glare test, 32 subjects were classified as having VD and 71 subjects were not. The initial threshold to detect global motion was significantly higher in subjects with VD (0.755 vs. 0.636, p=0.022). Although both group showed improvement, the threshold at the last test was still significantly higher in the subject.
Utility and Validity of the Handy Eye Chart™ in Non-English Speaking Populations
Caroline Cromelin, Amy Hutchinson, Praneetha Thulas, JP Gorham, Beau B. Bruce. Ophthalmology, Emory University, Atlanta, GA.

Purpose: The purpose of this study is to assess the utility of the Handy Eye Chart™ in non-English speaking individuals. Visual acuity results, testing times, and chart preferences for adult participants undergoing vision screening using the Handy Eye Chart™ were compared with results obtained using other established eye charts (Tumbling E or Early Treatment of Diabetic Retinopathy Study (ETDRS) charts) in two populations of participants for whom English is not the primary language.

Methods: Visual acuity of participants whose primary language was Spanish, and Amharic was tested with the Handy eye chart and an established eye chart at the Mexican Consulate in Atlanta, Georgia or the Menelik II Hospital in Addis Ababa, Ethiopia, respectively. We recorded the visual acuity and time required to complete testing with each chart, and the participants completed a short subjective survey indicating chart preference.

Results: There was a mean difference between the Handy Eye Chart™ and the ETDRS chart of 0.08 in the Spanish-speaking group, equivalent to 4 letters acuity difference. There was a mean difference between the Handy Eye Chart™ and the Tumbling E chart respectively of 0.003 and 0.06 in the Spanish-speaking and Amharic-speaking group. This is equivalent to less than 1 letter difference in the Spanish-speaking group, and 3 letters difference in the Amharic-speaking group. In all arms, the visual acuity obtained by the Handy Eye Chart™ was consistently slightly worse than the established eye charts. Testing times were shown to be similar between the Handy Eye Chart™ and established charts. In the Spanish-speaking group, the Handy Eye Chart™ was a mean of 31 seconds slower than the ETDRS chart (p<0.0001). The Handy Eye Chart™ was a mean of 4 seconds slower than the Tumbling E chart (p=0.65). In the Amharic-speaking population, the Handy Eye Chart™ was a mean of 4 seconds faster than the Tumbling E chart (p=0.65). 20% of patients across all groups preferred the Handy Eye Chart™ over the more familiar chart.

Conclusions: The Handy Eye Chart™ is an efficient and valid test of visual acuity in non-English speaking adults. Although participants tended to prefer testing with familiar eye charts, the Handy Eye Chart™ is a promising alternative for use in settings with a variety of language barriers.

Commercial Relationships: Caroline Cromelin, Patent Pending (P); Amy Hutchinson, Pending (P); Praneetha Thulasí, None; JP Gorham, None; Beau B. Bruce, None

Support: NIH Departmental Core Grant EY006360, Research to Prevent Blindness Individual Grant
The normative range and reproducibility of Camblobs2
Andrea Griffin
Mean logCS (NEI T35EY007088 B0693 ±, None; ±, None; ±, None; ±, None; ±, None; ±, None; ±, None; ±) was considerably less that the theoretical value of 1.4 (log 0.15). For comparisons to the average monocular acuity the binocular advantage averaged -0.068 and compared to the best monocular acuity -0.035. When binocular reading speed was compared to the average monocular speed there was a gain of only 1.6 words/min (p=0.696). However, the faster monocular speed was 11.643 words/min greater than binocular reading speed (p=0.005).

Conclusions: In our sample, binocular summation did not approach the theoretical and often observed square-root of 2 for acuity or contrast sensitivity. The present results are consistent with prior reports that the best monocular acuity can serve as a good surrogate for binocular acuity and with reports that reading speed in subjects with normal vision shows little if any binocular advantage. In fact, we observed that binocular speed was less than the fastest monocular speed.

Commercial Relationships: Benjamin Stephens, None; J Vernon Odom, None; Monique J. Leys, None; John Nguyen, None; Christopher Antonini, None

Program Number: 4233 Poster Board Number: B0694
Presentation Time: 8:30 AM–10:15 AM
Binocular summation and the correlation between spatial and temporal visual functions in normal and amblyopic subjects
Nairouz Farah1, Auria Eisen2, Zvia Burgansky-Eliash2, Uri Polat3, Yossi Mandel3.
1Life Sciences Optometry Track, Bar Ilan University, Ramat Gan, Israel; 2E. Wolfson Medical Center, Holon, Israel; 3Faculty of life Sciences, Optometry Track and Bar-Ilan Institute for nanotechnology and Advanced Materials (BINA), Bar Ilan University, Ramat Gan, Israel.

Purpose: Studies have shown that both temporal and spatial visual performance decreases in amblyopia, but there is lack of information regarding the correlation between these visual functions in such patients. Similarly, there is lack of information regarding binocular summation in visual temporal functions. In this study, we investigated both the correlation between temporal and spatial visual function and binocular summation in normal and amblyopic subjects

Methods: We investigated the temporal visual function performance by measuring the Critical Flicker Frequency (CFF) using a customized setup, based on a software controlled led. To measure the spatial visual function we used monitor projected stimuli generated by a customized computer software. We studied the contrast sensitivity (CS) at different spatial frequencies, presentation times and backward masking (BM) technique using Gabor patches as the stimuli. The experiments were performed using the staircase method in a 3/1 paradigm.

Results: A significant temporal binocular summation (~12%) was observed in normal subjects under mesopic luminance conditions. Binocular CS summation was observed in normal subjects with larger effect found for low spatial frequencies, longer stimuli presentation and long BM. Similar summation characteristics were found in amblyopes excluding temporal summation. In both normal and amblyopic subjects there is significant correlation between spatial and temporal performance. The highest correlations were observed between CFF and CS of 6 cycle per degree, in normal subjects (r=0.63, p<0.005) and amblyopes (r=0.75, p<0.001).

Conclusions: The superiority of binocular vision has distinct and different characteristics for spatial and temporal functions. Correlation between these two visual functions are dependent on stimuli characteristics and are different in amblyopes as compared to normal subjects. This study furthers our understanding of temporal and spatial visual functions in amblyopic subjects.

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Commercial Relationships: Nairouz Farah, None; Auria Eisen, None; Zvia Burgansky-Eliash, None; Uri Polat, None; Yossi Mandel, None

Program Number: 4234 Poster Board Number: B0695
Presentation Time: 8:30 AM–10:15 AM
Bionic Vision: Interaction between color luminance and on-screen shape recognition
Alex Gonzalez¹, Kasey Zann², Mariela C. Aguilar³, Cornelis J. Rowaan⁴, Byron L. Lam⁴, Ninel Gregori¹ ²
Jean-Marie A. Parel¹ ³, ⁴, ⁵Ophthalmic Biophysics Center, Bascom Palmer Eye Institute, University of Miami Miller School of Medicine, Miami, FL; ²Ophthalmology, VA Healthcare System, Miami, FL; ³Bascom Palmer Eye Institute, University of Miami Miller School of Medicine, Miami, FL; ⁴Brien Holden Vision Institute and Vision Cooperative Research Centre, Sydney, NSW, Australia.

Purpose: Luminance is a measure that describes the perceived brightness of a color, in this study we investigate the interaction between the color luminance of on-screen shapes and recognition accuracy as part of a home-based, rehabilitation program designed to help patients with bionic vision.

Methods: Home-based computer rehabilitation modules were programmed using National Instruments Labview Development Suite (Austin, TX.). The patient is emailed a web link allowing the download and installation of the module. Module instructions are administered via computer synthesized voice, and subject is shown a random solid filled shape (circle, square triangle), colored (red, green, blue, white, gray, pink, purple, brown, orange, yellow) and centered on the screen. Each session has eight items, and there is no time limit during the viewing phase. The subject presses the spacebar to enter the recognition phase and selects the shape by keyboard number press (1, 2 or 3). At the completion of each module data measuring accuracy and timing are programmatically transmitted back for analysis via secure email. Two subjects, one implanted with the Argus II retinal prosthesis for 12 months, the other for 24 months, completed 58 sessions, recognizing 465 shapes.

Results: Recognition accuracy was greater (82.6% ± 1.9) with low luminance colored shapes (brown, red, purple, and blue), compared to high luminance colors (gray, green, yellow, white) (76.0 ± 5.5), this difference trended toward statistical significance (p=0.09).

Conclusions: Artificial vision devices provide ultra-low vision, allowing for crude perception of objects. High luminance colored objects may be more challenging to identify due to haloing of the contours, a consequence of limited brightness levels and low density of electrodes in the implanted array.

This chart shows that blue has the lowest luminance value compared to yellow, which is only six percentage steps away from white.

Commercial Relationships: Alex Gonzalez, None; Kasey Zann, None; Mariela C. Aguilar, None; Cornelis J. Rowaan, None; Byron L. Lam, None; Ninel Gregori, None; Jean-Marie A. Parel, None

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Program Number: 4235 Poster Board Number: B0696
Presentation Time: 8:30 AM–10:15 AM
Occupational Lenses respect natural posture when interacting in near vision with digital devices
Damien Paille, Sarah Marié, Amandine Debievre, Céline Benoît
Vision Science Department - R&D, ESSILOR, Paris, France.

Purpose: In a previous work, we showed that the distance of use is smaller and the eye declination is higher when interacting with digital devices compared with traditional paper media (Paiellé, Perrin, Debievre ARVO 2015). Our new range of occupational lenses (OcLs) Varilux® Digiteme™ dedicated to the use of digital devices takes this result into account.

The first part of the present study consists in an evaluation of satisfaction wearing Progressive Additions lenses (PALS) and OcLs. The second part aims to investigate head and eye posture recorded for intermediate and near vision tasks wearing OcLs, PALS and near vision prescription in Single Vision lenses (SVLs).

Methods: 13 presbyopic PALs wearers were recruited. Following a satisfaction evaluation of their own PALS, they were fitted for two weeks with OcLs. After rating the new equipment, they performed postural measurements for intermediate and near vision tasks randomly wearing PALS, OcLs and SVLs, in different conditions. Postural data were recorded thanks to a VICON motion tracking system. Distance to the device, head pitch and eye declination were computed.

Results: Satisfaction questionnaire: Subjects were usual wearers of last generation of PALS and most of them were very satisfied with their PALs. Combined with sample size, this explains why there is no statistical significant difference between PALS and OcLs. Nevertheless, for 6 subjects who are less satisfied with their PALs, OcLs produce better performance for near and intermediate tasks.

Postural data: ANOVA showed significant differences (p<0.05) between the three equipments in terms of eye-device distance, head pitch and eye declination. We can consider that for a near vision task, the reference in terms of posture is the one measured with SVLs. Data measured with the OcLs show a clear tendency to being closer.

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to the one measured with the SVLs compared to PALs in near and intermediate vision. Eye-device distance is shorter, head pitch is higher and eye declination smaller with SVLs and OcLs compared to PALs.

Conclusions: Results from the questionnaires showed that OcLs are relevant in intermediate and near tasks. Moreover, the posture adopted with OcLs is more natural when dealing with digital devices in near vision.

Commercial Relationships: Damien Paille; Sarah Marié; ESSILOR (E); Amandine Debieuvre, ESSILOR (E); Céline Benoit, ESSILOR (E)

Program Number: 4236 Poster Board Number: B0697
Presentation Time: 8:30 AM–10:15 AM

Direct Integration of the Stiles-Crawford Effect of the First Kind using Pupil Flicker Methodology
Brian Vohnsen, Alessandra Carmichael, Najnin Sharmin, Salihah Qaysi, Denise Valente. School of Physics, University College Dublin, Dublin, Ireland.

Purpose: The Stiles-Crawford effect of the first kind (SCE-I) describes the psychophysically-determined visibility dependence on angle of incidence at the retina and is normally determined sequentially by scanning a Maxwellian secondary source of light across the pupil. The purpose of this study is to analyze the validity of pupil integration in normal non-Maxwellian viewing situations of a back-illuminated letter chart for healthy subjects.

Methods: A motorized pupil size flicker system has been constructed that alternates between a small (1.4 mm) reference and increasingly large test pupils (up to 7.4 mm) with flicker frequency set at 0.5 Hz. The motorized pupil is mounted in a conjugate plane to the eye pupil. Subjects adjust brightness of the light using a programmable neutral density filter until a satisfactory match has been found between the reference and test lights. The color of the light is adjusted with a tunable bandpass filter. Effective visibility is determined by the power ratio between the test and reference versus pupil size for five healthy emmetropic and slightly myopic subjects at 6 wavelengths across the visible spectrum.

Results: The subjective results confirm validity of the integrated SCE-I function using a characteristic directionality parameter, $\rho$, in the range of 0.04 - 0.10/mm². Although some wavelength variations are present these are minor. In turn, deviations for small and large pupils are present and may be a result of blur or inaccuracies in the standard Gaussian SCE-I function. We compare the results with those of an integrated Airy disc model based on model by one of the authors (Vohnsen, Biomedical Optics Express, 2014) and find correspondingly good agreement with SCE-I integration. Plots of the measured integrated SCE-I functions are used to determine the effective directionality parameter.

Conclusions: The experimental results show that the integrated SCE-I function is approximately valid for normal viewing situations although care needs to be taken for extreme pupil sizes where variations appear. These may have consequences for improved refractive optics designs that incorporate the SCE-I as a pupil apodization. An impact of the flicker frequency is also possible and is the subject of further ongoing research.

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Program Number: 4237 Poster Board Number: B0698
Presentation Time: 8:30 AM–10:15 AM

Bayesian adaptive assessment of reading performance: the quick Reading method
Zhong-Lin Lu1, Fang Hou1, Luis A. Lesmes2, Peter J. Bex1, Deyue Yu3. 1Psychology, The Ohio State University, Columbus, OH; 2Adaptive Sensory Technology, Inc, Washington, DC; 3School of Ophthalmology & Optometry, Wenzhou Medical University, Wenzhou, China; 4Psychology, Northeastern University, Boston, MA; 5College of Optometry, The Ohio State University, Columbus, OH.

Purpose: Reading is a fundamental skill and the reading performance is a key endpoint for quantifying normal or abnormal development and aging. Successful reading performance requires ophthalmic, cognitive and oculomotor proficiency. The deficit or pathology in any of these functions can lead to a deficit in reading performance (Legge et al 1985). Despite its importance for clinical and developmental assessment, existing reading tests are time consuming and difficult to administer. In this study, we propose a novel method, the quick Reading method, for automated measurement of reading speed at multiple letter sizes based on Bayesian adaptive testing (Lesmes et al., 2010).

Methods: A three-parameter exponential function is used to describe the reading speed vs print size function. The quick Reading method selects the optimal test stimulus (print size and presentation duration) by maximizing the expected information gain in each trial and updates the posterior distribution of the parameters of the reading function. The precision and bias of the estimated reading function of a simulated observer obtained using quick Reading were evaluated. Reading functions measured by the conventional (Psi method, Kontsevich & Tyler, 1999) and quick Reading methods in a true/false paradigm (Crossland et al, 2008) were compared in an experiment.

Results: The precision of quick Reading method was 0.26, 0.17 and 0.06 log10 unit after 10, 20 and 100 trials, respectively. The bias of the quick Reading method was 0.21, 0.17 and 0.10 log10 unit after 10, 20 and 100 trials, respectively. The estimated reading functions obtained with the conventional and quick Reading methods did not differ significantly (paired t-test, $p = 0.184$); There were highly correlated ($r = 0.969$, $p = 0.001$). The precision of the reading function obtained with 60 quick Reading trials was comparable to that of conventional method with 240 trials.

Conclusions: The quick Reading method can be used to precisely and efficiently assess reading performance, with great promise in clinical applications.

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