140 Eye movements
Sunday, May 07, 2017 1:30 PM–3:15 PM
Exhibit/Poster Hall Poster Session
Program #/Board # Range: 747–762/B0586–B0601
Organizing Section: Eye Movements/Strabismus/Amblyopia/Neuro-Ophthalmology

Program Number: 747 **Poster Board Number:** B0586
Presentation Time: 1:30 PM–3:15 PM

Normal Range of Eye Movement and Its Relationship to Age

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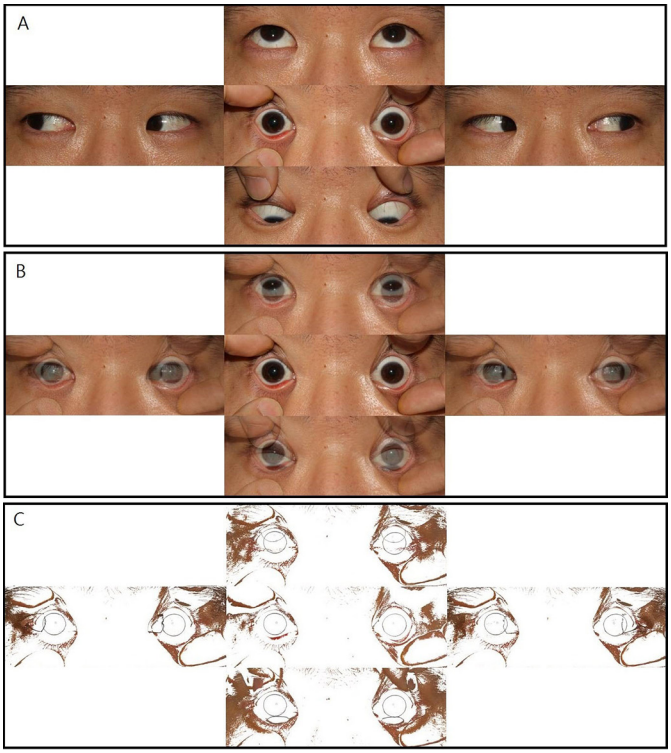
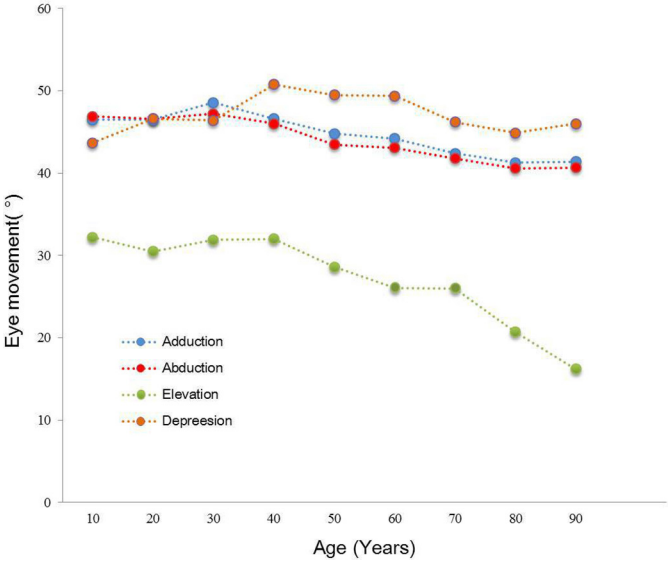
Purpose: To determinethe range of eye movement in normal human subjects and to investigate the effect of age on eye movement.
Methods: A prospective observational study. We enrolled 261 healthy subjects, 5 to 91 years of age. Photographs were obtained in the cardinal gaze positions and processed using Photoshop. The processed images were analyzed using the Image J program to measure the angle of eye movement. The angle of eye movement was quantified using a modified limbus test.
Results: The normal ranges of eye movement were 44.9±7.2° in adduction, 44.2±6.8° in adduction, 27.9±7.6° in elevation, and 47.1±8.0° in depression. There were significant negative correlations between the angles of horizontal and upward gazes and age (R=-0.294 in adduction, R=-0.355 in abduction, and R=-0.506 in elevation, all P<0.001). However, the angle of downward gaze was not significantly correlated with age (R=0.017, P=0.722).
Conclusions: The normal ranges for the angle of horizontal gaze were symmetric, whereas therange of upward gaze angle was smaller than that for the downward gaze among all ages. Unlike the age-related decline of range in other gazes, only downward gaze was not impaired by increasing age. Differencesineye-movement range based ongaze direction and their associated aging mechanisms should be considered when assessing eye movements.



Composite photographs were obtained in the 5 cardinal positions of gaze. The subject visually tracked the fixation target by shifting into maximum upward, downward, left, and right gazes.(A) Semitransparent image was overlapped with the primary position image.(B) The overlapping image was converted to identify the margin of the limbus.(C)



Graph showing the age-dependent changes in eye movements for each direction. The ranges forthe horizontal gazes (adduction and abduction) decreased with advancing age, and the ranges for upward gaze decreased more rapidly than those for the horizontal gaze. On the other hand, there was no associationbetween the range of downward gaze and age.

Commercial Relationships: Han Woong Lim, None; **Yumi Song**, None; **Ji Hong Kim**, None; **Yong Un Shin**, None; **Sun Jin Hwang**, None; **Sukwoo Hong**, None
Support: Korea Research Foundation

Program Number: 748 **Poster Board Number:** B0587
Presentation Time: 1:30 PM–3:15 PM
Model to simulate impact of eye oculomotor behavior under imaging condition
Alexander Dietzel[1], Daniel Baumgarten[1, 2]. [1]Institute of Biomedical Engineering and Informatics, Technische Universitaet Ilmenau, Ilmenau, Germany; [2]Institute of Electrical and Biomedical Engineering, UMIT-University of Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria.
Purpose: Fixational eye movements influence the measurement process of anterior and posterior examinations and effect the reliability. We developed a model of these movements in order to study their impact on simultaneous measurement processes, e.g. retina imaging by laser scanner ophthalmoscopy (SLO).
Methods: Geometrical eye: Based on published schematic eye models a geometrical model (cornea, bulbus oculi) was implemented in three degrees of abstraction. The highest degree considers all components as spheres whereas the medium degree provides ellipsoidal shapes. The lowest degree takes into account complex surfaces for cornea and retina. The lens was generally simplified by a plane characterizing the optical effect.
Oculomotor behavior: Based on published parameters individual oculomotor movements like micro saccade, drift and tremor were modelled as synthetic data. Specific eye movements from measured data of different eye tracker devices were also included. The rotation was implemented following Dondor's law and Listing's law. The plane of rotation is positioned 13.5 mm behind the apex of the cornea.
Measurement procedure: Based on current technical parameters for SLO, a rectangular scanning pattern was modelled covering a 30° x 30° field of view with 768 x768 pixel at 96 ms and 1,536 x 1,536 pixel at 192 ms scan time per image.
Validation: A phantom eye performing defined movements was constructed. It consists of a biconvex lens as anterior part and a concave posterior part covered with a printed vessel tree, at the ends of a water filled tube in their anatomical distance. The movement was realized by a Gimbal-Mirror-Mount (Newport) stirred by two stepping motors.
Results: For a most sensible setup we decided for a diagonal direction of motion in the phantom eye as well as our simulation. Therewith the first visible artifacts occurred in horizontal rather than in vertical direction. The movement of the phantom eye in one direction was visible over 35 frames. A displacement of 3.4° with a maximum velocity of 2° per second lead to the first horizontal artifacts in two consecutive images in both our SLO video data and our model.
Conclusions: Our customizable model allows simulation of monocular fixational behavior of the human eye during a measurement process. This provides comprehensible information regarding intended vs. real measurement position and measured value to specify measurement errors more precisely.
Commercial Relationships: Alexander Dietzel, None; **Daniel Baumgarten**, None
Support: German Federal Ministry of Education and Research (BMBF) Grant 3IPT605X

Program Number: 749 **Poster Board Number:** B0588
Presentation Time: 1:30 PM–3:15 PM
Influence of optical blur on eye movments in a free viewing task
Marta Salvador-Bernadí[1], Josselin Gautier[1], Carlos E. Garcia-Guerra[1, 2], Carles Otero[1], Jaume Pujol[1]. [1]Davalor Research Center (dRC), Universitat Politècnica de Catalunya, Terrassa, Spain; [2]Centre for Sensors, Instruments and Systems Development (CD6), Universitat Politècnica de Catalunya, Terrassa, Spain.
Purpose: To assess the influence of optical blur (spherical and cylinder defocus) on fixations, saccades and microsaccades in a free viewing task.
Methods: Monocular eye movements were measured using an eye-tracker (Eyelink 1000, SR Research, Canada) at 500 Hz on 11 healthy subjects with a mean age ± SD of 26 ± 3.8 years. All subjects had best-corrected visual acuity of 0 logMAR or better. All non-emmetropes were corrected with soft contact lenses during the experiment. Each subject was shown monocularly 22 different images during 3 seconds each at 80 cm distance for 7 different levels of optical blur (154 trials). 21 out of the 22 images represented a realistic color scene with some depth cues and only 1 image was comprised with 5 tumbling E letters on a white even surrounding. The 7 levels of optical blur were: 3 levels of spherical defocus (0 diopters (D), +0.5D, +1D) and 4 levels of cylinder defocus (-0.5Dx180°; -1.0Dx180°; -0.5Dx90° and -1.0Dx90°). Each level of optical blur was generated using one trial lens held at 9 cm in front of the participant's eye. A 9-point calibration was performed for each level of blur and subject to compensate for the lens' magnification, which changed the visual field from 14.7° to 16.8°. Images were presented in random order of blur magnitude. Participants were told to free-view each image.
Results: Seven variables were analyzed with a Friedman test considering all levels of optical blur. Values obtained (interquartile range (IQR), Friedman p-value) were: median duration of fixation 266.0 ms (74.75, p=0.87), median duration of saccades 34.0 ms (7.00, p=0.82), median amplitude of microsaccades 0.15° (0.11, p=0.42), median amplitude of saccades 2.3° (0.54, p=0.60), median number of fixations 9.5 (2.25, p=0.38), median number of microsaccades 7.5 (5.25, p=0.56) and median number of saccades 8.5 (2.25, p=0.38). Median (IQR) post-hoc statistical power of all seven variables was 0.99 (0.00).
Conclusions: Our results suggest that fixations, saccades and microsaccades are not influenced by low levels of spherical and astigmatic defocus in free viewing tasks. It is hypothesized that free viewing tasks is masking a potential effect of optical blur in ocular movements. Future studies might investigate whether optical blur affects ocular movements in activities with higher demands of visual acuity or higher cognitive demands (e.g., reading).
Commercial Relationships: Marta Salvador-Bernadí, DAVALOR SALUD S.L (E); **Josselin Gautier**, DAVALOR SALUD S.L (E); **Carlos E. Garcia-Guerra**, None; **Carles Otero**, None; **Jaume Pujol**, None
Support: Spanish Ministry of Economy and Competitiveness grant DPI2014-56850-R ; Davalor Salud, S.L (Spain); Generalitat de Catalunya by Predoctoral grant FI-DGR (CO)

Program Number: 750 **Poster Board Number:** B0589
Presentation Time: 1:30 PM–3:15 PM
Binocular fixation reduces fixational eye movements in the most affected eye of patients with center involving diabetic macular oedema
Nanna S. Jakobsen, Dorte A. Larsen, Toke Bek. Department of Ophthalmology, Aarhus University Hospital, Aarhus C, Denmark.

Purpose: Treatment of diabetic maculopathy by intravitreal injection of VEGF-inhibitors is not effective in all patients, and therefore parameters should be identified for predicting the visual outcome after anti-VEGF treatment of the disease. It has previously been shown that fixational saccades are increased in patients with reduced visual acuity secondary to diabetic maculopathy, but it is unknown to what extent these saccades in an eye affected by diabetic maculopathy are influenced by the other eye during binocular fixation.
Methods: In fifty-nine eyes from 30 diabetic patients with clinically significant macular oedema, fixational eye movements were recorded using the iView X™ video based eye tracker during monocular and binocular fixation.
Results: Fixational saccades during monocular fixation had a significantly higher frequency (p=0.008), a larger amplitude (p=0.02), and involved a larger retinal area (p=0.01) than during binocular fixation. There was a significant negative correlation (r^2=0.21, p=0.01) between visual acuity and the area of fixation during monocular fixation whereas this correlation disappeared during binocular fixation (r^2=0.004, p=0.74).
Conclusions: Binocular fixation reduces the area of fixation and the amplitude of fixational saccades in the most severely affected eye in patients with diabetic maculopathy. Studies of pathological changes of fixational saccades in diabetic maculopathy should be performed using monocular fixation.
Commercial Relationships: Nanna S. Jakobsen, None; **Dorte A. Larsen**, None; **Toke Bek**, None

Program Number: 751 **Poster Board Number:** B0590
Presentation Time: 1:30 PM–3:15 PM
Effect of target parameters on fixational saccades in normal monkeys
Mythri Pullela, Suraj Upadhyaya, Santoshi Ramachandran, Anand C. Joshi, Samuel Adade, Vallabh E. Das. College of Optometry, University of Houston, Houston, TX.
Purpose: Previously others and we have shown that target shape and size parameters can influence the stability of fixation as measured by a bivariate contour ellipse area (BCEA) metric. Eye movements during fixation of a stationary target are primarily made up of fixational saccades (fast) and drift (slow) components. The present study aims to study the influence of target parameters on fixational saccades in normal monkeys.
Methods: Two juvenile rhesus monkeys (M1, M2), implanted with binocular scleral search coils, were presented with fixation targets of two different sizes (2° and 0.5°), and two different shapes (optotype - '%' and disk) during monocular and binocular viewing. Each combination of target size, shape and viewing condition was presented 5 times and duration of each trial was 60sec. A saccade detection algorithm modified from an unsupervised clustering method published by Otero-Millan and colleagues was used to detect fixational saccades within the fixation data. Amplitude, frequency and direction of fixational saccades were recorded and compared across different stimulus conditions using multi-factorial ANOVA at a significance level of 0.05.
Results: We analyzed ~5200 fixational saccades in the two normal monkeys. The mean amplitude of fixational saccades in M1 was 0.42±0.24° and in M2 was 0.87±0.47. Mean frequency of fixational saccades was 1.38 saccades/sec in M1 and 2.37 saccades/sec in M2. Fixational saccade amplitude was significantly influenced by target shape and size in both monkeys. Fixational saccade frequency increased with target size in M1 only. A polar histogram developed from fixational saccade directions resembled target shape ('%' optotype or disk) for the larger targets. The relationship between BCEA and fixational saccade amplitude could be modeled as an exponential rise to maximum suggesting that fixational saccade amplitude was the primary determinant of the BCEA for stimulus conditions that resulted in high fixation stability.
Conclusions: Target parameters such as size and shape influence fixational saccade amplitude with larger target sizes resulting in larger amplitude fixational saccades. The distribution of fixational saccade directions shows that they play a role in scanning the features of the presented target. Fixational saccade amplitude is a limiting factor when fixation stability is high while drift components likely contribute significantly when fixation stability is poor.
Commercial Relationships: Mythri Pullela; **Suraj Upadhyaya**, None; **Santoshi Ramachandran**, None; **Anand C. Joshi**, None; **Samuel Adade**, None; **Vallabh E. Das**, None
Support: NIH Grant EY026568; NIH Grant EY022723; NIH Grant EY07551

Program Number: 752 **Poster Board Number:** B0591
Presentation Time: 1:30 PM–3:15 PM
Microsaccades as recorded by the tracking scanning laser ophthalmoscope are associated with disability in MS
Christy K. Sheehy[4], Ethan Bensinger[1, 2], Michael P. Devereux[4], Nicholas S. Baker[4], Alexandra E. Boehm[1, 2], Scott stevenson[3], Ari J. Green[4]. [1]Vision Science, University of California, Berkeley, Berkeley, CA; [2]Optometry, University of California, Berkeley, Berkeley, CA; [3]Optometry, University of Houston, Houston, CA; [4]Neurology, University of California, San Francisco, San Francisco, CA.
Purpose: To evaluate the tracking scanning laser ophthalmoscope as a potential novel clinical biomarker of disability progression in multiple sclerosis.
Methods: The tracking scanning laser ophthalmoscope (TSLO) was used to perform retinal imaging and eye-tracking for 16 patients with confirmed multiple sclerosis (MS) from the UCSF MS center. The TSLO system uses 840 nm light to raster scan the retina over a 5-degree field of view. Videos of the retina were recorded at a 30 Hz frame rate and image-based software methods were used to extract eye motion for patients with MS (ages 21-70), with an average Expanded Disability Status Score (EDSS) of 3.3. For each recording, the patient was instructed to fixate on the upper right hand corner of the imaging raster for three, 10-second scans per eye. In an offline motion analysis, each of the 300 frames recorded was broken up into 16 strips to track fixational eye motion at 480 Hz. Blinks and low light levels were excluded from analysis. A median-Gaussian smoothing of the data was performed in order to eliminate eye motion artifacts at 30 Hz caused by the reference frame. Fixational eye motion metrics including velocity, amplitude, direction, frequency, standard deviation of frequency, and number of microsaccades were analyzed for each patient.
Results: Each patient's average fixational eye motion metrics were compared to their EDSS, which quantifies the extent of disability in MS. A multivariable linear regression, accounting for age as a possible confounding variable, revealed the number of microsaccades occurring within a 10-s interval increased with increasing EDSS score (p=0.016). Aside from the comparisons of motion metrics, five of the sixteen patients exhibited a clear micro-nystagmus throughout recordings, with amplitudes as small 8 arcminutes recorded.
Conclusions: In this cohort, the TSLO system was used to successfully measure and quantify the fixational eye motion of patients with MS and these were correlated to their degree of overall clinical disability. Additional patients will need to be recruited in order to determine the significance of TSLO for use as a prognostic and monitoring tool.

Commercial Relationships: Christy K. Sheehy, C. Light Technologies (F), C. Light Technologies (I), University of California, Berkeley (P), C. Light Technologies (E); **Ethan Bensinger**, None; **Michael P. Devereux**, None; **Nicholas S. Baker**, None; **Alexandra E. Boehm**, None; **Scott stevenson**, C. Light Technologies (S); **Ari J. Green**, None
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Program Number: 753 **Poster Board Number:** B0592
Presentation Time: 1:30 PM–3:15 PM
Timing of concurrent visual stimuli determines modulation of saccadic amplitude
Moritz Feil, Mathias Abegg. Department of Ophthalmology, Inselspital, Bern University Hospital, and University of Bern, Bern, Switzerland.
Purpose: The temporal relation of competing visual stimuli may determine the corresponding oculomotor response. In this study we systematically varied the temporal coincidence of two conflicting stimuli and we investigated saccades that were elicited from such stimuli.
Methods: We varied the time of presentation of two identical spatially separated stimuli between -150ms and +150ms and we measured the amplitude of the saccade elicited by these stimuli using infrared eye tracking. In the first experiment, all stimuli were shown for 25ms only. In the second experiment, stimuli remained on the screen until the subsequent stimulus appeared, while all stimuli were removed after saccade onset in the third experiment.
Results: We found saccadic averaging if stimuli were presented at intervals up to 75ms, i.e. the saccades landed at an intermediate position. The strongest effect was observed if a stimulus was shown 25ms after or before another stimulus. This led to a strong deviation of the landing point towards the second stimulus. In contrast time intervals longer than 75ms elicited saccade adaptation, i.e. the saccadic landing point gradually moved toward the second location over time.
Conclusions: The timing of two conflicting stimuli determines whether the saccade is directed at an averaged intermediate position or whether the saccadic amplitude undergoes adaptation.
Commercial Relationships: Moritz Feil, None; **Mathias Abegg**, None
Support: Mathias Abegg was supported by the Swiss National Science Foundation (Grant 320030_147023)

Program Number: 754 **Poster Board Number:** B0593
Presentation Time: 1:30 PM–3:15 PM
Does Saccade Response Amplitude Gain Vary with the Amplitude of Target Demand?
Lynn D. Greenspan. Graduate Program in Biomedicine, Department of Optometry, Salus University, Elkins Park, PA.
Purpose: To assess the effect of saccade length on response accuracy as measured by %overshoot and %undershoot in normal controls and in concussed subjects. Studies report that it is common to undershoot larger saccades(20^0) and to overshoot smaller saccades(5^0). Is there a saccade length which maximizes response accuracy and minimizes position error? Understanding typical patterns of saccade response accuracy is beneficial when comparing normal controls to concussed subjects.
Methods: In accordance with human research subject protocol and as part of an IRB approved study, 5 control & 5 post-concussion subjects viewed 720 custom generated (VisualEyes software, VNEL, NJIT) Landolt-C targets in 5, 10, 15 & 20^0 horizontal pseudorandom pro-saccades (gap-0 paradigm) on a monitor @40cm with chin and head stabilization. A binocular infrared ISCAN eye tracker (Woburn, MA, USA) recorded saccades. MATLAB (MathWorks inc. Waltham,MA) and SPSS software(IBM inc. Armonk,NY) were used to analyze saccade data. Blinks, wrong turns, outliers, anticipatory and non-movements were excluded. Saccade response amplitude gain (SRAG) is calculated as +%overshoot or -%undershoot. Mean absolute% position error is compared between the 2 subject groups.
Results: *Control subjects*: 45% of the 5^0 saccades undershoot, 60% of the 10^0 saccades, 74% of the 15^0 saccades and 81% of the 20^0 saccades undershoot. Mean absolute% position error @5^0= 9.18%(range 4.46-13.17), @10^0= 6.3%(5.83-6.62), @15^0= 9.81%(3.37-17.73), and @20^0=11.08%(6.3-20.3). *Concussed subjects*: 47.5% of the 5^0 saccades undershoot, 69% of the 10^0 saccades, 84% of the 15^0 saccades and 92% of the 20^0 saccades undershoot. Mean absolute% position error @5^0=3.36%(range 2.34-4.87), @10^0=10.05%(8.44-12.94), @15^0= 20.04%(17.89-24.08), and @20^0=26.23%(19.85-33.32).
Mean overall accuracy measures for controls=9.08% and concussed=14.9%. Significant internal variance exists.
Conclusions: Saccadic eye movement responses tend to undershoot the longer 20^0 demands at a greater frequency than the shorter 5^0 demands. Concussed subjects undershoot large saccade demands (20^0) at a higher rate than control subjects. Additionally, concussed subjects show greater %position error than normal control subjects. Low-midrange saccade lengths of near 10^0 yield maximum precision in SRAG with lower mean absolute %position error.
Commercial Relationships: Lynn D. Greenspan, None

Program Number: 755 **Poster Board Number:** B0594
Presentation Time: 1:30 PM–3:15 PM
Evaluation of saccades show ocular-motor fatigue in internuclear ophthalmoparesis due to multiple sclerosis
Jonathan B. Jacobs[1, 2], Alessandro Serra[1, 3], Clara Chisari[4], Margaret Skelly[1], Manuela Matta[5], Mark Walker[1, 3], Jeffrey Cohen[6].
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Purpose: To investigate the fatigue-based changes of saccadic properties produced by subjects with multiple sclerosis who displayed uni- or bi-lateral intranuclear ophthalmoplegia (INO), as compared to those made by unaffected subjects.
Methods: Subjects were selected from patients to the MS clinic. They were included in this study if they had a clinically apparent INO in either eye, and had no other neurological conditions. We recorded fixation, saccades and smooth pursuit in 30 MS patients (median age xx, median EDSS 3) with INO. We tested fatigue using a saccadic stimulus requiring tracking of a +/-10 degree, high-contrast laser target (diameter 0.1 deg) at 0.5Hz. Data were recorded using the Eyelink 2 video system, sampled at 500 Hz and 16-bit resolution. Subjects were asked to fixate a straight-ahead target for sixty seconds. They then performed the 10-minute saccadic fatigue test before being asked to perform an additional sixty-second fixation of the central target. We measured pulse-size ratio (PSR) and interocular timing of saccade onset (PTD) using a 10 deg/sec velocity threshold for saccades made during the first ("time 1") and last ("time 2") 90 seconds. Mean and proportion differences were calculated with paired t-test and chi-square test respectively.
Results: Overall, the INO group showed increased PSR [average from 1.596 (range 1.001-3.70) at time 1 to 1.67 (range 1.11-5.56) deg/sec at time 2), p=0.01] and increased PTD [average from 0.015

(range 0.001-0.218) at time 1 to 0. 021 (range 0.001-0.318) msec at time 2), p=0.002]. After fatigue 17 INOs showed increased PSR with 20 INOs showing PTD increase ≥ 2 msec. 10 INOs showed increased PTD without increased PSR.
Conclusions: Ocular-motor fatigue in MS-related INO may be secondary to decreased size (increased PSR) and/or delayed delivery (increased PTD) of the saccadic pulse for the adducting eye. Adding a measure of interocular timing of saccade onset (PTD) may expand the ability to capture ocular-motor fatigue in INO. Ocular-motor fatigue may be due to compromised axonal transmission in the MLF under high-demand ocular-motor tasks. INO may represent an accessible model to understand motor fatigue in MS and test therapies intended to ameliorate axonal transmission and improve INO-related visual disability.
Commercial Relationships: Jonathan B. Jacobs; **Alessandro Serra**, Biogen Idec (R); **Clara Chisari**, None; **Margaret Skelly**, None; **Manuela Matta**, None; **Mark Walker**, None; **Jeffrey Cohen**, Novartis (C), Genentech (C), Receptos (C), Genzyme (C), Merck (C)
Support: VA Career Development Award (Serra)

Program Number: 756 **Poster Board Number:** B0595
Presentation Time: 1:30 PM–3:15 PM
Gaze patterns are largely normal but performance is impaired during visual search in frontotemporal dementia
Amanda Douglass[1], Mark Walterfang[2, 1], Larry A. Abel[1]. [1]The University of Melbourne, Melbourne, VIC, Australia; [2]The Royal Melbourne Hospital, Melbourne, VIC, Australia.
Purpose: Behavioural variant frontotemporal dementia (bvFTD) is an insidious progressive disease which affects speech and behaviour. BvFTD patients are known to have difficulty with visual search. This study aimed to explore eye movements during visual search in these patients.
Methods: 15 bvFTD as well as 19 age and sex matched control participants were recruited to undertake two visual search tasks: a colour visual search, and a conjunction task requiring both colour and orientation to be correctly identified. Each task presented visual search targets in a grid pattern (4x4, 5x5… etc.) with between 16 and 100 items present on the screen. Participants were asked to indicate if the target was present or absent.
Results: In all search tasks bvFTD participants produced more errors. Slope values for reaction time by array size were not significantly different between bvFTD and controls, whilst bvFTD participants consistently displayed a significantly increased intercept value on both colour ($W=236$, $p<0.001$), and conjunction ($W=296$, $p<0.001$) searches. BvFTD participants, when performing the task correctly, examined more objects for both colour ($F(1,219)=11.260$, $p<0.001$), and conjunction searches ($F(1,232)=11.800$, $p<0.001$), as well as making more fixations for both colour ($F(1,219)=55.479$, $p<0.001$), and conjunction ($F(1,232)=30.045$, $p<0.001$). For the conjunction task this was due to an increase at small array sizes, with no significant difference for larger arrays. An effect of array size was also present for string editing, with bvFTD participants displaying greater variability in their scan paths than controls only for smaller arrays.
Conclusions: BvFTD participants displayed grossly normal patterns of eye movements in the visual search task. A small increase is seen in reaction time, but this is due to an increased latency for the task as indicated by the increased reaction time intercept, rather than difficulty processing the task. Differences are primarily seen between the two groups for smaller array sizes where control participants perform optimally. The grossly normal eye movements and impaired performance have potential to differentiate these patients from other diagnostic groups including Alzheimer's disease, which display abnormal scan paths in these tasks.
Commercial Relationships: Amanda Douglass, None; **Mark Walterfang**, None; **Larry A. Abel**, None
Support: Australian Postgraduate Award

Program Number: 757 **Poster Board Number:** B0596
Presentation Time: 1:30 PM–3:15 PM
Repeatability of Visual Acuity Measured in Eccentric Gaze in Patients with Infantile Nystagmus Syndrome
Kristi Kester, Tawna L. Roberts, Richard W. Hertle. Department of Ophthalmology, Akron Children's Hospital, Akron, OH.
Purpose: Infantile nystagmus syndrome (INS) is a specific ocular motor disorder with characteristic clinical findings and electrophysiology. Patients with INS often have a null-zone (eye in orbit, or gaze position) where the nystagmus intensity is at its minimum. This physiological null zone often results in an anomalous head posture by the patient to achieve better visual function. Optotype visual acuity (OVA) as a measure may not reflect the deficit imposed on the visual system as a result of the nystagmus. A better measure may be OVA as a function of gaze. The purpose of this study was to assess the test-retest reliability of OVA across horizontal gaze in patients with INS and adult controls to determine if gaze dependent OVA (GDOVA) is a reliable methodology.
Methods: Test and re-test OVA were measured binocularly using the ETDRS protocol on the Electronic Visual Acuity (EVA) testing system. Subjects (n=34; 20 INS ages 8-47 years, and 14 control ages 21-65 years) were seated 3 M from a monitor and OVA measured in 7 horizontal gaze positions from 30 degrees left to 30 degrees right in 10 degree steps with the order randomized. OVA testing was repeated twice in each of the 7 gaze positions. Head position was monitored using a cervical range of motion headpiece (CROM^R). The letter score obtained by the EVA system was converted to logMAR. Test-retest reliability was assessed using intraclass correlation coefficients (ICC) and two-factor repeated measures (gaze position and group) analysis of variance (ANOVA).
Results: Test-retest reliability was high in both the INS and control subjects as the difference in test-retest OVA for both the experimental and control groups was on average less than 0.1 logMAR in each of the 7 gaze positions. The ICC was ≥0.98 in the INS group and ≥0.88 for the control group in each of the 7 gaze positions. A significant difference in letter score was not detected using a two-factor repeated measures ANOVA between group ($p=0.053$), gaze ($p=0.266$), or interaction of group and gaze ($p=0.789$).
Conclusions: OVA testing has excellent repeatability across 60 degrees of horizontal gaze in patients with INS and normal adult controls. GDOVA is a reliable measure and may be a valuable tool as an outcome variable in studies involving patients with INS.
Commercial Relationships: Kristi Kester, None; **Tawna L. Roberts**, None; **Richard W. Hertle**, None

Program Number: 758 **Poster Board Number:** B0597
Presentation Time: 1:30 PM–3:15 PM
Quantifying The Improvement In Optotype Visual Acuity In Patients With Infantile Nystagmus Syndrome As A Function of Gaze Dependent Visual Acuity Pre- And Post-Treatment
Tawna L. Roberts, Richard W. Hertle. Ophthalmology, Akron Children's Hospital, Akron, OH.
Purpose: Optotype visual acuity (OVA) in patients with infantile nystagmus syndrome (INS) is time, attention, and gaze (eye in orbit) dependent (GDVA). In their alert state, these patient's best GDVA occurs at their null-position where their nystagmus is most dampened. Treatment goals for these patients are multifactorial as

one goal is to improve best corrected VA; whereas another goal is increase the breadth and depth of the null-position. If OVA is to be used as an outcome measure for interventional studies in patients with INS, a method of collection needs to address its dynamicity. The purpose of this case-series is to present a novel method to quantify OVA across horizontal gaze as a measure called "functional vision space" (FVS) in patients with INS and show its utility as a measure of treatment effects.

Methods: OVA (logMAR) was measured binocularly with best correction horizontally from -20 to +20 degrees in 5 degree intervals before and after combined medical, optical and surgical treatment in 85 patients with oculocutaneous albinism type 1 and INS. The best and worst OVA and the size of the null-position (degrees) was determined pre- and post-treatment. Additionally, the area under-the-curve (AUC) was calculated by integration with the horizontal eye position on the x-axis while logMAR OVA was on the y-axis to represent the zone of FVS with respect to horizontal eye position. A paired t-test was used to determine statistical significance between best and worst static OVA, size of the null-position and AUC for the zone of FVS pre- and post-treatment.

Results: As a group, patients had a significant improvement in both their best ($p<0.001$) and worse ($p<0.001$) static OVA. Patients also had a significant increase ($p<0.001$) in the size of their null-position and a significant decrease ($p<0.001$) in the AUC (increase in FVS) after treatment.

Conclusions: Specific changes of OVA in patients with INS can be quantified as a static change in best corrected OVA, worst OVA or improvement as a function of gaze (eye in orbit). We have also proposed a method of integration for calculating changes in OVA across horizontal gaze positions, e.g., GDVA, which encompass all three static measures into one metric, representing an area of functional vision space. The new metric may be used to monitor treatment outcomes in patients with INS.

Commercial Relationships: Tawna L. Roberts, None; **Richard W. Hertle**, None

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Program Number: 759 **Poster Board Number:** B0598
Presentation Time: 1:30 PM–3:15 PM

A Normative Study of Objective Measures of Disparity Vergence in Children 9 to 17 years old

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Purpose: To develop normative values for objective measures of disparity vergence in children.

Methods: Potential participants (9 to 17 years of age) had a vision examination including refraction, accommodative, and binocular vision testing. Eligibility criteria included 20/25 visual acuity with best correction, normal accommodation and binocular vision. The ISCAN RK-826PCI (240 Hz) binocular tracking system was used to objectively record horizontal vergence eye movements. Participants were presented with 48, 4° symmetrical convergence step stimuli. Twenty-four of the stimuli began at an initial vergence angle between 2° to 8° (referred to as far stimuli) and 24 began at an initial vergence angle between 6° to 12° (referred to as near stimuli). Objective parameters assessed included peak velocity, time to peak velocity, latency, settling time and response amplitude.

Results: We recruited 51 subjects between the ages of 9 and 17 years old (mean age: 13, 58.8% were female). The mean values for peak velocity, time to peak velocity, latency, settling time, and response amplitude were 26.38°/sec, 0.58 sec, 0.28 sec, 2.60 sec, and 3.74°, respectively for 4° convergence step stimuli at far, and 26.25°/sec, 0.61 sec, 0.31 sec, 2.63 sec, 3.67° respectively for 4° convergence step stimuli at near. We divided the subjects into three groups by age (9-11 years n=13, 12-14 years n=17, 15-17 years n=21 years old) to determine if there was a development trend in the mean values. We did not find a statistically significant difference between the 3 groups for any of the parameters.

Conclusions: The data from this study can be used by researchers to help determine the significance of objective disparity vergence measures when comparing children with binocular vision problems to those with normal binocular vision. In addition, these data may be useful for researchers planning future treatment studies and provide data that may be useful for determining sample size and outcome measures.

Commercial Relationships: Mashael Namaeh, None; **Mitchell Scheiman**, None; **G.Lynn Mitchell**, None; **Tara L. Alvarez**, None

Program Number: 760 **Poster Board Number:** B0599
Presentation Time: 1:30 PM–3:15 PM

Vergence and accommodation in non-strabismic hyperopic children

Vidhyapriya Sreenivasan, Yifei Wu, Sonisha Neupane, Don Lyon, Katie S. Connolly, T Rowan Candy. Optometry, Indiana University, Bloomington, IN.

Purpose: About 20% of children with significant hyperopia decompensate into refractive esotropia while others with similar refractive error remain aligned (Babinsky & Candy 2013). How does the hyperopic oculomotor system achieve focused and aligned images despite the conflict between accommodation & vergence? Here we compared vergence and accommodation during monocular and binocular viewing between young non-strabismic hyperopic & typically developing children.

Methods: Purkinje image tracking & eccentric photorefraction (MCS PowerRefractor, PR) were used to record vergence & refractive state of non-strabismic children (1-9 years) with uncorrected hyperopia (UHY; N=9, Mean cyclo SE=+3.4 D, SD 0.5), partially corrected hyperopia (PCY; N=7, Mean cyclo SE=+5.0 D, SD 2.1; SRx: +3.9 D, SD 1.7) or typical development (TYP, N=11; Mean cyclo SE= +1.0 D, SD 0.8). Children viewed naturalistic targets at 1m & 0.33m in monocular and binocular viewing. Monocular responses were compared between right & left eye viewing & after dissociation of 5s & 30s. Phoria was derived from the difference between binocular & monocular alignment.

Results: There was no difference (mixed model) in accommodative accuracy across groups ($p=0.7$) (refractive state values at 1m, UHY +0.9 D, SD 0.7; PCY +0.2D, SD 0.2; TYP +0.2 D SD 0.3, and at 0.33m, UHY -1.3D, SD 1; PCY -1.5D, SD 1; TYP -2.0D, SD 0.7). The ratio of change in vergence to accommodation (V:A) showed significantly smaller monocular viewing ratios than binocular ratios (mean diff=0.2MA/D; $p=0.00$). The hyperopic groups showed lower monocular ratios than the TYP (Mean diff=0.1MA/D), although this difference was not significant ($p=0.4$). Phoria was also not different on average ($p=0.9$) between hyperopes and TYP (Exophoria at 0.33m: UHY -1.9 pd, SD 3; PCY -4.3pd, SD 4.5; TYP -2.7pd, SD 3.2). However, we found significant effects of viewing distance (mean 3.2 pd more exophoric at 0.33m, $p=0.000$) & dissociation time (mean 0.9 pd more exophoric for 30s; $p=0.009$) on phoria.

Conclusions: These data suggest some hyperopes, who remain binocularly aligned, show simultaneous accommodative & vergence performance comparable to that seen in typically developing children under both monocular & binocular viewing conditions

Commercial Relationships: Vidhyapriya Sreenivasan; **Yifei Wu**, None; **Sonisha Neupane**, None; **Don Lyon**, None; **Katie S. Connolly**, None; **T Rowan Candy**, None
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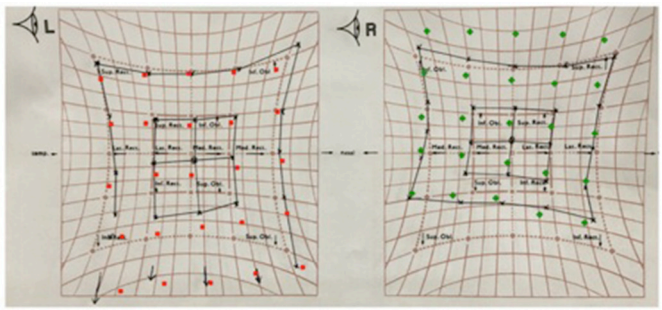
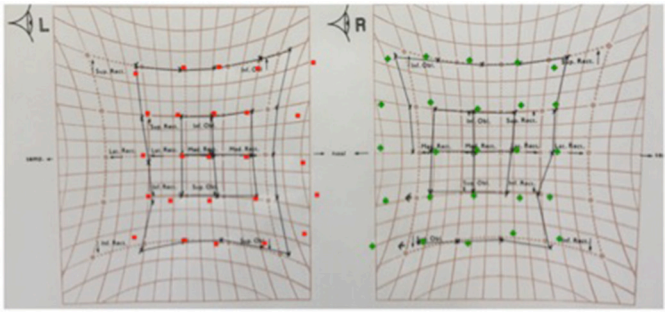
Program Number: 761 **Poster Board Number:** B0600
Presentation Time: 1:30 PM–3:15 PM
Does cover test overestimate systematically the phoria values?
Clara Mestre, Carles Otero, Josselin Gautier, Jaume Pujol. Davalor Research Center (dRC). Universitat Politècnica de Catalunya, Terrassa, Spain.
Purpose: To analyze the differences between deviations of both eyes and the displacement of one single eye during the measurement of horizontal phoria in the cover test.
Methods: Both right and left eye movements were recorded synchronously with the eye-tracker embedded in the stereoscopic virtual reality system EVA (Eye and Vision Analyzer, Davalor Salud, Spain) during the performance of the cover test at near vision (40 cm). Participants were asked to fixate a stimulus during 2 cycles, each cycle comprised the following states: binocular vision, right eye occlusion, binocular vision, left eye occlusion. Each state lasted 4 s (seconds) but only the last 0.5 s was considered to compute the median eye's position of each state. Two different computational methods were used to measure the phoria. First, it was computed as the displacement of the occluded eye from the previous binocular state. Second, phoria was calculated as the difference between the displacements of the occluded and fixating eyes from their respective binocular positions. In all cases the final phoria value was computed as the average of the 4 trials.
Results: 19 subjects were included in the study, with a mean age ± standard deviation (SD) of 22.3 ± 3.5 years, normal or corrected-to-normal visual acuity and a horizontal phoria greater than 1 PD (prism diopter) (8 exophoric and 11 esophoric). The average accuracy ± SD of the eye-tracker recordings was 0.37° ± 0.18°. The dependent t-test showed statistically significant differences between the phoria values computed as one eye's displacement and between eyes deviations ($t(18)=6.2$, $p<0.001$). The mean difference ± SD was 0.67 ± 0.47 PD (range from 0.17 PD to 1.68 PD). In 21.1% of the subjects the differences were greater than 1 PD.
Conclusions: Major advantages of using an eye-tracker during the cover test are the possibility of registering both eyes' movements synchronously and the increased resolution of the measure with respect to the clinician's observations. Our results suggest that the phoria measurement considering one eye's deviation is greater than when the deviation of the visual axes of both eyes is taken into account. It is hypothesized that under dissociated conditions the fixating eye moves according to Hering's law of equal innervation, which leads to an overestimation of the phoria value when deviations of one single eye are measured.
Commercial Relationships: Clara Mestre, DAVALOR SALUD S.L. (F); **Carles Otero**, DAVALOR SALUD S.L. (F); **Josselin Gautier**, DAVALOR SALUD S.L. (E), DAVALOR SALUD S.L. (F); **Jaume Pujol**, DAVALOR SALUD S.L. (F)
Support: Spanish Ministry of Economy and Competitiveness grant DPI2014-56850-R; Generalitat de Catalunya by Predoctoral grant FI-DGR (CM; CO); Davalor Salud, S.L. (Spain)

Program Number: 762 **Poster Board Number:** B0601
Presentation Time: 1:30 PM–3:15 PM
Stepping into the virtual unknown: feasibility study of a virtual reality-based test of ocular misalignment
Nisha Nesaratnam, Peter Thomas, Anthony Vivian. Department of Ophthalmology, Addenbrooke's Hospital, Milton Keynes, United Kingdom.
Purpose: Dissociated tests of incomitant strabismus, such as the Lancaster red-green test, Hess screen and Lees screen, provide valuable tools for diagnosis and monitoring of ocular misalignment in patients with normal retinal correspondence. However, they all lie vulnerable to operator error and rely on head fixation. Virtual reality headsets obviate the need for head fixation, whilst providing other clear theoretical advantages, including complete control over the illumination, background and nature of targets presented for the patient to interact with. We compared the performance of a virtual reality-based test of ocular misalignment to that of the traditional Lees screen, to establish the feasibility of virtual reality technology use in the diagnosis and monitoring of ocular misalignment in the future.
Methods: Each patient recruited to this prospective study underwent a traditional Lees screen test, and a virtual reality headset-based test of ocular motility. The virtual reality headset-based program was written in PsychoPy, and consisted of an initial test to measure horizontal and vertical deviation, followed by a test for torsion. Deviations from each test were compared using Bland-Altman analysis.
Results: The pattern of deviation obtained using the virtual reality-based test showed agreement with that obtained from the Lees screen for a variety of paretic and restrictive conditions, including fourth nerve palsy (Fig. 1), restrictive thyroid eye disease (Fig. 2).
Conclusions: This study reports the first use of a virtual reality headset in assessing ocular misalignment, and demonstrates that it is a feasible dissociative test of incomitant strabismus. It also highlights challenges of virtual reality technology, including the deprivation of absolute depth cues leading to accommodative flux, which may limit quantification of ocular deviation.





Commercial Relationships: Nisha Nesaratnam, None; **Peter Thomas**, None; **Anthony Vivian**, None