Novel dual arc stimulus aids sensitive detection of early AMD


Purpose: The rate of recovery of rod vision following a bleach is emerging as highly clinically significant. It is systematically slowed in the older eye and in many clinical conditions, notably Age-Related Macular Degeneration (AMD). It is not known for certain whether this is a pan-retinal effect or if there are localised regions of impaired rod function. To address this issue a dual arc stimulus was developed that simultaneously samples sensitivity recovery in two retinal locations and we present data for three groups of observers, younger normals (n=13), older normals (n=13) and early AMD patients (AREDS grade 2 or 3, n=47).

Methods: Arc-shaped white stimuli were presented on an otherwise black CRT screen at two locations in the inferior visual field. Recovery of sensitivity to the two stimuli was measured concurrently using method of adjustment by alternately presenting them following a localised bleach of at least 80%. Neutral density filters were used to extend the luminance range of the CRT. Data were fitted by non-linear regression to either a seven- or five-parameter model to characterise the dark adaptation curves.

Results: The two stimuli produced similar cone recovery curves within each normal age group. Rod recovery slope, S2, was significantly different between the tested locations for the normal age groups (young 6°=-0.21±0.03, 11°=-0.24±0.03, p=0.02; old, 6°=-0.18±0.05, 11°=-0.20±0.04, p=0.01) but not for the AMD group (6°=-0.10±0.06, 11°=-0.11±0.05, p=0.11). S2 slopes were significantly shallower at both testing locations in the AMD group compared to the age-matched normals (6° p < 0.001 and 11° < 0.001). Alpha and beta points were significantly delayed in the AMD group compared to the age-matched normals at both testing locations (α, 6° p=0.035, 11°=0.038 and β, 6° p<0.001, 11° p<0.001). ROC analysis showed testing the extra location enhanced the diagnostic capability of the test in detecting early AMD.

Conclusions: The new technique increases the information yield without placing any additional demands on subjects. Previous findings regarding normal dark adaptation across the life span are confirmed. Additional novel data are revealed by the technique regarding normal dark adaptation across the life span are confirmed. Additional novel data are revealed by the technique without placing any additional demands on subjects. Previous findings regarding normal dark adaptation across the life span are confirmed. Additional novel data are revealed by the technique.

Commercial Relationships: Humza J. Tahir, None; Elena Cerio, None; Neil R. Parry, None; Jeremiah M. Kelly, None; David Carden, None; Tariq M. Aslam, None; Ian J. Murray, None

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### Table 1, Mean (standard deviation) cone- and rod-mediated sensitivity (dB) tested at 68 points in the central 10° radius of macula with a Goldman size III target presented for 200 msec using a 4-2 threshold strategy.

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Drusen</th>
<th>SDD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cone-Mediated Sensitivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central 5°</td>
<td>19.8 (0.2)</td>
<td>19.1 (0.9)</td>
<td>13.0 (5.7)</td>
<td>0.072</td>
</tr>
<tr>
<td>Peripheral 5-10°</td>
<td>18.5 (0.5)</td>
<td>17.7 (1.5)</td>
<td>11.5 (1.2)</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Rod-Mediated Sensitivity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central 5°</td>
<td>6.0 (1.2)</td>
<td>5.8 (0.4)</td>
<td>0.8 (1.0)</td>
<td>0.003</td>
</tr>
<tr>
<td>Peripheral 5-10°</td>
<td>8.6 (1.2)</td>
<td>8.2 (1.1)</td>
<td>2.1 (0.8)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Results: Average foveal reading speed with no micro-scotomas was ± 269 WPM. Reading speeds at 5 and 10 deg eccentricity were similar and approximately half of the foveal value. With 39% micro-scotomas, average RSVP reading speeds decreased at the fovea, 5 and 10 deg locations by approximately 80, 65 and 25%, respectively, from the no-scotoma condition.

**Conclusions:** The impact of simulated micro-scotomas on reading speed for words that scale in size with eccentricity is greater in the central compared to peripheral retina. This outcome can be accounted for by the probability that randomly positioned micro-scotomas “cluster” into groups that approximate individual letter features in size.

**Commercial Relationships:** Arunkumar Krishnan, None; Hope M. Queener, None; Harold E. Bedell, None

**Support:** Student Vision science Grant to advance Research (SVGR - UHCO). We thank Drs. Gordon Legge, Steve Mansfield and Susana Chung for providing the sentences used in this study.

**Program Number:** 2620

**Presentation Time:** 9:15 AM–9:30 AM

### Scotoma Awareness and Eye Movement Training in Age-Related Macular Degeneration

**Preeti Verghese1, Christian P. Janssen1, 2. 1Smith-Kettlewell Eye Res Inst, San Francisco, CA; 2Utrecht University, Utrecht, Netherlands**

**Purpose:** As most individuals with age related macular degeneration are unaware of their scotoma, we seek to: 1. Develop a paradigm to increase scotoma awareness and 2. Train the preferred retinal locus (PRL) to move towards the scotoma to reveal information obscured by the scotoma.

**Methods:** We first estimated the extent of monocular scotoma and the loci of fixation using a scanning laser ophthalmoscope. We also estimated the location of the binocular scotoma using a custom program that projected stimuli on a large screen. Our goal was to train individuals to direct their PRL toward the scotoma, to uncover missing information. The training paradigm involved comparing two stimuli located on opposite sides of the PRL to determine if they were the same or different. One stimulus was hidden behind the individual’s binocular scotoma and the other was clearly visible in the location opposite the scotoma. As the task required knowing the identity of both stimuli, moving the PRL towards the scotoma was the best way to reveal the obscured stimulus. Observers were trained in multiple blocks over two practice sessions.

**Results:** At the start of training, patients initially looked at the visible stimulus (away from the scotoma), but with practice they began to direct their PRL toward the scotoma. The attached figure shows how well participants were able to direct their saccades towards the target, after training and at a 2-month follow-up visit. At the end of training, 4 out of 7 individuals made saccades more than half way toward the hidden target. At the 2-month retention assessment, all observers consistently made saccades toward the target hidden in the scotoma. Self-reports suggest increased subjective awareness of scotoma location for some, which could explain the high proportion of saccades towards the scotoma.

**Conclusions:** A visual search task designed to direct eye movements toward the scotoma improves both scotoma awareness and eye movement efficiency.
The box plots show the distribution of saccade length relative to the target distance from fixation, for each of 7 participants. (Saccades that reach the center of target are denoted by 1, saccades that do not move toward the target by 0.) The upper and lower panels show data at the end of training and at a 2-month retention assessment, respectively.

**Commercial Relationships:** Preeti Verghese, None; Christian P. Janssen, None

**Support:** NIH R01 EY022394; Pacific Vision Foundation

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**Program Number:** 2621

**Presentation Time:** 9:30 AM--9:45 AM

**Comparing the Shape of the Contrast Sensitivity Functions of Normal and Low Vision**

Susana T. Chung1, Gordon E. Legge2. 1School of Optometry, University of California, Berkeley, CA; 2Department of Psychology, University of Minnesota, Minneapolis, MN.

**Purpose:** The contrast sensitivity function (CSF) provides a comprehensive description of an individual’s spatial-pattern detection capability. Because most low vision patients suffer from impaired acuity and contrast sensitivity, their CSFs will differ from those of people with normal vision. The goal of this study was to test the hypothesis that the CSFs of people with low vision differ from a “normal” CSF only in their horizontal and vertical positions along the spatial frequency (SF) and the contrast sensitivity (CS) axes.

**Methods:** Contrast sensitivity for detecting the presence of a horizontal sinewave grating was measured with a two temporal-interval forced-choice staircase procedure, for a range of SFs spanning 5–6 octaves. CSFs were measured for 23 low-vision eyes (11 with AMD, 5 with Stargardt’s disease and 7 with other pathologies). CSFs were also measured for five adults with normal vision, and the aggregate data were fit with an asymmetric parabolic function. This “normal template”, with the width parameters (shape) of the function constrained, was shifted horizontally and vertically along the SF and CS axes (both in log coordinates) to find the best fit for each of the 23 low-vision CSFs. The low-vision CSFs were also directly fit with best-fitting asymmetric parabolic functions (“free-fit”).

**Results:** A comparison of the peak CS, the SF at which peak CS occurs (SFpeak) and the high-frequency cut-off derived from the two fitting methods (template vs. free-fit) reveals that the values are highly correlated (r=0.77 to 0.98) and in good agreement (Bland-Altman analysis) with one another, suggesting that the template fit is comparable with the free-fit method in estimating these parameters. The width of the left-half of the low-vision CSFs was 1.72±0.64×[mean±SD] that of the normal’s (p<0.0001) while the width of the right-half of the low-vision CSFs was 0.90±0.15× that of the normal’s (p=0.005), implying that the low-vision CSFs are wider on the left and slightly narrower on the right than a normal CSF.

**Conclusions:** Although the low-vision CSFs are wider than that of a normal CSF, a normal CSF template predicts the peak CS, SFpeak and the high-frequency cut-off of low-vision CSFs reasonably well. Our results suggest that a normal template provides an approximate description of the spatial-pattern detection capability of low vision patients, especially if the emphasis is on the high-SF half of the function.

**Commercial Relationships:** Susana T. Chung, None; Gordon E. Legge, None

**Support:** NIH Research Grants R01-EY012810 and R01-EY017835

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**Program Number:** 2622

**Presentation Time:** 9:45 AM–10:00 AM

**Low Vision Patients Can Transfer Skills They Learned From Virtual Reality to Real Streets**

Ellen Bowman1, Lei Liu2. 1Vision Science, University of Alabama at Birmingham, Birmingham, AL; 2Optometry, University of Alabama at Birmingham, Birmingham, AL.

**Purpose:** Virtual reality holds great potential to improve efficiency, affordability and accessibility of low vision rehabilitation. However, whether patients with impaired vision can learn useful skills in a virtual environment and then apply them to solve real world problems has not been tested.

**Methods:** Twelve subjects with vision too poor to use pedestrian signals to make a safe street crossing were trained to use the start (surge) of the traffic in the lanes next to her (near lane) going in the same direct (parallel) to determine the safest time to cross a street within a WALK cycle. A safe surge came a few seconds after the onset of the pedestrian signal, when cars entered the intersection. The subject was asked to say “GO” on the curb when she felt the safest to initiate crossing. The time of the onset of the pedestrian signal, the surge time (first straight-going car passing through the outer boundary of the crosswalk) and the GO time were recorded using


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stopwatches by two testers. The GO time was converted to a safety score (SS) which was the proportion of remaining “WALK” cycle after GO. SS=0 if GO was in the red cycle. The SS for all subjects was evaluated at 4 real street corners before and after training, at least 3 attempts per corner. A certified orientation & mobility specialist taught the subjects how to use near lane parallel traffic surge. Eight subjects were trained in virtual streets generated by a semi-cave simulator (VS group) and 4 were trained in real streets (RS group).

**Results:** Both groups showed a significant increase in SS after training (0.25 vs. 0.81, t=15.11; p<.0001 for VS; 0.29 vs. 0.76, t=8.48, p<.0001 for RS). Repeated measure ANOVA showed no significant interaction between training effect and group. Before training, VS group said GO 65% of the time in the red cycle (InRed), 17% in the WALK cycle but before surge (BeforeSurge), 1% in the WALK cycle but with less than half the cycle left (SafeLow) and only 17% in the WALK cycle with more than half the cycle left (SafeHigh). After training in virtual streets, the numbers became 3%, 4%, 2% and 91% (Fig. 1). The RS group showed a similar pattern after real street training (Fig. 2).

**Conclusions:** Patients with severely impaired vision can learn important visual skills in a virtual environment and can apply the skills to solve real world problems. The effectiveness of virtual street training can be as good as real street training.

**Program Number:** 2623  
**Presentation Time:** 10:00 AM–10:15 AM  
**Auditory spatial representations of distance are compressed in blind individuals**

Andrew J. Kolarik1, 2, Brian Moore2, 1, Silvia Cirstea1, Shahina Pardhan1. 1Vision and Eye Research Unit, Anglia Ruskin University, Cambridge, United Kingdom; 2Psychology, Cambridge University, Cambridge, United Kingdom.

**Purpose:** Blind individuals primarily rely on sound for spatial information about their environment in far space. However, it is currently unknown how well they are able to judge the distance of sound sources. We investigated whether lack of visual information, which aids in calibrating audition in far space, leads to poorer estimation of the apparent distance of sounds by blind participants.

**Methods:** Virtualization techniques were used to simulate virtual anechoic and reverberant rooms. Single, unmoving sounds were presented at virtual distances between 1.2 and 13.8 m to 10 blind and 12 normally sighted participants. All had normal hearing. Stimuli were speech, music or noise. Participants were instructed to report the apparent distance of each sound source. Within a series of trials the stimulus type was held constant.

**Results:** For normally sighted participants, perceived distance to farther sounds was underestimated. For blind participants, the distances for closer sounds were overestimated, and those for farther sounds were underestimated. Accuracy of distance judgements was quantified as the mean unsigned error. For both groups, errors increased with increasing virtual distance, and errors were higher for the blind than the sighted group. A mixed-model ANOVA with distance, room reverberation, stimulus and blindness as factors showed main effects of distance and blindness (p<0.05). No other main effects or interactions were significant.

**Conclusions:** Absolute auditory distance judgements are less accurate for blind participants than for normally sighted controls. The internal representation of auditory distance for blind participants is compressed. These findings suggest that accurate calibration and fidelity for sound cues used to perceive auditory distance is compromised as a result of blindness.

**Commercial Relationships:** Andrew J. Kolarik, None; Brian Moore, None; Silvia Cirstea, None; Shahina Pardhan, None

**Support:** MRC grant G0701870 and the Vision and Eye Research Unit (VERU), Postgraduate Medical Institute at Anglia Ruskin University.

**Commercial Relationships:** Ellen Bowman, None; Lei Liu, None

**Clinical Trial:** NCT02310880

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