



# CURRENT RESEARCH IN BEHAVIORAL & DEVELOPMENTAL OPTOMETRY

*The following article summaries were compiled from submissions from the students and residents who received Travel Grants to attend the COVD 41<sup>st</sup> Annual Meeting.*

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## CONTENTS

Accommodation .....	8
Koslowe K, Glassman T, Tzanani-Levi C, Shneur E. Accommodative amplitude determination: pull-away versus push-up method. <i>Optom Vis Dev</i> 2010;41:28-32.....	8
Sreenivasan V, Irving EL, Bobier WR. Effect of near adds of variability of accommodative response in myopic children. <i>Ophthal Physiol Optics</i> 2011; 31: 145-154.....	8
Tosha C, Borsting E, Ridder WH, Chase C. Accommodation Response and Visual Discomfort. <i>Oph Physiol Opt</i> 2009;29:625-33. ....	9
Berntsen DA, Mutti DO, Zadnik K. The effect of bifocal add on accommodative lag in myopic children with high accommodative lag. <i>Invest Ophthal Vis Sci</i> 2010; 51(12):6104-6110. ....	9
Amblyopia.....	10
Barnes G, Li X, Thompson B et al. Decreased gray matter concentrations in the lateral geniculate nuclei in human amblyopes. <b><i>Invest Ophthal Vis Sci</i> 2010; 51:1432-8</b> .....	10
Niechwiej-Szwedo E, Goltz HC, Chandrakumar M, et al. Effects of anisometropic amblyopia on visuomotor behavior, I: saccadic eye movements. <i>Invest Ophthal Vis Sci</i> 2010; 51:6348-6354.....	11
<b>Hess R, Mansouri B, Thompson B. A Binocular Approach to Treating Amblyopia: Antisuppression therapy. <i>Opt Vis Sci</i> 2010;87:697-704</b> .....	12
<b>Kanonidou E, Proudlock FA, Gottlob I. Reading Strategies in Mild to Moderate Strabismic Amblyopia: An Eye Movement Investigation. <i>Invest Ophthal Vis Sci.</i> 2010; 51:3502-3508.</b> .....	13
<b>Pediatric Eye Disease Investigator Group Writing Committee. <i>A Randomized Trial Comparing Bangerter Filters and Patching for the Treatment of Moderate Amblyopia in Children. Ophthalmology</i> 2010; 117:998-1004</b> .....	14
Li C-H, Chen P-L, Chen J-T, Fu J-J. Different corrections of hypermetropic errors in the successful treatment of hypermetropic amblyopia in children 3 to 7 years of age. <i>Am J Ophthalmol</i> 2009;147:357-63.....	14
PEDIG. Randomized trial of treatment of amblyopia in children aged 7 to 17 years. <i>Arch Ophthalmol.</i> 2005; 123: 437-47.....	15
Repka M, Simons K, Kraker R, et al. Laterality of amblyopia. <i>Am J Ophthalmol</i> 2010; 150:270-4 .....	16
Holmes, J.M., Melia, M., Bradfield YS, et al. Factors Associated with Recurrence of Amblyopia on Cessation of Patching. <i>Ophthalmology.</i> 2007; 114: 1427-1432 .....	16
Repka MX, Kraker RT, Beck RW et al. Contrast sensitivity following amblyopia treatment in children. <i>Arch Ophthalmol</i> 2009;127:1225-1227. ....	17
Dobson, V, Harvey, EM, et al. Amblyopia in Astigmatic Infants and Toddlers. <i>Optom Vis Sci.</i> 2010; 87(5): 330-336. ....	17

Altinas O, Etus V, Etus H, et al. Risk of strabismus and amblyopia in children with hydrocephalus. Graefe's Arch Clin Exp Ophthalmol 2005; 243: 1213-1217. ....	18
Suttle CM, Melmoth DR, Finlay AL, et al. Eye hand coordination skills in children with and without amblyopia. Invest Ophthal Vis Sci. 2011;52:1851-64. ....	18
Autism Spectrum Disorders .....	19
Franklin, A, Sowden, P, Notman, L, et. al. Reduced chromatic discrimination in children with autism spectrum disorders. Dev Sci 2010;13:188-200. ....	19
Milne E, Griffiths H, Buckley A and Scope A. Vision in children and adolescents with autistic spectrum disorder: evidence for reduced convergence. J Autism Dev Disord 2009;39(7):965-75. ....	20
The Pediatric Eye Disease Investigator Group (PEDIG). Risk of amblyopia recurrence after cessation of treatment. JAAPOS. 2004;8:420-8. ....	21
Binocular Vision/Stereopsis .....	21
O'Connor AR, Birch EE, Anderson S, Draper H. Relationship between binocular vision, visual acuity, and fine motor skills. Optom Vis Sci, 2010; 87: 942-7. ....	21
Brain Injury .....	22
Ciuffreda KJ, Ludlum D, Thiagarajan P. Oculomotor diagnostic protocol for the mTBI population. Optometry 2011; 82:61-3. ....	22
Rowe F. The profile of strabismus in stroke survivors. Eye. 2010; 24:682-5 .....	23
Ciuffreda KJ, Kapoor N. Oculomotor dysfunctions, their remediation, and reading-related problems in mild traumatic brain injury. JBeh Optom 2007; 18:72-77. ....	23
Binocular Vision Testing.....	24
Wood J, Chaparro A, Anstey K, et. al. Simulated visual impairment leads to cognitive slowing in older adults. Optometry Vision Science. 2010; 87:1037-1043.....	24
Computer Vision Syndrome .....	25
Rosenfield M, Gurevich R, Wickware E, Lay M. Computer vision syndrome: accommodative and vergence facility. J Beh Optom. 2010; 21: 119-122. ....	25
Collier JD, Rosenfield M. Accommodation and convergence during sustained computer work.Optometry. 2011; 82: 434-40 .....	25
Convergence Insufficiency .....	26
Rouse Michael OD., Borsting Eric, et al. Academic Behaviors in Children with Convergence Insufficiency ...	26
with and without Parent-Reported ADHD. Optom Vis Sci. 2009 October ; 86: 1169-1177. ....	26

Scheiman, M, Kulp, M, Cotter, S, et. al. Vision therapy/ orthoptics for symptomatic convergence insufficiency in children: treatment kinetics. <i>Optom Vis Sci.</i> 2010; 87: 593-603.....	27
Alvarez TL, Vicci VR, Alkan Y, Kim EH, et al. Vision therapy in adults with convergence insufficiency: clinical and functional magnetic resonance imaging measures. <i>Optom Vis Sci.</i> 2010; 87: E985-E1102. ....	27
Convergence Insufficiency Treatment Trial Study Group.....	28
Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. <i>Arch Ophthalmol</i> 2008;126:1336-49.....	28
Down Syndrome.....	28
Al-Bagdady M, Stewart RE, Watts P, et al Bifocals and down's syndrome: correction or treatment? <i>Ophthalmic and Physiol Optics</i> 2009; 29: 416-21 .....	28
Eye Movements .....	29
Fischer B, Hartnegg K. Instability of fixation in dyslexia: development - deficits - training. <i>Optom Vis Dev</i> 2009; 40: 221-228. ....	29
Exotropia .....	29
Matsuo T, Yabuk A, Hasebe K, Shire YH et al. Postural Stability Changes during the prism adaptation test in patients with intermittent and constant exotropia. <i>Invest Ophthal Vis Sci</i> 2010; 51:6341-6347 .....	29
Memory.....	30
Harrison SA, Tong F. Decoding reveals the contents of visual working memory in early visual areas. <i>Nature.</i> 2009; 458: 632-5. ....	30
Myopia .....	31
Marsh-Tootle WL, Dong LM, Hyman L, et. al. Myopia progression in children wearing spectacles vs. switching to contact lenses. <i>Optom Vis Sci</i> 2009; 86:741-7 .....	31
Jones-Jordan LA, Sinnutt LT, Manny RE, Cotter SA, et. al. Early Childhood refractive error and parental history of myopia as predictors of myopia. <i>Invest Ophthal Vis Sci</i> 2010; 51:115-121 .....	31
<b>Borsting E, Tosha C, Chase C, Ridder WH. Measuring near-induced transient myopia in college students with visual discomfort. <i>Optom Vis Sci</i> 2010;87:760-66. ....</b>	<b>32</b>
Rudnicka AR, Owen CG, Nightingale CM, et al. Ethnic differences in the prevalence of myopia and ocular biometry in 10- and 11-year-old children: the child heart and health study in England (CHASE). <i>Invest Ophthal Vis Sci</i> 2010; 51:6270-76.....	33
Pediatric Vision .....	33
Maples WC. Frequency and types of pediatric symptoms in a clinical population. <i>Optom Vis Dev</i> 2010; 41(2):74-80.....	33

Deng L, Gwiazda J, Thorn F. Children's refractions and visual activities in the school year and summer. <i>Opt Vis Sci</i> 2010;87:406-13. ....	34
Ibironke JO, Friedman DS, Repka MX, Katz J et al. Child development and refractive errors in preschool children. <i>Optom Vis Sci.</i> 2010; 88:181-7.....	35
Presbyopia.....	35
Polat U. Making perceptual learning practical to improve visual functions. <i>Vision Res</i> 2009: 49:2566-73.	35
Saccades/Reading Eye Movements .....	36
Webber A, Wood J, Gole G, Brown B. DEM test, visagraph eye movement recordings and reading ability in children. <i>Optom Vis Sci</i> 2011; 88: 295-302 .....	36
Tian J, Ethier V, Shadmehr R, et al. Some perspectives on saccade adaptation. <i>Ann NY Acad Sci</i> 2009;1164:166-172.....	36
Kis AC, Singh VWA, Niemeier M. Short- and long-term plasticity of eye position information: Examining perceptual, attentional, and motor influences on perisaccadic perception. <i>J Vis</i> 2009;9:1-21.....	37
Okumura, T., Laukkanen, H., & Tamai, H. "Computerized saccadic eye movement therapy to improve oculomotor control during reading and reading rate in adult Japanese readers: by <i>Optom Vis Dev.</i> 2008; 39:191-7 .....	38
Reading.....	38
Cohen Y, Segal O, Barkana Y, et al. Correlation between asthenopic symptoms and different measurements of convergence and reading comprehension and saccadic fixation eye movements. <i>Optometry</i> 2010; 81: 28-34. ....	38
Stereopsis .....	39
O'Connor AR, Birch EE, Anderson S, et al. The functional significance of stereopsis. <i>Invest Ophthal Vis Sci</i> 2010;51(4):2019-23.....	39
Vestibular Dysfunction .....	40
Winkler PA, Ciuffreda KJ. Ocular Fixation, vestibular dysfunction and visual motion hypersensitivity. <i>Optometry</i> 2009; 80:502-12.....	40
Vision Development.....	40
Mitchell DE, Kennie J, and Kung D. Developmental of global motion perception requires early postnatal exposure to patterned light. <i>Curr Biology</i> 2009: 19; 645-9.....	40
Daw NW. Critical Periods: Motion sensitivity is early in all areas. <i>Curr Biol</i> 2009;19:R336-8.....	41
Visual Acuity.....	42
Drover JR, Morale SE, Wang YZ et al. Vernier acuity cards: examination of development and screening validity. <i>Optom Vis Sci</i> 2010;87:E806-E812.....	42

Vision and Aging.....	42
Wood J, Chaparro A, Anstey K, et. al. Simulated visual impairment leads to cognitive slowing in older adults. Optometry Vision Science. 2010; 87:1037-1043.....	42
Visual Motor Integration .....	43
Koslowe, K. Bienenfeld, N. Tanamai, S. Shneur, E. The relationship between heterophoria and visual organization in first and second grade children on the Gesell Copy Form Test. Optom Vis Dev. 2010; 41: 33-37.....	43
Vision Perception.....	44
Burr D, Banks MS, Morrone MC. Auditory dominance over vision in the perception of interval duration. Exp Brain Res 2009;198:49-57.....	44
Censor N, Bonneh Y, Arieli A, Segi D. Early-vision brain responses which predict human visual segmentation and learning. J Vision 2009;9: 1-9 .....	44
Op deBeeck H, Baker CI. The neural basis of visual object learning. Trends Cog Sci. 2009;14:22-30.....	45
Roelfsema PR, van Ooyen A, Watanabe T. Perceptual learning rules based on reinforcers and attention. Trends in Cognitive Sciences. 2009; 14: 64-71.....	46
Jordan TR, Paterson KB, Stachurski M. Re-evaluating split-fovea processing in word recognition: effects of word length. Cortex. 2009; 45: 495-505. ....	46
Albrecht , T. et al. Individual differences in metacontrast masking are enhanced by perceptual learning. Consciousness and Cognition 2010; 19: 656-66. ....	47
Houtkap R, Roelfsema PR. Matching of visual input to only one item at any one time. Psych Res 2009;73:317-26. ....	48
Vision Screening.....	48
VIP Study Group. Effect of Age Using Lea Symbols or HOTV for Preschool Vision Screening. Optom Vis Sci. 2010; 87 .....	48
Marsh-Tootle WL, Funkhouser E, Frazier MG, Crenshaw K, Wall TC. Knowledge, attitudes, and environment: What primary care providers say about pre-school vision screening. Optom Vis Sci 2010; 87: 104-111. ....	49
Register SJ. Visual acuity and stereopsis screening results in an underserved community. Optometry 2010;81:200-4. ....	50

## ACCOMMODATION

KOSLOWE K, GLASSMAN T, TZANANI-LEVI C, SHNEOR E. ACCOMMODATIVE AMPLITUDE DETERMINATION: PULL-AWAY VERSUS PUSH-UP METHOD. OPTOM VIS DEV 2010;41:28-32.

Two established methods for accommodative amplitude measurement are the push-up and minus-lens method. These tests rely on a patient's ability to determine first sustained blur, which can be a difficult concept for patients. This disadvantage has led to the search for more reliable tests. A third method, the pull-away method, has recently gained support based on the belief that it is a more reliable measurement, though data does not currently support this claim.

This study compared the push-up and pull-away tests. The push-up test requires the patient to determine when a target becomes blurred as it is moved toward the spectacle plane. The pull-away test requires a target to be pulled away from the spectacle plane until the patient can correctly identify the target.

In this study there were 79 subjects ranging in age from 7 to 35 years. Amplitude of accommodation was measured on subjects split into three age groups (7-12, 13-20, 21-35) whose visual acuity had been corrected to 20/20 or better. Two different examiners administered first the pull-away test then the push-up test on every subject, and an average value of the two trials for both methods was calculated. Both examiners used the same instructional set. The correlation test showed a strong correlation between the two methods in all age groups ( $p < .0005$ ). However the  $t$  test showed a statistically significant difference between mean values obtained by both methods; the pull-away test consistently gave values between 2.0 and 2.6 diopters lower for total amplitude of accommodation.

Several factors likely contributed to the statistical differences between tests. The psychophysical error of habituation acts oppositely on the two methods by exaggerating amplitude on the push-up test and minimizing it on the pull-away test. In addition, it may be easier to recognize the point of identification (pull-away test) than the point of sustained blur (push-up test). Changes in the instructional set in comparison to other studies may also explain the discrepancy from previous results. This study suggests that a new set of normative data should be obtained if the pull-away method continues to be utilized.

SREENIVASAN V, IRVING EL, BOBIER WR. EFFECT OF NEAR ADDS OF VARIABILITY OF ACCOMMODATIVE RESPONSE IN MYOPIC CHILDREN. OPHTHAL PHYSIOL OPTICS 2011; 31: 145-154

The study's goal was to determine how near adds affect accommodative variability (VAR) in patients with a myopic or emmetropic prescription with varying degrees of near phoria. The effect of viewing conditions, either binocular or monocular, was also investigated.

The study was made up of 27 myopic (-0.75 to -6 diopters) and 25 emmetropic (+0.25 to +1.50 diopters) patients between 7-14 years of age. Participants were also classified based on near phoria: 0-4 exo (normophores), >6 exo (exophores), >2 eso (esophores). Accommodation was

measured for 5 s using the PowerRefractor with distance prescription, -2.00D and +2.00D adds. Accommodation was also recorded for monocular and binocular viewing conditions.

Results show that myopes have a higher VAR than emmetropes through their distance refractions. Through +2.00D, VAR decreased in myopes to a level equal that of emmetropes. Through -2.00D, VAR for myopes and emmetropes both increased, with myopes increasing more than emmetropes. Near phoria did not affect the VAR for either group with or without an Add. VAR correlated with the accommodative error in both myopes and hyperopes.

TOSHA C, BORSTING E, RIDDER WH, CHASE C. ACCOMMODATION RESPONSE AND VISUAL DISCOMFORT. OPH PHYSIOL OPT 2009;29:625-33.

The objective of this study was to determine whether or not clinical measures of accommodation were different among subjects with and without visual discomfort. This study specifically measured accommodative responses for longer periods of exposure (2 minutes) than previously published studies. Subjects included 31 college students group into either a high or a low visual discomfort group based upon their responses to the Conlon Visual Discomfort Survey. The subjects were blind as to their group assignment.

Testing was standardized and performed by researchers, using the mean of three measurements used in each category. Inclusion criteria included best corrected visual acuity of 20/25 or better, no constant strabismus, normal stereopsis, minimal refractive error, and no significant ocular pathology. Protocol included tests of vergence, accommodation, and fixation disparity. For determination of accommodative response, an auto refractor was used. Subjects were asked to view a 2 cm high-contrast star and to keep it in focus throughout the entire testing period. The accommodative response was recorded every 200 ms for two minutes at five consecutive viewing distances.

Both the high and low discomfort groups showed a larger accommodative lag at near viewing distances; however, the lag of accommodation increased over time for the high discomfort group while the lag of accommodation remained stable among the low discomfort group.

The authors felt that measurement of accommodation over a period of 90 seconds or more may be necessary to determine the difference between the low and high visual discomfort groups. Results indicate that an “accommodative fatigue effect” rather than accommodative insufficiency.

The authors note that other sources for potential fatigue and further study include the effect of wavelength on accommodative response and a slow accommodative adaptation mechanism.

BERNTSEN DA, MUTTI DO, ZADNIK K. THE EFFECT OF BIFOCAL ADD ON ACCOMMODATIVE LAG IN MYOPIC CHILDREN WITH HIGH ACCOMMODATIVE LAG. INVEST OPHTHAL VIS SCI 2010; 51(12):6104-6110.

Bifocal adds and progressive addition lenses (PALs) have been found to decrease accommodative lag and reduce hyperopic blur during near work, possibly delaying myopia

progression. This study investigates how a bifocal add influences accommodative lag in children with myopia and a high accommodative lag.

Subjects included eighty-three (83) children between 6 to 11 years of age who fit the following criteria: myopia ranging from -0.75 diopter (D) to -4.50 D in either eye, accommodative lag of at least 1.30 D when presented with a 4 D stimulus, and near esophoria if the cycloplegic spherical equivalent refractive error was greater than -2.25 D. The children received either single vision spectacles or PALs with a +2.00 D add. The accommodative lag to a 4 D Badal stimulus was measured with both the child's habitual correction and manifest correction in place.

Results of this study showed that a +2.00 D bifocal add does not eliminate a lag of accommodation, but can reduce accommodative lag by about 25% of the bifocal power. These results indicate that children with a higher accommodative lag had a greater reduction in the lag with a bifocal. There was a floor effect for every 1 (D) of lag (i.e. the +2.00 Add had no effect) but approximately a 50% reduction in lag for every diopter of lag great than 1. The authors recommend that future studies obtain data through both habitual and manifest correction in order to gain an appropriate measure of a myopic child's accommodative lag.

## AMBLYOPIA

BARNES G. LI X, THOMPSON B ET AL. DECREASED GRAY MATTER CONCENTRATIONS IN THE LATERAL GENICULATE NUCLEI IN HUMAN AMBLYOPES. INVEST OPHTHAL VIS SCI 2010; 51:1432-8

Single-cell studies have identified the input layers of the primary visual cortex as the site from where the amblyopic deficit arises. However, a previous case study of humans with anisometropic amblyopia revealed a functional magnetic resonance deficit at the level of the lateral geniculate nucleus (LGN). This current study investigated 3 questions: 1. Is the LGN in humans with amblyopia structurally and functionally abnormal 2. Do structural anomalies in the visual cortex exist, and 3. Is there a relationship with functional anomalies in the visual cortex and structural anomalies in the LGN. Voxal-based morphometry and functional magnetic resonance imaging were used to compare structural and functional differences between 16 strabismic amblyopic patients (mean age 37.9) and 11 normal controls (mean age 34). Six of the amblyopic patients also had anisometropia. All subjects wore their full refractive correction during testing.

The results showed significantly less gray matter in the LGN of the amblyopic group compared to the controls. It was suggested that the reduced LGN responses in amblyopic patients may be a result of reduced geniculate function. No other difference in grey matter was found between the two groups in the occipital lobe or temporal lobe. There were positive correlations between the functional difference of amblyopic eyes and the amount of gray matter in visual areas VP and V4. More gray matter in the area correlated with a larger difference in function between the amblyopic and fixating eyes. It was suggested that cells are not lost but migrate from the amblyopic to the fixating eye. Finally, the activity in the visual cortex was found to be related to the amount of

LGN gray matter in an individual. Amblyopic subjects had less grey matter in the LGN and greater functional deficits. The authors concluded that the LGN must have a fundamental role in the processing deficit in amblyopic patients. There was no significant relationship between the response magnitude in the visual cortex and LGN structure in amblyopic or control groups. However, amblyopic subjects had less grey matter in the LGN than normal subjects. The amblyopic subjects also had greater functional deficits, suggesting a relationship between the LGN grey matter and the magnitude of the functional deficit.

NIECHWIEJ-SZWEDO E, GOLTZ HC, CHANDRAKUMAR M, ET AL. EFFECTS OF ANISOMETROPIC AMBLYOPIA ON VISUOMOTOR BEHAVIOR, I: SACCADIC EYE MOVEMENTS. INVEST OPHTHAL VIS SCI 2010; 51:6348-6354

This study investigated saccadic eye movements in age-matched control group (with normal vision) and patients with anisometropic amblyopia. Anisometropic amblyopia was defined in this study as the presence of a difference in refractive error between both eyes of greater than or equal to 1 diopter (D) of spherical or cylindrical power.

Thirteen (13) subjects with anisometropic amblyopia and thirteen (13) normal sighted (corrected to 20/20) subjects of average age of 27 participated in the study. Subjects were stabilized with a chin rest and shown a fixation target along their mid-sagittal plane. A visual target (a white square with a visual angle of 0.5 degrees) was presented randomly nasally or temporally along the horizontal plane at 5 or 10 degrees of eccentricity. Subjects were instructed to look and point at the target quickly and accurately using their right index finger. Randomly, half of the time, the target would remain on the screen, while the other time, the target would disappear after 350ms. The test was performed under three randomly assigned viewing conditions (binocular and each eye monocularly). Eye movements were recorded in a dimly lit room at 200Hz using a video-based pupil/iris tracking system.

There were three main findings:

1) Anisometropic amblyopic subjects exhibited significant increase in saccade latency and variability

Saccadic latency was increased and more variable under binocular and monocular (amblyopic eye) conditions.

This study supports previous studies that suggest that longer saccade latency in the amblyopic eye results from an abnormally long spatiotemporal sensory acquisition rather than a motor deficit. In other words, increased saccade latency in amblyopia represents slower visual processing in the afferent (sensory) pathway rather than a deficit in the efferent (motor) pathway of the saccadic system. The increased variability in saccade latency and amplitude during amblyopic eye viewing suggested that patients had difficulty detecting and localizing the target. However, variability is an inherent feature of motor control and may come from both sensory and motor processing.

2) Anisometropic amblyopic subjects had no binocular advantage (no reduction in saccade latency during binocular viewing).

Visually healthy patients demonstrated reduced response times viewing binocularly versus monocularly. It has been suggested that during binocular viewing, input from each eye contains correlated stimulus signals that summate during visual processing and the uncorrelated noise signals from each eye cancel each other when combined. As a result, the signal-to-noise ratio in the stimulus signals increases during binocular viewing, which, in turn, leads to more accurate, precise, and faster responses. However, this binocular advantage is not present in those patients with amblyopia due possibly to disruption of binocular organization and a loss of binocularity in neurons in the visual cortex.

3) Anisometric amblyopic subjects did not increase corrective saccades despite a decrease in precision of saccade amplitude during amblyopic eye and binocular viewing.

Both saccadic peak velocity and amplitude were higher under binocular conditions. More corrective saccades were found when amblyopic subjects were viewing with the non-amblyopic eye compared to binocular and monocular (amblyopic eye) viewing conditions. No interaction was found between severity of amblyopia and viewing condition.

The authors suggest that it is possible that when using the eye with normal acuity to view a target, patients used both retinal and extraretinal feedback to generate more corrective saccades. In contrast, during amblyopic eye and binocular viewing, retinal feedback mechanism may be impaired due to less reliable retinal position error signals of the target image from the amblyopic eye.

In conclusion, this study demonstrated that saccade initiation was prolonged and highly variable during amblyopic eye viewing, suggesting that the efficiency of the sensory (visual) component of the saccadic system was decreased for the detection (latency) and localization (amplitude variability) of the target. The dynamics of primary and corrective saccades, however, were not altered once eye movement was initiated, suggesting that the efferent (motor) component of the saccadic system is spared in anisometric amblyopia.

HESS R, MANSOURI B, THOMPSON B. A BINOCULAR APPROACH TO TREATING AMBLYOPIA: ANTISUPPRESSION THERAPY. OPT VIS SCI 2010;87:697-704

The most common form of treatment for amblyopia is to patch the good eye to improve the function of the amblyopic eye. This study proposes a new way to treat amblyopic patients utilizing a binocular method to treat amblyopia. The theory behind the study is that recent research has shown that amblyopes have intact, but suppressed, binocular systems.

These researchers developed a novel approach of quantifying and treating the amblyopic suppression. Using random dot kinematograms and a coherence motion discrimination task, they found that they can determine how much binocularity a patient has. The subject would look at a "signal" consisting of dots that move in the same direction in 1 eye while looking at "noise" consisting of random movement in the other eye. The "noise" in one makes it harder to see the "signal" in the other. In a normal binocular patient, it does not matter which eye sees the signal and which sees noise. However, in amblyopes there is an imbalance; if the fixating eye sees the signal and the amblyopic eye sees noise, performance is at a ceiling. If the fixating eye sees the noise and the amblyopic eye sees the signal, performance is at chance. However, a balance can be found showing that eyes can work binocularly.

In this case report 3 patients underwent the treatment procedure. All patients had decreased best corrected visual acuity (BCVA) in the amblyopic eye from 20/63 to 20/400, intermittent fusion or no fusion on Worth 4 Dot, and no Randot. Two had strabismic amblyopia and one had anisometropic amblyopia. All three showed improvements in BCVA and Randot stereopsis at the end of treatment.

The researchers also note an improvement in 8/10 adult amblyopes treated to date and suggests a new method of treatment for amblyopes.

KANONIDOU E, PROUDLOCK FA, GOTTLÖB I. READING STRATEGIES IN MILD TO MODERATE STRABISMIC AMBLYOPIA: AN EYE MOVEMENT INVESTIGATION. INVEST OPHTHAL VIS SCI. 2010; 51:3502-3508.

The purpose of this study was to evaluate, the oculomotor characteristics associated with decreased reading performance in adult strabismic amblyopia during both monocular and binocular reading.

Twenty adults with unilateral strabismic amblyopia were compared to a control group of twenty normal adult volunteers. The subjects were required to silently read paragraphs of continuous text while their gaze position was measured with an infrared, video-based pupil-tracking system. Two comparisons were made during monocular reading. The amblyopic eye was compared to the nondominant eye of the control subjects while the nonamblyopic eye was compared to the dominant eye of the control subjects. A comparison between amblyopes and control subjects was also made under binocular reading conditions.

Fixation duration, mean reading speed, number of progressive and regressive saccades per line and saccadic amplitude (of progressive saccades) were estimated. Mean reading speeds were significantly slower in the amblyopes compared to the control subjects for all three conditions. Mean reading speed in the amblyopes was 55% of that in the control subjects for amblyopic/nondominant eye viewing, 72% for nonamblyopic/dominant eye viewing, and 67% for binocular viewing. Fixation duration and the number of regressive saccades per line were the oculomotor parameters most associated with these changes in reading speed. No significant differences were apparent for the number of progressive saccades per line or the amplitude of progressive saccades.

In conclusion, this study showed impaired reading in both the amblyopic and non-amblyopic eye, and during binocular viewing, in amblyopic patients. These reading deficits are associated with saccadic and fixation patterns and may be the result of crowding and suppression scotomas experienced by amblyopes. This study suggests that there may be value in including reading charts, in addition to using high-contrast visual acuity charts, in the assessment of visual function in patients with strabismic amblyopia.

PEDIATRIC EYE DISEASE INVESTIGATOR GROUP WRITING COMMITTEE. A  
RANDOMIZED TRIAL COMPARING BANGERTE FILTERS AND PATCHING FOR THE  
TREATMENT OF MODERATE AMBLYOPIA IN CHILDREN. OPHTHALMOLOGY 2010;  
117:998-1004

The purpose of this study was to determine whether visual acuity improvement with Bangerter filters is similar to improvement with patching as initial therapy for children with moderate amblyopia. To determine this, the investigators incorporated a randomized clinical trial with 186 children, from ages 3 to <10 years, with moderate amblyopia (20/40-20/80).

The authors noted that potential advantages of using Bangerter filters versus patching include: the ability to change the density of the filter to alter levels of deprivation, the possibility of better compliance due to the filter being placed on the patients actual glasses, the possibility of less disruption of binocular vision, and better acceptance because the filter is not readily apparent to casual observers.

To participate in the study, participants had to meet the following criteria: age 3 to <10 years, visual acuity of 20/40 to 20/80 in the amblyopic eye, visual acuity of 20/40 or better in the fellow eye, and an interocular acuity difference >3 lines. The participants must also be currently wearing glasses and have the presence or history of an amblyogenic factor meeting study-specified criteria for strabismus and/or anisometropia.

Patients were seen for follow-up visits at 6, 12, 18, and 24 weeks. 81 of 89 (91%) Bangerter participants and 88 of 97 (91%) patching participants completed their 24 week primary outcome examination. Visual acuity in the Bangerter group was improved from baseline by an average of 1.9 lines, while the patching group improved by 2.3 lines. The rate of amblyopic eye improvement, time to 20/25 or better amblyopic eye acuity, and improvement of visual acuity by 3 or more lines were not statistically different between treatment groups. Therefore, the authors could not conclude that either patching or Bangerter treatment is superior to the other. Parent reported negative impact of treatment with respect to adverse effects, compliance, and social stigma was lower with the Bangerter filters than with patching based on the Parental Amblyopia Treatment Index completed by parents.

Bangerter foils remain an option for treating amblyopia in children.

LI C-H, CHEN P-L, CHEN J-T, FU J-J. DIFFERENT CORRECTIONS OF HYPERMETROPIC  
ERRORS IN THE SUCCESSFUL TREATMENT OF HYPERMETROPIC AMBLYOPIA IN  
CHILDREN 3 TO 7 YEARS OF AGE. AM J OPHTHALMOL 2009;147:357-63.

This retrospective study explored the improvement in visual acuity with different refractive treatment options for children with hypermetropic amblyopia. The population of this study included children seen at the Tri-Service General Hospital in Taiwan who were between 3 and 7 years of age and were diagnosed with hypermetropic amblyopia from January 1, 2001 to July 31, 2007. Children with a history of prior spectacle correction, large amounts of astigmatism, asymmetric amounts of astigmatism, total follow-up of less than one year, an ocular disease that may interfere with visual acuity, learning difficulties, or strabismus were excluded from this study. Children were also excluded if refractive correction and occlusion were prescribed at the same time.

Patients were given either the full hyperopic correction or a partial (decrease 0.75 to 1 diopter) correction. Follow-up visits occurred every four weeks, for a mean of 30 months. At each visit, patients underwent visual acuity (VA) testing and a repeat cycloplegic refraction. A difference of VA of 0.1 logMAR or greater was considered a significant improvement.

The full correction group consisted of 102 children, in which the mean baseline VA was 0.59 logMAR in the amblyopic eyes. The partial correction group consisted of 80 children, and the mean baseline VA was 0.57 logMAR in the amblyopic eyes. Changes of spectacle prescriptions may have been made at follow-up visits because of complaints of blurred vision or increase in VA with more minus power. VA improved 3 or more lines (resulting in an average VA of 0.12 logMAR) in the amblyopic eyes in 97% of the full correction group and in 95% of the partial correction group. Therefore, there was no significant difference in the improvement in VA between both groups. The regression of hyperopia was 0.44 diopters/year in the full correction group, and 0.43 diopter/year in the partial correction group. Compliance of spectacle wear was shown to be an important factor in both groups.

In conclusion, both full and partial corrections of hypermetropia similarly improved VA in children ages 3 to 7 with hypermetropic amblyopia. Reduction of hypermetropia was also similar between the two groups. However, it is important to consider subtle differences between both types of correction. For children over 5 years of age, full correction should be carefully given due to increased complaints of blur in this group. In addition, for younger children, full correction may be indicated for high amounts of hypermetropia or to avoid a concurrent strabismus.

PEDIG. RANDOMIZED TRIAL OF TREATMENT OF AMBLYOPIA IN CHILDREN AGED 7 TO 17 YEARS. ARCH OPHTHALMOL. 2005; 123: 437-47.

This study evaluated the effects of treatment of moderate and severe amblyopia in children aged 7 to 17 years.

The requirements for the participants were children 7 to 17 years old with best-corrected visual acuities (VA) between 20/40 and 20/400 in the amblyogenic eye and 20/25 or better in the sound eye. Amblyopia treatment was not permitted for at least one month prior to the commencement of the study, nor could the patient have had more than one month of treatment in the prior 6 months. Participants were given full optical correction with the exception of correction for hyperopia (which could be reduced by no more than 1.50 diopters from the cycloplegic refraction). Patients were randomized into an optical correction only group, or a treatment group prescribed with 2-6 hours of patching combined with near activities. For those aged 7-12 years, a daily drop of 1% atropine sulfate was also prescribed for the sound eye. Participants were considered a responder if visual acuity improved by at least 10 letters ( $\geq 2$  lines). Non-responders were patients whose VA did not improve by at least 10 letters by 24 weeks, 0 letters at 6 weeks, less than 3 letters at 12 weeks or less than 5 letters at 18 weeks. Five hundred and seven (507) patients were enrolled in the study.

Optical correction alone improved vision by 2 lines in 25% of participants aged 7 to 12 years. Fifty-three percent (53%) of participants aged 7 to 12 years improved 2 lines when prescribed patching with near activities and atropine, regardless of their amblyopia and amblyopia treatment history. In the moderate (20/40 to 20/80 VA) group, 36% of the treatment group and 14% of the optical correction alone group reached a VA of 20/25+. In the severe amblyopia

(20/100-20/400 VA) group, 23% of the treatment group and 5% of the optical correction alone group reached a VA of 20/40+.

In the patients aged 13-17 years, 25% of the treatment group and 23% of the optical correction group showed improvement in VA of 2 lines. In the moderate amblyopia group, 14% of the treatment group and 11% of the optical treatment group reached a VA of 20/25. In the patients with severe amblyopia, 14% of the treatment group and 0% of the optical treatment group reached a VA of 20/40+. Of the 13 to 17 years olds without previous amblyopia treatment, 47% of the treatment group and 20% of the optical treatment group showed an increase in VA of 2 lines.

REPKA M, SIMONS K, KRAKER R, ET AL. LATERALITY OF AMBLYOPIA. AM J OPHTHALMOL 2010; 150:270-4

The purpose of this study was to determine the laterality of amblyopia right eye versus left eye in patients with unilateral strabismic, anisometropic, or combined (strabismic/ anisometropic) amblyopia. The patient population examined were 2635 subjects, <18 years of age, who were participants in the multicenter prospective randomized treatment trials conducted by the Pediatric Eye Disease Investigator Group.

The study found that amongst 2635 patients with unilateral amblyopia, 56.6% of amblyopic eyes were left eyes. In patients with anisometropic amblyopia (747 subjects with strabismus and 1071 without strabismus) amblyopia was present in the left eye in 59% of patients. There was no significant difference in laterality when comparing subjects with strabismic amblyopia; 50% of patients had amblyopia in the left eye. Furthermore, in patients with amblyopia with or without strabismus, there was no association of laterality with age, race, amblyopia severity, or degree of anisometropia.

The authors propose that microtropia, sighting dominance, developmental or neurological factors and emmetropization, or a combination of factors, may be responsible for this laterality preference.

HOLMES, J.M., MELIA, M., BRADFIELD YS, ET AL. FACTORS ASSOCIATED WITH RECURRENCE OF AMBLYOPIA ON CESSATION OF PATCHING. OPHTHALMOLOGY. 2007; 114: 1427-1432

In a previous prospective study of cessation of amblyopia treatment in young children, the risk of recurrence was higher when abruptly stopping treatment of 6 to 8 hours of daily patching rather than if it was weaned to 2 hours per day before cessation. In this prospective observational study, additional factors associated with recurrence were analyzed in the same cohort. The study included children less than 8 years of age, amblyopia due to strabismus, anisometropia, or both, acuity before treatment in the amblyopic eye of 20/40 or worse with at least 3 logMAR levels of interocular acuity difference, and an improvement of amblyopia during the preceding period of continuous treatment of at least 3 logMAR levels.

The factors not associated with recurrence of amblyopia were gender, race, and age of diagnosis. There was no statistical significance of association between recurrence and increased

age at cessation of treatment. The factors associated with recurrence included better visual acuity at cessation of treatment, greater improvement in visual acuity during previous treatment, and previous recurrence. The authors also found that at the time of patching cessation, orthotropia and excellent stereoacuity did not have a protective effect on the risk of recurrence. The authors, therefore, concluded that long-term monitoring of visual acuity is necessary in all children after cessation of amblyopia treatment to detect potential recurrence.

REPKA MX, KRAKER RT, BECK RW ET AL. CONTRAST SENSITIVITY FOLLOWING AMBLYOPIA TREATMENT IN CHILDREN. ARCH OPHTHALMOL 2009;127:1225-1227.

Both the Pelli-Robson chart and sinusoidal gratings have been used to evaluate contrast sensitivity loss in children with strabismic and anisometropic amblyopia. Prior studies have shown a greater decrease in contrast sensitivity using sinusoidal gratings. This article examines contrast sensitivity in patients 4-7 years after atropine penalization or patching for amblyopia treatment. Subjects included 86 children with a mean age of 10.3 years. Subjects were tested with the Pelli-Robson low contrast letter chart. Each child read from highest to lowest contrast. The child's score was calculated when at least 2 or 3 letters were read correctly at the first attempt. Monocular acuity was also measured using the Electronic Treatment of Diabetic Retinopathy Study visual acuity testing protocol. Results showed a mean visual acuity of 20/20 in the non-amblyopic eye and 20/32 in the amblyopic eye. The mean log low contrast identification score was slightly better in the non-amblyopic eye compared to the amblyopic eye. A weak correlation was reported for both the interocular difference in contrast sensitivity and visual acuity. Furthermore, contrast sensitivity scores did not differ between the atropine and patching groups. The data suggest that children who had participated in the randomized trial at an earlier age (age 3 to  $\leq$  5) were more likely than those treated at a later age to have better contrast sensitivity in the amblyopic eye at age 10. The authors noted that the Pelli-Robson chart only measures contrast in medium spatial frequency range. They caution that higher spatial frequency losses have been reported in patients.

DOBSON, V, HARVEY, EM, ET AL. AMBLYOPIA IN ASTIGMATIC INFANTS AND TODDLERS. OPTOM VIS SCI. 2010; 87(5): 330-336.

In order to determine if astigmatic children younger than three years of age demonstrate reduced acuity for orientation-specific gratings and/or meridional amblyopia (MA), investigators compared astigmatism-corrected acuity for vertical (V) and horizontal (H) gratings in with-the-rule astigmatic versus low/non-astigmatic infants and toddlers.

The 448 children subjects who participated in this study were recruited from Women, Infants and Children clinic on the Tohono O'odham reservation. Participants were divided into groups based on age (6 months to <1 year, 1 to <2 years, or 2 to <3 years). Right eye non-cycloplegic SureSight autorefraction measurements were taken. Children with  $\geq$ 2.00 diopters (D) astigmatism

were classified as astigmats while those with  $\leq 2.00D$  were considered low/non-astigmats. After obtaining SureSight readings, investigators selected an appropriate spectacle correction (lenses that correct cylinder only for astigmats and plano lenses for low/non-astigmats) and visual acuity (VA) for H and V gratings was measured with Teller Acuity Cards.

For all three age groups evaluated, astigmatism-corrected acuity for both V and H gratings was decreased in astigmatic children with high astigmatism ( $> 2 D$ ) compared to that of low/non-astigmatic children suggesting that astigmatism impairs early visual development. No orientation-related differences in astigmatism-corrected grating acuity were observed, indicating that MA does not develop prior to age 3 years, or that most of the children tested had hyperopic astigmatism, a type of astigmatism which typically does not result in MA.

ALTINAS O. ETUS V, ETUS H, ET AL. RISK OF STRABISMUS AND AMBLYOPIA IN CHILDREN WITH HYDROCEPHALUS. GRAEFE'S ARCH CLIN EXP OPHTHALMOL 2005; 243: 1213-1217.

The purpose of this study was to establish whether children with hydrocephalus who were treated with operation have a higher probability of developing amblyopia or strabismus. Subjects included 25 children, ages 3 months to 18 years. Evaluation included visual acuity testing (tumbling "E" chart), determination of strabismus (alternating cover test and Hirschberg test) determination of refractive error (cycloplegic refraction), and ocular health assessment.

The study found that 40% of patient had a manifest strabismus and 20% had amblyogenic refractive errors. Eight percent (8%) of children had temporal disc pallor. Overall 56% were at risk for amblyopia (strabismic or refractive). Surgery increased the risk of amblyopia: 88% of those patients with shunt revision and 41% of those without shunt revision surgery had amblyopia. Similarly, 75% of children who underwent surgery, compared with 24% of those who had not had surgery were strabismic.

SUTTLE CM, MELMOTH DR, FINLAY AL, ET AL. EYE HAND COORDINATION SKILLS IN CHILDREN WITH AND WITHOUT AMBLYOPIA. INVEST OPHTHAL VIS SCI. 2011;52:1851-64.

This study was designed to investigate whether binocular vision affects eye-hand coordination in children with and without amblyopia.

This study compared performances of non-amblyopic patients (36 children, ages of five and 11, and 11 adults, ages 20-42 years) to 21 children with strabismic or anisometropic amblyopia. Each participant was seated at a table, asked to reach out with his or her preferred hand and grasp an object by its middle, transplant the object on the table, and return his or her hand to starting position. Infrared markers, on the patients' hands and objects, and cameras, captured aspects of the task, including reaction time, velocity, trajectory, grip adjustments, and overall execution time.

Patients were tested under binocular, non-dominant monocular, and dominant monocular viewing conditions.

The amblyopic patients' performance was more poorly controlled under all viewing conditions than age-matched peers in the control group. These patients took longer to reach the object and made more frequent errors. The deficiencies in performance were more obvious when amblyopic patients with poor/absent stereopsis—not necessarily poor visual acuity—were tested under binocular conditions. In particular, amblyopic patients performed equally poorly when viewing monocularly with either eye, supporting the belief that the “good,” or dominant, eye of a patient with amblyopia is not the same as the dominant eye of a patient with normal vision.

Children in both groups showed normal developmental changes in visuomotor control. Young children (ages 5-8) show strong tendencies to use a “feed forward” system of processing—spending most time and energy on gathering information about the subject and environment before action, then making ballistic movements to execute the task. Children aged 7-8 years showed signs of transition, as they divided time between pre-action data collection and “online” or live-action feedback to make corrective movements when reaching. At this age, children began to incorporate visual feedback.

Improvements in reach-grasp deficits may be accelerated with improvements in stereopsis.

## AUTISM SPECTRUM DISORDERS

FRANKLIN, A, SOWDEN, P, NOTMAN, L, ET. AL. REDUCED CHROMATIC DISCRIMINATION IN CHILDREN WITH AUTISM SPECTRUM DISORDERS. DEV SCI 2010;13;188-200.

Children with autism spectrum disorders often exhibit atypical perception. This paper investigated chromatic discrimination in children, of the same age and non-verbal cognitive ability, with autism spectrum disorders compared to children with typical development. Two experiments were performed.

Experiment one measured the chromatic discrimination of fourteen children with high functioning autism (HFA) and fourteen children, average age 14, with typical development (TD). Participants were given the Farnsworth-Munsell 100 hue test and an achromatic control test.

Experiment two measured the chromatic threshold of 34 children with high functioning autism and 33 children with typical development. Participants were shown a circle with a color boundary created by having a different color on each half of the circle. Participants were then asked which direction the color boundary was tilting, left or right. The chromatic difference between the two halves of the circle was increased or decreased based on participant responses to estimate the just-noticeable difference (JND). The same test was performed using a circle with different luminance on each half to assess the participants' luminance threshold as a control measure.

Experiment one showed that the HFA group made more errors in chromatic discrimination than the TD group. Comparing normative test values, the HFA group performed at a level similar to children with typical development three years younger. Both groups made similar errors on the achromatic control test. Experiment two showed that chromatic thresholds were elevated for the

HFA group compared to the TD group. There was no difference between groups on the luminance task. Both experiments show that reduced chromatic discrimination was caused by a general reduction in chromatic sensitivity instead of difficulty with either the red-green or blue-yellow color vision system. Moreover, because both groups performed equally well on all control testing, the study supports true differences in chromatic sensitivity rather than differences in overall testing ability. Therefore, this study provides evidence that chromatic discrimination is reduced in children with high functioning autism.

Study authors suggest that reduced chromatic discrimination could be due to atypical processing at the retinal level, over-functioning of neurons in V1, or reduced synchrony of V1 and other cortical areas.

MILNE E, GRIFFITHS H, BUCKLEY A AND SCOPE A. VISION IN CHILDREN AND ADOLESCENTS WITH AUTISTIC SPECTRUM DISORDER: EVIDENCE FOR REDUCED CONVERGENCE. J AUTISM DEV DISORD 2009;39(7):965-75.

Prior studies have found conflicting results as to whether or not those affected by autistic spectrum disorder (ASD) experience a higher prevalence of vision disorders than the normal population. The "Vision in children and adolescents with autistic spectrum disorder: evidence for reduced convergence" study attempted to identify and better describe visual disturbances in ASD through a wide array of clinical tests. The study sample included 51 individuals with ASD and 44 typically developing (TD) controls with no history of developmental or neuropsychiatric disorders. The autistic group consisted of 25 with autistic disorder, 10 with Asperger's disorder and 16 with PPD-NOS. Subtests from Wechsler Abbreviated Scale of intelligence were used to determine low functioning ASD (LF ASD) individuals from high functioning ASD individuals (HF ASD).

The clinical and laboratory tests used to evaluate all subjects were administered by orthoptists and included visual acuity, stereoacuity, convergence/divergence (prism fusion range at near, near point of convergence [NPC]), presence of strabismus, ocular motility (pursuits), and optokinetic response (OKR). Each of these tests were performed once with the exception of NPC, which was completed three times.

The results were as follows-

Visual acuity: ASD group showed statistically poorer visual acuity in both right and left eyes compared to the TD group, however, the difference was not statistically significant.

Stereoacuity/Divergence/Ocular Motility/OKR: There were no statistical differences between the groups.

Convergence: Base out fusion range of ASD group was significantly lower than that of the TD group. The participants with ASD had significantly receded NPC compared to the TD group. All of the participants with reduced (>10.5cm) or abnormal (>12cm) NPC were low functioning.

Presence of strabismus: 10.6% of ASD individuals and 0% of TD group exhibited strabismus, a difference which was not statistically significant. Those subjects who were diagnosed with strabismus were not included in the testing/analysis.

The total incidence of abnormal vision was 11.4% in the TD group and 31.3% in the ASD group, indicating a significant difference between groups and visual system function. The authors note that the total incidence of abnormal vision experienced by those with ASD was lower than previously reported by various studies.

Additionally, the authors note that others have suggested that the receded NPC in ASD individuals may be explained by ASD participants' becoming uncomfortable with a stranger close to their face, however the authors note that patients would likely have difficulties with base in/divergence measurements. As divergence measurements were normal, the findings provide support for a convergence abnormality in ASD.

#### THE PEDIATRIC EYE DISEASE INVESTIGATOR GROUP (PEDIG). RISK OF AMBLYOPIA RECURRENCE AFTER CESSATION OF TREATMENT. JAAPOS. 2004;8:420-8.

This study investigated the recurrence rate of amblyopia, either anisometric and/or strabismic in nature, once patching or atropine treatment was discontinued. Recurrence was defined as two consecutive visual acuity measurements in the amblyopic eye that were two or more logMAR levels worse than visual acuity at the time of enrollment. One hundred and fifty-six children, all under eight years of age (average age 5.9 years old), were enrolled into the study, 145 met all the criteria. Eligibility criteria included continuous amblyopic treatment three months prior, either at least two hours of daily patching or at least one drop of atropine per week. Visual acuity prior to treatment was 20/40 or worse in the amblyopic eye, with at least three logMAR levels in inter-ocular acuity difference. Successful treatment was defined as improved visual acuity by three logMAR levels by the end of treatment.

Subjects were monitored for a total of fifty-two weeks, at intervals of five, thirteen, twenty-six, and fifty-two weeks. The study found that recurrence of amblyopia occurs in approximately one-fourth (21-24%) of cases during the first year after cessation of treatment, and is similar in the patching or atropine groups. Recurrence was found to occur most frequently (in 69% of patients) during the first thirteen weeks after completing treatment. The risk of recurrence was greater in patients who were patching greater than six hours per day when amblyopia treatment was stopped, compared to those patching fewer than 6 hours when treatment was stopped (41% compared to 21%).

#### BINOCULAR VISION/STEREOPSIS

#### O'CONNOR AR, BIRCH EE, ANDERSON S, DRAPER H. RELATIONSHIP BETWEEN BINOCULAR VISION, VISUAL ACUITY, AND FINE MOTOR SKILLS. OPTOM VIS SCI, 2010; 87: 942-7.

This study looked at whether or not amblyopia or abnormal binocular fusion affects motor skills tasks. Researchers looked at the effects of sensory fusion (Worth 4 Dot, 4 Base out Test), motor fusion (phasic and tonic vergence), and visual acuity (VA) on the performance of fine motor

skills tasks, specifically Purdue pegboard (number of pegs placed in 30 seconds), bead threading (time taken to thread a fixed number of beads), and a water pouring task (accuracy and time to pour a fixed quantity into five glass cylinders). There were 121 subjects aged 12 to 28 years.

Researchers found that subjects that possessed sensory fusion performed significantly better than subjects with a suppression response on the bead threading tasks and the pegboard task.

Subjects with normal or even reduced phasic motor fusion performed significantly better than those without phasic motor fusion on both the pegboard and the large bead tasks. Subjects with normal phasic motor fusion performed better than those with low or no tonic fusion on the small bead stringing task.

Looking at the 21 subjects with amblyopia, there was a significant reduction of ability on the bead threading task and the water pouring task in subjects with decreased VA. The errors were significantly related to the VA level of the poorer seeing eye.

As this study shows, sensory and motor fusion are important for performing simple motor skill tasks.

## BRAIN INJURY

CIUFFREDA KJ, LUDLUM D, THIAGARAJAN P. OCULOMOTOR DIAGNOSTIC PROTOCOL FOR THE MTBI POPULATION. OPTOMETRY 2011; 82:61-3.

As a result of increased numbers of soldiers returning from war with traumatic injuries and more thorough investigations of professional athletes post-concussion, there is a heightened awareness of TBI. Some of the ocular conditions resulting from a TBI are easily detected, while others, particularly in cases of mild TBI (mTBI), are more difficult to definitively diagnose. Patients who have had a mTBI often seem complicated and intimidating due to the vast array of visual, as well as behavioral, symptoms they report. These patients most often complain of difficulty reading, and also may complain of having difficulty functioning in visually complex environments, due to problems with scanning, tracking, and/or focusing. In addition, mTBI patients can experience diplopia, eye strain, vertigo, nausea, decreased visual memory, motion and light sensitivity, poor attention, and fatigue.

The most common oculomotor related issues occurring in mTBI patients are convergence insufficiency, accommodative insufficiency, and saccadic dysmetria. The diagnostic protocol for any TBI patient should consist of the tests which address vergence ranges, accommodation, and versions, including near point of convergence (NPC) break and recovery repeated several times, positive fusional vergence (PFV) ranges, vergence facility, horizontal dissociated and associated near phorias, accommodation convergence (AC/A) ratio, stereoacuity, accommodative amplitude and facility, negative and positive relative accommodation (NRA/PRA), fixational stability, saccades, pursuits, and the Developmental Eye Movement Test (DEM) or a Visagraph. Abnormalities in the findings from these tests occur in high frequency with patients who have mTBI. Once specific oculomotor and/or accommodative diagnoses are concluded, the patient can be successfully treated with vision therapy, including use of lenses and prisms. Tints can be utilized to decrease

photosensitivity, and binasal occlusion may help in patients with motion sensitivity. Patients with visual field defects or difficulty with spatial localization may benefit from the use of prism.

ROWE F. THE PROFILE OF STRABISMUS IN STROKE SURVIVORS. EYE. 2010; 24:682-5

The Vision In Stroke (VIS) Group is a group of investigators who conducted a prospective multi-center cohort trial. The goal of this study was to look at strabismus and binocular function in stroke survivors.

Subjects included 512 stroke patients with a median age of 69. Subjects were examined by orthoptists with distance and near cover test, evaluation of motilities, Bagolini test, fusional vergence testing and stereopsis (Frisby test). Nineteen percent (19%) of the stroke patients studied had a strabismus (the majority of which were exotropia), but 2.5% of the strabismus patients reported that the strabismus was present prior to the stroke. Thus 16.5% of the total patients acquired a strabismus after the stroke. Patients with both right- and left-sided strokes had similar frequency in the occurrence of strabismus. Nearly 70% of the patients manifested ocular motility abnormalities (saccadic dysfunction, internuclear ophthalmoplegia, cranial nerve palsy). Thirty six percent (36%) of the patients complained of diplopia as a primary symptom, and 16% complained of diplopia associated with other symptoms; all of these patients presented with ocular motility abnormalities. Sixty four percent (64%) of patients with diplopia were treated with interventions, using Fresnel prisms, occlusion, orthoptic exercises, typoscopes, and compensatory head postures. Thirty percent (30%) of patients had multiple interventions.

CIUFFREDA KJ, KAPOOR N. OCULOMOTOR DYSFUNCTIONS, THEIR REMEDIATION, AND READING-RELATED PROBLEMS IN MILD TRAUMATIC BRAIN INJURY. JBEH OPTOM 2007; 18:72-77.

In patients with mild traumatic brain injury (TBI), symptoms of oculomotor-based reading problems are common. This review examines the most common reading-related problems in patients with mild TBI, and the effects of simple oculomotor training on these symptoms.

The first retrospective study examined the most common categories of oculomotor dysfunction and their frequency amongst 160 patients with TBI. Vergence, saccade, and accommodative dysfunctions had the highest frequency of occurrence. 90% of patients in this TBI sample manifested a deficit in one or more of the following: vergence (56.3%), version (51.3%), accommodation (41.1%), strabismus (25.6%), and cranial nerve palsy (6.9%).

The second retrospective study showed the treatment success of conventional optometric vision therapy for 33 patients with mild TBI. These patients received between 10 and 30 in-office vision therapy sessions coupled with 10-40 hours of home training. The most common symptom related to near work was oculomotor difficulty when reading (~80%), and the most common signs were receded near point of convergence and abnormal saccadic tracking (~70%). 90% of patients in this study showed improvement or normalization of at least one symptom and one sign following treatment.

The third study aimed to show whether simple versional oculomotor techniques could improve reading ability, both objectively and subjectively, for patients with mild TBI. In this small

group (n=9), every patient had symptoms and signs of poor reading ability. Reading rate and eye movements were assessed objectively using the Visagraph.

Training consisted of two 36 minute sessions a week, for eight weeks using computer-controlled stimuli; including fixation, saccade, pursuit, and simulated reading protocols. Following oculomotor training, each individual could read for a longer time and with greater comfort. Reading rates increased 10-33% in five patients. All improvements were maintained at the three-month follow-up.

These three studies show the frequency of oculomotor dysfunction, the symptoms experienced while reading, and the improvements following vision therapy both subjectively and objectively, for patients with mild TBI. The combinations of these studies, along with brain imaging techniques to show neural changes produced by optometric vision therapy, will be used to design an oculomotor training protocol for individuals with mild TBI.

## BINOCULAR VISION TESTING

WOOD J, CHAPARRO A, ANSTEY K, ET. AL. SIMULATED VISUAL IMPAIRMENT LEADS TO COGNITIVE SLOWING IN OLDER ADULTS. OPTOMETRY VISION SCIENCE. 2010; 87:1037-1043.

Subjects included adults, 65 years of age and older. All were free of neurological conditions, ocular disease, and were not taking any medication. Age-related cataracts were simulated using 2 different levels of Vistech light scattering filters. The purpose of the filters was to cause an increase in intraocular light scatter and glare sensitivity. During the study, patients were tested under three conditions: no filter, one filter (88% light transmission), and two filters (75% light transmission). For each condition, visual acuities were taken using a logMAR chart and a Pelli-Robinson chart and contrast sensitivity was assessed with a Pelli-Robinson chart. Cognitive testing for each of the conditions included that of standard pen-and-paper tests, a Digit Symbol Substitution Test (DSST), a Trial Making Test (TMT), and the Stroop Color Word Test.

The results of this study showed that both visual acuity and contrast sensitivity did in fact decline when a subject had on the Vistech filters, most drastically in the 2 filters condition. Near visual acuity was four times greater than the visual requirements for the cognitive tests. Performance on all cognitive tests worsened when more filters were added. The filters had a greater effect on visual and cognitive in the older subjects. The decrease in cognitive function was greater than expected by visual deterioration. Contrast sensitivity, and not visual acuity, was a better predictor of decrements in cognitive test performance.

## COMPUTER VISION SYNDROME

ROSENFELD M, GUREVICH R, WICKWARE E, LAY M. COMPUTER VISION SYNDROME: ACCOMMODATIVE AND VERGENCE FACILITY. J BEH OPTOM. 2010; 21: 119-122.

This study evaluates the role of the accommodative and vergence systems in computer vision syndrome (CVS). Visual symptoms reported include eyestrain, headaches, blur, ocular discomfort and dry eyes. Prevalence of CVS symptoms are between 64% and 90% of all computer users. Prior studies showed that symptoms increase with increased computer use. Various studies have cited contradictory results as to whether or not there are changes in static measures of accommodation and vergence. This current study asserts that CVS symptoms may result from stress placed on these systems by dynamic changes required when often using computers (e.g. looking at the screen and looking in the distance). To test the dynamic abilities of the accommodative and vergence systems, this study uses  $\pm 2.00$  diopter flipper lenses and 12 $\Delta$ BO and 3 $\Delta$ BI prisms, respectively.

Twenty-two (22) young visually normal subjects were given the task of reading for 25 minutes from a computer screen located 50 cm away. Accommodative and vergence facilities were taken before and after the reading task. After the post-testing measurements, the subjects were also given a questionnaire evaluating their symptoms. The data show no statistically significant change in pre and post task accommodative or vergence facility. The binocular accommodative facility showed a statistically significant increase from pre to post-task. The highest rated symptoms were tired eyes and eyestrain, although there was no - significant correlation between pre- and post-task accommodative facility. There was also not a significant association between pre-task vergence facility and tired eyes.

These authors postulate that symptoms are not related to either accommodative or vergence abnormalities, but they may be due to dry eye symptoms.

COLLIER JD, ROSENFELD M. ACCOMMODATION AND CONVERGENCE DURING SUSTAINED COMPUTER WORK. OPTOMETRY. 2011; 82: 434-40

This study measured accommodation and convergence while performing sustained computer work.

Twenty subjects, with a mean age of twenty-four, were given a text to read aloud from a laptop computer at a viewing distance of 50 cm for 30 minutes. All subjects used their habitual refractive correction. The accommodative response was measured using a Grand Seiko WAM-5500 open field, infrared optometer every 2 minutes. The vergence response, associated phoria, was measured using a fixation disparity target that would appear on the computer screen. Subjects were also asked to rate the level of ocular discomfort experienced during the reading task on a scale from 1 ("negligible") to 10 ("agony").

The results showed that mean accommodative response during the task was 1.07 diopters and the mean associated phoria was 0.74 BI. The mean difficulty score was a 4.9. There were no significant changes in accommodative response or associated phoria during sustained computer work. There was no significant difference in the accommodative response as related to subjects'

discomfort level. However, there was a relationship with associated phoria and discomfort noted while doing the task. The mean associated phoria for subjects who reported the least amount of discomfort was 1.55 BI and zero (0) for subjects who reported the greatest discomfort.

Symptoms of computer vision syndrome were not related to accommodative response but to fixation disparity. Subjects with zero fixation disparity were more symptomatic than subjects with a mild exo fixation disparity.

## CONVERGENCE INSUFFICIENCY

ROUSE MICHAEL OD., BORSTING ERIC, ET AL. ACADEMIC BEHAVIORS IN CHILDREN WITH CONVERGENCE INSUFFICIENCY

WITH AND WITHOUT PARENT-REPORTED ADHD. OPTOM VIS SCI. 2009 OCTOBER ; 86: 1169-1177.

This study investigated whether or not children aged 9 to 17 years with convergence insufficiency, (a binocular problem manifesting in near task difficulty), without parent reported attention deficit hyperactivity disorder (ADHD) had higher scores on the parent reported Academic Behavior Survey (ABS). The ABS is composed of six items relating to school performance and problem behaviors that may manifest in a typical convergence insufficiency (CI) case, such as avoidance of, inattention during, and difficulty completing near tasks. Each item was ranked according to the parent's perception of the extent of difficulty their child had with each task, from 0 (never) to 4 (always). Parents were to indicate if their child had been diagnosed with Attention Deficient/Hyperactivity Disorder or Attention Deficient Disorder.

The survey was administered to the parents of 261 patients, of these, 221 children were documented as symptomatic for CI and 49 children were reported as having normal binocular vision. Results indicated that children with CI symptoms and parental report of ADHD had significantly higher scores (mean ABS score of 15.6) on the ABS survey than the children with CI symptoms and without parental report of ADHD (mean ABS score of 11.7). The ABS scores for children in the normal binocular vision group were significantly lower, mean ABS score of 8.7, than either group of children with CI symptoms. Results of the study also showed that both children who were symptomatic for convergence insufficiency and their parents reported a significant increase in the number of academic performance symptoms than the children with normal binocular vision.

This study demonstrated that the presence of convergence insufficiency influences a parent's report of their child's ability to efficiently complete school work. The study also indicated that children diagnosed with ADHD and/or related behavioral disorders should undergo a comprehensive vision evaluation to dismiss the possibility of convergence insufficiency.

SCHEIMAN, M, KULP, M, COTTER, S, ET. AL. VISION THERAPY/ ORTHOPTICS FOR SYMPTOMATIC CONVERGENCE INSUFFICIENCY IN CHILDREN: TREATMENT KINETICS. OPTOM VIS SCI. 2010; 87: 593-603.

The initial study, the Convergence Insufficiency Treatment Trial, was conducted in 2010. The purpose of this follow up study was to evaluate change in the signs and symptoms of convergence insufficiency throughout 12 weeks of treatment. Subjects included children, aged 9 to 17 years, symptomatic for convergence insufficiency. All subjects had an exo deviation of at least 4 prism diopters, a receded near point of convergence (NPC) (>6 cm), and insufficient positive fusional vergence (PFV) at near.

Treatment groups consisted of the following: 15 minutes of pencil push-ups 5 days per week; the Home Therapy System (HTS) computer software and 5 minutes of pencil push-ups 5 days a week; office based vision therapy (VT)/ orthoptics for a weekly 60 minute office visit with additional vergence and accommodative home therapies; and office based placebo therapy with home support activities.

This study found that clinical signs improved before symptoms. Within the first 4 weeks of treatment, the NPC and PFV improved. Improvement in these values at the 8 and 12 week visits was noted only in the office based VT group. Patients were still symptomatic at the 4 and 8 week visits. In the office based VT group, 73% of patients were asymptomatic or improved, while patients in the other groups remained symptomatic.

ALVAREZ TL, VICCI VR, ALKAN Y, KIM EH, ET AL. VISION THERAPY IN ADULTS WITH CONVERGENCE INSUFFICIENCY: CLINICAL AND FUNCTIONAL MAGNETIC RESONANCE IMAGING MEASURES. OPTOM VIS SCI. 2010; 87: E985-E1102.

This pilot study aimed to provide data about vergence system changes in patients undergoing vision therapy for convergence insufficiency (CI), by measuring neural changes with functional magnetic resonance imaging (fMRI) scans. The study included four CI patients undergoing vision therapy, consisting of 18 hours of in-office and at-home therapy. There were 13 controls who did not receive therapy.

The fMRI scans were taken before and after vision therapy by measuring the activation extent of five different regions of interest (ROIs) of the brain: dorsolateral prefrontal cortex, frontal lobe, parietal lobe, cerebellum, and the brain stem. The researchers found there was an increase in extent of activation of several of the ROIs (frontal lobes, cerebellum and brainstem) after vision therapy compared to before vision therapy.

Five different static clinical parameters, stereopsis, NPC break value, recovery point of convergence (RPC), near fusional vergence amplitude, and dissociated near phoria, were measured before, midway, after, and 1 year post-vision therapy. These parameters positively correlated with the changes in cortical activity seen on fMRI. After vision therapy, the static parameters (except for stereopsis) and vergence dynamics significantly improved.

These results support that increased functional activity on fMRI after vision therapy may represent a correlation between clinical and physiological modifications of the visual system.

## CONVERGENCE INSUFFICIENCY TREATMENT TRIAL STUDY GROUP.

### RANDOMIZED CLINICAL TRIAL OF TREATMENTS FOR SYMPTOMATIC CONVERGENCE INSUFFICIENCY IN CHILDREN. ARCH OPHTHALMOL 2008;126:1336-49

The purpose of this study was to compare the efficacy of different therapeutic treatments for convergence insufficiency (CI) in children. In this randomized clinical trial, 221 children aged 9 to 17 with symptomatic CI were assigned to one of four 12 week treatments. Therapies compared included home-based pencil push-ups (HBPP), home-based computer vergence/accommodative therapy and pencil push-ups (HBCVAT+), office-based vergence/accommodative therapy with home reinforcement (OBVAT), and office-based placebo therapy with home reinforcement (OBPT).

Outcomes were measured using a standardized 15 question symptom survey, the convergence insufficiency symptom survey (CISS), administered before and after 12 weeks of a randomly-assigned therapy. Secondly, outcomes were measured by comparing pre and post-therapy near point of convergence (NPC) and positive fusional vergence (PFV) values.

After 12 weeks of treatment, the OBVAT group demonstrated the most improvement in both the CISS and in NPC/positive fusional vergence measurements. A successful or improved outcome based on pre-determined success criteria was found in 73% of the OBVAT group, 43% of the HBPP, 33% of the HBCVAT+, and 35% of the OBPT groups, respectively.

The results of this study are directly applicable to clinical practice in the treatment of convergence insufficiency. Results clearly indicate that a 12 week regimen of OBVAT with home reinforcement is more effective in improving signs and symptoms associated with CI than a 12 week program of HBPP or HBCVAT+.

## DOWN SYNDROME

### AL-BAGDADY M, STEWART RE, WATTS P, ET AL. BIFOCALS AND DOWN'S SYNDROME: CORRECTION OR TREATMENT? OPHTHALMIC AND PHYSIOL OPTICS 2009; 29: 416-21

This study looked at the effectiveness of bifocals in improving accommodation in children with Down's Syndrome, since approximately 75% of these children have reduced accommodation. The author reviewed the clinical records of 40 children with Down's Syndrome (ages 4.96-14.64) who were prescribed bifocals, and the effects these bifocals had on their accommodation at three different distances (10, 16.7, and 25 cm). Changes in accommodation with bifocals or after bifocals were discontinued was also assessed.

With bifocal treatment, 95% of the children achieved accurate accommodation when looking through their bifocal segment. When looking through the distance portion, 65% of the children had improvement in accommodation. Thirty five percent (35%) of the total study participants were able to discontinue bifocal lenses. All of the children who discontinued bifocals were reassessed at a later date, and all maintained accurate accommodation. Age, gender, visual acuity, presence of strabismus, and refractive error did not affect these results. Bifocals as a treatment for reduced accommodation in children with Down's Syndrome can be considered a temporary treatment in at least one-third of children.

## EYE MOVEMENTS

FISCHER B, HARTNEGG K. INSTABILITY OF FIXATION IN DYSLEXIA: DEVELOPMENT - DEFICITS - TRAINING. OPTOM VIS DEV 2009; 40: 221-228.

The purpose of this study was to investigate the role and management of two different types of fixation instability in dyslexic patients; by comparing diagnosed dyslexic patients to their age-matched control subjects.

The two types of fixation instability studied were binocular and simple. Binocular fixation instability occurs when one of the patient's eyes moves at a different velocity as compared to the patient's other eye. Simple fixation instability refers to the number of saccades that occur before the target stimulus is presented.

The data for this article were collected from 1991 to 2006. The subjects in the study were between the ages of 7 and 17 years old. They were divided into the following groups: specific dyslexics (confirmed by IQ testing), dyslexics (not confirmed) and controls.

Each subject underwent 200 eye movement trials, 100 trials with the saccadic stimulus to the left and the other 100 trials with the stimulus to the right. Each trial was assigned a percentage of time, during which the binocular stability was lost. The percentage of trials where the instability exceeded 15% was assigned for each patient; this number was called the binocular index (Bindex). When the subject made a saccade before the target stimulus was presented it was counted as a simple fixation instability and the number was recorded.

The study compared the fixation instabilities with the different age groups in the study and found that binocular instability showed a slow increase in stability with increased age. Binocular instability was consistently higher for the dyslexic groups, but there was much variability within groups. Simple instability also showed an improvement with age, although a higher percentage of dyslexic children continued to have problems with simple fixation instability.

The researchers also wanted to know if training visual fixation would improve the stability of the subjects' eyes. The subjects underwent monocular fixation training for 7-15 minutes a day for 3 weeks. After treatment, binocular stability improved by about 55%, and simple stability improved by about 19%. The overall success was 74%.

The final results show that these two fixation instabilities are independent from one another. Both instabilities could contribute to learning problems for patients with dyslexia and can be improved with therapy.

## EXOTROPIA

MATSUO T, YABUK A, HASEBE K, SHIRE YH ET AL. POSTURAL STABILITY CHANGES DURING THE PRISM ADAPTATION TEST IN PATIENTS WITH INTERMITTENT AND CONSTANT EXOTROPIA. INVEST OPHTHAL VIS SCI 2010; 51:6341-6347

In this study the authors evaluated postural stability in patients with intermittent and constant exotropes after being exposed to prism adaptation. Both intermittent (10 subjects) and

constant (7 subjects) exotropes were evaluated before the prism adaptation, 15 minutes and 60 minutes after adaptation, using the computerized static stabilometry. Stabilometry is a quantitative measure of postural stability obtained by recording the electrical signals as the patient stands on a vertical force platform. Measurements were taken once with eyes open and once with eyes closed. Comparison of the open eye value and the closed eye value gives the Romberg quotient which is the most reliable parameter of postural stability.

Before prism adaptation, patients with constant exotropia showed more postural swaying with eyes open when compared to those with intermittent exotropia. However, this difference was not significant. With the eyes closed, body sway appeared to be the same between the two groups. During the 60 minutes of prism adaptation the Romberg quotient increased, returning to pretest levels in 60 minutes.

This study showed how binocular vision problems can affect postural stability.

## MEMORY

HARRISON SA, TONG F. DECODING REVEALS THE CONTENTS OF VISUAL WORKING MEMORY IN EARLY VISUAL AREAS. NATURE. 2009; 458: 632-5.

This study examines the role of early visual areas (areas V1 to V4) in visual working memory.

Functional magnetic resonance imaging (fMRI) was used to monitor cortical activity during each trial. There were six subjects, ages 24-36, with normal, or corrected-to-normal, vision. In the first experiment, the subjects were shown two orientation gratings and then were instructed to remember one of them. Eleven seconds later, a new orientation grating was presented to the subject, and he or she had to determine how the grating was rotated compared to the cued grating.

The second experiment incorporated direct viewing of letters presented rapidly at fixation while subject's ignored low-contrast orientated gratings flashing in the surround. The final experiment was a visual-field localizer experiment, which presented random flickering dots in an annulus of 1-4° eccentricity. The smaller size was chosen to minimize selection of retinotopic regions, corresponding to the edges of the grating stimuli.

These experiments found that specific orientations can be held in working memory. In the first experiment, fMRI results found that activity in areas V1 to V4 could predict which orientation was held in working memory. In the second, experiment, activity in areas V1, V2, and V3 was "highly predictive of the orientation of the unattended gratings." The experiments found that these early visual areas can maintain information in store for seconds; therefore they have more than a sensory processing role.

## MYOPIA

MARSH-TOOTLE WL, DONG LM, HYMAN L, ET. AL. MYOPIA PROGRESSION IN CHILDREN WEARING SPECTACLES VS. SWITCHING TO CONTACT LENSES. OPTOM VIS SCI 2009; 86:741-7

In this study, 286 ethnically diverse children who participated in the 5-year Correction of Myopia Evaluation Trial (COMET) study, where 6-11 year-old myopic children were randomly assigned to wear progressive addition lenses (PAL) or single vision lenses over a 5-year period. After three years, slower progression of myopia was found in the PAL group; however, the difference was statistically but not clinically significant. After the 5-year initial study, parents and children had the option of continuing observation in the study and were able to choose their vision correction, which included contact lenses. There were 87/286 children who choose to switch to contact lenses from spectacles.

The investigation of the progression of myopia in this cohort study group consisted of gathering refractive error and axial length data after the participants were cyclopleged with 1% tropicamide. The study found that both groups showed myopia progression over one year. Children who switched to contact lenses had a statistically significant increase in myopia progression compared to the children who remained in spectacles (0.28 diopters versus 0.14 diopters). The two-year change in myopia progression showed a similar statistically significant progression in myopia (0.52 diopters versus 0.25 diopters). No significant difference in axial length between the spectacle group and contact lens group was found.

The conclusion of this study was that the children that chose to wear contact lenses after their participation in the 5-year COMET study, showed a small, statistically significant, but clinically inconsequential increase in myopia progression.

JONES-JORDAN LA, SINNUTT LT, MANNY RE, COTTER SA, ET. AL. EARLY CHILDHOOD REFRACTIVE ERROR AND PARENTAL HISTORY OF MYOPIA AS PREDICTORS OF MYOPIA. INVEST OPHTHAL VIS SCI 2010; 51:115-121

The purpose of this study was to determine if a child's refractive error in first grade as well as their parental history of myopia is a predictor of myopia onset between second and eighth grades.

Data were collected from children enrolled in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) Study, a multicenter cohort study. 1854 non-myopic first graders, examined between 1989 and 2005 that had one additional examination each year from grades 2-8 were included in the study. Parental history of myopia was determined by a parental completed survey. Refractive error was determined by cycloplegic autorefraction. Myopia was considered to be  $-0.75D$  or more in both meridians. Children were classified as either at high risk or low risk of developing myopia. Children were placed in the high risk category if, in the first grade, their spherical component of hyperopia was  $+0.75D$  or less, and the low risk category if the

spherical component of hyperopia was greater than +0.75D in the first grade. The study compared the risk status and the number of myopic patients as predictors of myopia

Of the 1854 children in the study, 21.3% were classified as high risk, and 78.7% as low risk. 25.4% of high risk children had two myopic parents, compared to 16.5% of low risk children. In the low risk category, 47.7% had no myopic parents, compared to 35.5% in the high risk category. The chance of being in the high risk group increased with the number of myopic parents.

Overall 334 of the 1854 children (18%) became myopic by 8<sup>th</sup> grade. Within the high risk category, 77% of children with two myopic parents became myopic themselves. No statistically significant difference was found in the age of onset of myopia and the number of myopic parents.

Parental myopia and first grade refractive error can be used to predict development of myopia. The risk of myopia was shown to increase with the number of myopic patients. Although, the study accurately identified 82% of the children who did not become myopic, proving good specificity, the study only accurately identified 62.5% of those who became myopic by eighth grade, proving its sensitivity to be low. A study with more accurate prediction of myopia is needed. Further studies to determine a more accurate predictor of myopia are needed.

**BORSTING E, TOSHA C, CHASE C, RIDDER WH. MEASURING NEAR-INDUCED TRANSIENT MYOPIA IN COLLEGE STUDENTS WITH VISUAL DISCOMFORT. OPTOM VIS SCI 2010;87:760-66.**

Visual discomfort is a common symptom for prolonged near-point activities for college students. Several factors, including pattern glare, uncorrected refractive errors, and disorders of accommodation or vergence, may contribute to visual discomfort at near. The purpose of this study was to assess the amount of near-induced transient myopia and accommodation in college students with and without visual discomfort.

This study involved 12 college students (ages 18-22) with high visual discomfort and 12 college students with low visual discomfort. All participants had a visual acuity of 20/25 or better, no strabismus, stereoacuity of 70 seconds of arc or better, random dot stereopsis and no significant uncorrected refractive error. All refractive errors and accommodative measurements were completed with a WAM-5500 auto refractor. The procedure involved 5 minutes of dark adaptation, after which time subjects' distance refraction at 6 meters were assessed for 1 minute. The subjects were then given a 10 minute reading task at 20 cm. The accommodative response was measured at two 30 second intervals during the reading task. After the reading task, the distance refraction measurements were again assessed for 2 minutes.

The results of this study showed a significant interaction ( $p=0.05$ ) in terms of level of visual discomfort and pre- and post-task distance refraction. In terms of refraction, the high discomfort group showed no myopic shift, while the low discomfort group showed a 0.13D myopic shift.

The authors concluded that a near-induced transient myopia response is not associated with high visual discomfort experienced during prolonged near-point activities by college students.

The researchers hope to assess the association between the adaptation to accommodation and lag of accommodation and visual discomfort.

RUDNICKA AR, OWEN CG, NIGHTINGALE CM, ET AL. ETHNIC DIFFERENCES IN THE PREVALENCE OF MYOPIA AND OCULAR BIOMETRY IN 10- AND 11-YEAR-OLD CHILDREN: THE CHILD HEART AND HEALTH STUDY IN ENGLAND (CHASE). INVEST OPHTHAL VIS SCI 2010; 51:6270-76.

A cross-sectional study from June 2007-March 2008 was performed to investigate possible ethnic differences in the prevalence of myopia. In the study 1179 children aged 9.8 to 11.9 years from 46 public schools in three UK cities participated. Students were classified according to parental report of ethnicity according to one of the following classifications White (European), Black (African/ Caribbean), South Asian (India, Pakistan, Bangladesh, Sri Lanka) and Asian (other). Measurements included non-cycloplegic refractive status with an open-field auto refractor and ocular biometry including axial length, anterior chamber depth, and front surface keratometry. Overall, the prevalence of myopia was 11.9%. South Asian children had the highest prevalence of myopia at 25%, followed by African Caribbean (10%) and white Europeans (3%). South Asian children also had the longest axial lengths of the three groups, followed by African Caribbean and white European children.

These results from the study revealed that certain ethnic groups may be more prone to develop myopia in response to their visual environment. Since the children were all living in the UK and attending state schools, the study was in the unique position of comparing equal percentages of children with similar educational and living demands.

## PEDIATRIC VISION

MAPLES WC. FREQUENCY AND TYPES OF PEDIATRIC SYMPTOMS IN A CLINICAL POPULATION. OPTOM VIS DEV 2010; 41(2):74-80.

As the presence of symptoms is central to the diagnostic process and indicative of the patient's quality of life, this study examines what symptoms presented within the pediatric population are most frequent and severe.

With the pediatric population in particular, the College of Optometrists in Vision Development-Quality of Life Questionnaire (COVD-QOL) has been used extensively and is known to have good test-retest reliability. While the original COVD-QOL is comprised of 30 items, a more user friendly COVD-QOL Short Form (SF) modifies the language of the questionnaire and removes the most infrequently reported symptoms. The SF has become more widely used than the original COVD-QOL, and was the instrument used to document patient symptoms in this study.

In order to determine the most frequent and severe pediatric symptoms presented, the study retrospectively analyzed the SF data from 199 consecutive pediatric (ages 7-12) examination

charts over a two-month period. When comparing the symptoms, the data were split into a younger 7 to 9 year old group, and an older 10 to 12 year old group.

The symptoms reported by the SF were generally consistent across all ages of pediatric patients within the study. The highest mean score for both the younger group and the overall group was “does not use his/her time well,” while the highest mean score for the older group was “loses belongings/things.” While the highest mean score was different for each age group, three of the top five symptoms were common to all three data groups (younger, older, and overall): “difficulty copying from the chalkboard,” “low attention while reading,” and “difficulty completing assignments on time.” Of the top three symptoms, each one respectively belongs to a different expert-defined category: accommodation, binocularity, and perception respectively.

DENG L, GWIAZDA J, THORN F. CHILDREN'S REFRACTIONS AND VISUAL ACTIVITIES IN THE SCHOOL YEAR AND SUMMER. OPT VIS SCI 2010;87:406-13.

Genetic and environmental factors contribute to the development of myopia. Near work and outdoor activities have been cited as negative and positive contributors of myopia development. Investigators examined the association of children’s refractive error with the number of hours spent on visual activities during the school year and summer break.

Who was included in this study?

147 children ages 6 to 18 years of age were examined. 33 children were myopic (spherical equivalent  $< -0.50$  diopters) and 114 children were non-myopic (spherical equivalent  $\geq -0.50$  diopters).

What did the subjects have to do?

Parents of subjects completed a questionnaire listing the number of weekly hours outside of school and during the summer (June, July, and August) that the children read for pleasure, studied, watched TV, used computer/played video games and engaged in sports/outdoor activities. Parental refractive information (including the age when parent(s) first started to wear glasses) was also collected.

What was found during the study?

During the school year, but not summer break, myopes engaged in fewer hours of sports/outdoor activity and more hours watching TV than the non-myopes. The non-myopes’ high number of weekly sports/outdoor activities during the school year might protect against myopic development. Similarly, the high number of sports/outdoor activity hours for both myopes and non-myopes during the summer may contribute to slowed eye growth in all children.

The purpose of the study was to determine whether parental concerns about their children's overall development, as assessed by the Parents' Evaluation of Developmental Status instrument (PEDS), are associated with significant refractive errors in preschool children.

In this study, 2381 children with a mean age of 38.5 months (range 6 to 71 months). Forty percent (40%) were white, 50.3% were black and 9.7% were other ethnicities. Parental concerns were more prevalent in children older than 36 months than in younger children. The authors speculate that the odds of parental concerns may have been increased in older preschool children because older children have visual demands that are different from younger children. There was more likely a concern from parents when a child (over 36 months) had hyperopia  $\geq 3.00$ , astigmatism  $\geq 1.50$  D, or anisometropia  $\geq 2.00$  D. No association was found between myopia and parental concerns about development problems. The authors also speculate that symptoms associated with uncorrected myopia common in school settings are not apparent in preschool children. The study could not determine a causal relationship between refractive error and parental concerns about development. However, the authors recommend that a cycloplegic refraction be done on preschool children whose parents have developmental concerns.

## PRESBYOPIA

POLAT U. MAKING PERCEPTUAL LEARNING PRACTICAL TO IMPROVE VISUAL FUNCTIONS. VISION RES 2009; 49:2566-73.

The purpose of this article was to review the results of structured perceptual learning used in amblyopia and myopia (from previous studies), and to apply it to presbyopia. In prior studies, perceptual learning, using contrast detection of Gabor target found that patients with amblyopia show improvement in abnormal lateral interactions, contrast sensitivity functions, visual acuity and binocular fusion/stereoacuity. Patients with low myopia showed improvement in visual acuity and contrast sensitivity function.

The most recent study included subjects with presbyopia. The training procedure for patients was aimed at improving the spatial and temporal contrast sensitivity using perceptual learning. The first group of patients included 13 subjects ( $50 \pm 1.1$  years old, initial VA 0.385 LogMar) and the second group included 14 subjects ( $51.6 \pm 0.05$  years old, initial VA 0.47 LogMar). The first group completed the training and the second group had not completed training.

After training, the first group showed a 73% improvement in visual acuity, similar to the improvement seen in the amblyopia and low myopia studies. Eleven (11) out of 13 patients, were able to read without reading glasses. The other 2 patients could read at 40cm and only needed to use reading glasses for extensive reading. Contrast sensitivity function showed an average improvement of 0.19 log units (54%).

The results of this study found how perceptual learning can be used to improve visual function. Improvement of both spatial and temporal contrast sensitivity transferred to other visual functions in patients with presbyopia, ultimately improving visual acuity.

## SACCADES/READING EYE MOVEMENTS

WEBBER A, WOOD J, GOLE G, BROWN B. DEM TEST, VISAGRAPH EYE MOVEMENT RECORDINGS AND READING ABILITY IN CHILDREN. OPTOM VIS SCI 2011; 88: 295-302

This study evaluated how well the Developmental Eye Movement (DEM) Test correlated with Visagraph eye movement patterns and standardized reading achievement scores in visually normal children.

The subjects were 59 fourth and fifth graders (ages 9-10) with normal visual development. Subjects had a visual acuity better than 0.1 LogMAR and 60" or better of stereoacuity. Subjects' visual acuity, stereoacuity, fine motor skills, and perceived self-esteem were assessed. Additionally, the DEM and Visagraph were administered. All but 2 children were administered the Reading Progress Test (RPT).

The study found that the DEM ratio, horizontal reading time divided by vertical rapid automatic naming time, showed only a 13% association with Visagraph measured reading rate. The DEM horizontal adjusted time actually showed a larger association to the objective eye movements of the Visagraph than did the DEM ratio. DEM outcomes were not associated with RPT scores. The duration of fixation and reading rate as measured with the Visagraph were the best indicators of RPT scores. The results of this study suggest that cognitive, rather than motor factors, control the reading rate when reading for comprehension.

TIAN J, ETHIER V, SHADMEHR R, ET AL. SOME PERSPECTIVES ON SACCADE ADAPTATION. ANN NY ACAD SCI 2009;1164:166-172.

The saccadic system has been used as a model to study how the brain works with the motor system. Saccade adaptation refers to the ability to maintain the accuracy of saccades in order to prevent dysmetria, which is an overshoot or undershoot of a saccade.

Short-term saccadic adaptation is one method of studying motor learning. Short term saccade adaptation has been evaluated. Short-term saccade adaptation has been evaluated in patients with muscle weakness and in normal patients with "simulated" motor weakness. In both cases, the brain gradually learned to readjust the saccade to the expected location of the target. This correction was not forgotten immediately, showing that it is a true form of motor learning.

Studies on short-term saccade adaptation have also used a "cross axis" adaptation, where the second target jump presented is orthogonal to the first. In this case, learning occurred, but the saccades were not linear; they became curved. Based on this enduring adaptive response, it might be possible to derive that the brain decides what the overall saccade trajectory must be, reflecting a

higher-level cognitive strategy. Further studies used “on-axis” adaptation and error clamp trials, where the target is extinguished as the saccade is initiated. After training, the adaptation stimulus was reversed. These studies showed that the longer-term during the saccade learning was slowly decaying but still present during the reversed training. There was a fast process that adjusted saccade of the cross-axis and on-axis adaptation can point to the specific physiological experiments combining lesions, artificial stimulation, and neural recordings that will help show the brain’s defenses against inaccurate motor behavior. Additional studies on monkeys, using gain decrease and gain increase paradigms found slower, longer-lasting saccades after gain decrease but no change in speed or duration after gain increase. In the natural world, saccades occur in changing visual environments and are combined with head movements. Saccades can be internally generated scanning saccades and reflexive saccades to a novel visual stimulus. This review has shown that there is potential to discovering how the brain deciphers from the behavioral and sensory milieu and what is needed to prevent dysmetria.

KIS AC, SINGH VWA, NIEMEIER M. SHORT- AND LONG-TERM PLASTICITY OF EYE POSITION INFORMATION: EXAMINING PERCEPTUAL, ATTENTIONAL, AND MOTOR INFLUENCES ON PERISACCADIC PERCEPTION. J VIS 2009;9:1-21.

There are mechanisms in place that allow us to view the world around us without any perceived interruptions, despite our rapid eye and retina movements. Under certain conditions, this ability is lost, resulting in perisaccadic shifts, causing stimuli to appear to “jump.” Information on eye position is obtained from the retinae and extraretinal sources. One extraretinal source is an “efference copy” of oculomotor command involving the superior colliculus, thalamus and frontal eye fields. Another source is cortical involving oculomotor signals in the cortex or mechanisms relating to attention. Researchers examined “influences of eye posture, attentional cueing, and trial history on perisaccadic misperceptions” to determine what extraretinal source is responsible for these perceptions.

The study consisted of 11 healthy subjects, ages twenty to thirty seven, with normal visual acuity. Four experiments were carried out in dim lighting conditions, and head movements were controlled by utilizing a bite bar. Patients fixated a target which disappeared and was followed by a new target in a different location. Patients responded to the perceived location of the flash by clicking a mouse. Eye movements were additionally controlled for by visual observation of the subjects. All trials containing possible contaminations (e.g. eye blinks, and unstable fixation) were not included.

Results of the study found that a visual stimulus presented around the time of a saccade causes a perception that the stimulus is shifted in the direction of the saccade. These studies did not find evidence that oculomotor control signals are responsible for this shift. This shift is plastic on different time scales and appears to constantly calibrate itself to result in a stable percept of the environment in spite of changes to oculomotor systems.

OKUMURA, T., LAUKKANEN, H., & TAMAI, H. "COMPUTERIZED SACCADIC EYE MOVEMENT THERAPY TO IMPROVE OCULOMOTOR CONTROL DURING READING AND READING RATE IN ADULT JAPANESE READERS: BY OPTOM VIS DEV. 2008; 39:191-7

This study investigated whether computerized eye movement therapy (CEMT) improved oculomotor control in adult Japanese readers. Past studies have shown a positive effect of therapy on English speaking students. Because the difference in Japanese written language (e.g. symbols instead of letters, absence of spaces between words, and vertical spatial organization of the reading material) examiners waited to determine if computerized eye movement therapy alone would be effective in improving eye movement skills in Japanese language readers.

Sixteen adult Japanese foreign exchange students participated in this study. Those involved in the study were high school graduates without reading disabilities or dyslexia, which were reading at the high school level or higher. They had near visual acuities of 20/30 or better without deficiencies in accommodative or vergence skills. Subjects were divided into two groups: an experimental (computerized eye movement therapy or CEMT) group and a control group. The CEMT group was prescribed 10 minutes of computerized eye movement therapy per day. Each group was evaluated before and after the five week treatment time using a Visagraph II level with 3-10 passages translated into Japanese text. A statistical analysis on the pre and post experiment findings of each group were performed in each of the following areas: Fixation, Span of Recognition, Regression, Duration of Fixation, Reading Rate with Comprehension, The Number of Correct Answers (out of 10 questions).

Examiners found that those among the CEMT group demonstrated a significant decrease in the number of fixations and regressions, as well as an increase in reading rate and span of recognition, relative to the control group. The study showed that computerized eye movement therapy could be effective in improving oculomotor skills associated with reading Japanese text in spite of apparent differences in the Japanese structure of written language. However, this study does not indicate whether CEMT alone would be effective in treating those students who either have reading disabilities or wish to improve their own reading abilities.

## READING

COHEN Y, SEGAL O, BARKANA Y, ET AL. CORRELATION BETWEEN ASTHENOPIC SYMPTOMS AND DIFFERENT MEASUREMENTS OF CONVERGENCE AND READING COMPREHENSION AND SACCADIC FIXATION EYE MOVEMENTS. OPTOMETRY 2010; 81: 28-34.

This study looked at the possible correlation between asthenopic symptoms, convergence amplitude, reading comprehension and saccadic eye movements. Sixty-three children, ages 8 to 10 years, were included in this study.

Asthenopic symptoms were evaluated by using a symptom questionnaire of 8 questions and 3 response choices. Convergence was evaluated using three different techniques; the near point of convergence (NPC) was measured using an accommodative target. Positive fusional vergence (PFV) was measured at distance and near with a non-accommodative target. Convergence was also

measured at near using a computerized stereogram. Reading comprehension was evaluated by having the subjects read a paragraph and then answering 50 multiple choice questions. Saccadic eye movements were evaluated by administering the Developmental Eye Movement (DEM) test.

The results of this study found that the NPC on a near accommodative target best correlated with asthenopic symptoms. There was not a correlation between asthenopic symptoms and PFV on distance and non-accommodative targets. There was also a relationship between symptoms and NPC (break), convergence amplitude on a distance target (break) and convergence amplitude on a near stereogram (recovery). Convergence on a near penlight was not statistically correlated with symptoms. There was not a correlation between asthenopic symptoms and reading comprehension. However, there was a correlation between asthenopic symptoms and time to complete the test; the greater the symptoms, the longer time to complete the test. There was also a correlation between the symptom score and the DEM ratio.

## STEREOPSIS

O'CONNOR AR, BIRCH EE, ANDERSON S, ET AL. THE FUNCTIONAL SIGNIFICANCE OF STEREOPSIS. INVEST OPHTHAL VIS SCI 2010;51(4):2019-23.

This study included 143 subjects ranging from 10-30 years of age with normal to no stereoacuity to assess the relationship between stereopsis and motor skills. Approximately 33% of the subjects had a manifest strabismus.

The subjects completed the following three (3) tasks with and without occlusion of one eye: Purdue Pegboard, large and small, bead threading and water pouring. Stereoacuity was assessed with the Randot Preschool Stereo Test, the Frisby Stereotest and the TNO Test. On all tasks subjects with stereoacuity performed better than those without stereoacuity. Subjects with amblyopia were slower on the bead tasks than those without amblyopia. A significant difference between the pegboard and bead tasks was found between stereoacuity groups, while, on average, those with normal stereoacuity performed better than those with no stereoacuity on binocular tasks. In some cases, patients without stereoacuity performed a task better than those with normal stereopsis who had occluded one eye, suggesting a long-term adaptation to no stereoacuity.

The results of the study suggest that the Preschool Randot Stereoacuity test may be more indicative of performance on motor skill tasks. The authors also suggest that the level of stereoacuity has a bigger impact on motor skills tasks than the presence of amblyopia.

## VESTIBULAR DYSFUNCTION

WINKLER PA, CIUFFREDA KJ. OCULAR FIXATION, VESTIBULAR DYSFUNCTION AND VISUAL MOTION HYPERSENSITIVITY. OPTOMETRY 2009; 80:502-12.

The purpose of this study was to investigate ocular fixational stability among patients who have vestibular dysfunction with visual motion hypersensitivity (VMH) to those without VMH and a healthy control group.

Sixty-four patients were included in the study: 24 with vestibular disorders with VMH, 20 with vestibular disorders without VMH, and a control group of 20 normal individuals. The diagnosis of VMH was made clinically through the use of the visual motion hypersensitivity questionnaire (VMHQ).

Ocular fixational stability was assessed during tasks with and without visual background movement by using an electro-oculogram recording of horizontal/vertical eye position and blink. In one condition the eye movements were recorded as the patients looked at a fixation point with a moving background in a darkened room. The other condition had the patient look at a fixation point with a neutral wall in the background of an illuminated room. Eye movements of 1° or greater were considered a fixation error.

Binocular vision functions including: stereopsis, near point of convergence (NPC), fixation disparity, and fusional vergence. Dizziness was assessed with the Dizziness Handicap Inventory (DHI).

The results found that the VMH group had significantly more refixations than both the vestibular and control groups when trying to fixate a target with background movement. The study also found that both the VMH subjects and vestibular dysfunction subjects had difficulty with fusional vergence tasks. Fifty percent of VMH subjects and forty percent of vestibular subjects had less than normal stereopsis. Thirty six (36%) percent of patients with VMH had fixation disparity and 30% without VMH had fixation disparity (gross vergence error with peripheral fusion only), compared to 10% of the controls. Patients with VMH also had higher dizziness scores on the DHI.

## VISION DEVELOPMENT

MITCHELL DE, KENNIE J, AND KUNG D. DEVELOPMENTAL OF GLOBAL MOTION PERCEPTION REQUIRES EARLY POSTNATAL EXPOSURE TO PATTERNED LIGHT. CURR BIOLOGY 2009; 19; 645-9.

In this article, consequences of early visual deprivation on global motion perception as well as the timing of the critical period for such effects were investigated.

A total of fifteen kittens were studied in this experiment. In the first group eight kittens were binocularly deprived from near birth, 2 by suturing the eyelids and 6 by being reared in total darkness. In the second group, four kittens were binocularly lid sutured at the age of four, five or six weeks for either 4 or 6 weeks. The result from each group was compared to that of a control group.

The 6 week dark reared kittens recovered grating acuity to the equivalent of the age-matched normal. The kittens with bilateral lid suture took longer for the visual acuity to stabilize and acuity was reduced.

Although all the binocularly deprived animals were able to discriminate the simple unilateral motion all exhibited profound deficits of global motion perception that were long lasting. The rapid rate of the global motion deficits with increasing length of deprivation was also observed. The deficits of global motion sensitivity were more severe in the lid-suture group; the kittens were unable to discriminate coherent motion even at 100% coherence. The deficits for those deprived at six weeks were minimal. These results suggested a brief critical period for the effects of binocular deprivation.

The discrepant magnitudes of the deficits of simple and global motion perception reported in this study argue for a larger effect of early deprivation on suprasylvian cortex than on primary visual cortex within a critical period that extends no longer in the simple motion perception than the global motion perception.

The results of this study argue for a larger effect of early visual deprivation on suprasylvian cortex than the primary visual cortex. Light may serve as a signal during development of a gene/protein necessary for refinement of neuronal networks for motion sensitivity in the striate and extrastriate cortex.

DAW NW. CRITICAL PERIODS: MOTION SENSITIVITY IS EARLY IN ALL AREAS. CURR BIOL 2009;19:R336-8.

Daw reviews the findings of studies conducted by Mitchell et al, and Ellenberg et al. regarding critical periods in the visual system.

Simple motion sensitivity has been thought to be a function of the primary visual cortex and global motion sensitivity is believed to be a function of areas outside the primary visual cortex. Mitchell et al. found that binocularly deprived animals have global motion sensitivity deficiencies but monocularly deprived and dark-reared animals have normal global motion sensitivities post therapy. Ellenberg et al. found that motion sensitivity is normal in patients with monocular cataracts.

Both studies support the concept of the development of motion areas outside the primary visual cortex in animals and patients with monocular deprivation.

Additionally, work by Mitchell et al. showed that the critical period for global motion sensitivity ends sooner than the critical period for binocular connections. Ellenberg et al. found that motion and direction sensitivity develop earlier than other areas of vision measured.

These new results also contradict the theory that properties addressed by higher visual systems end earlier than those at lower levels.

## VISUAL ACUITY

DROVER JR, MORALE SE, WANG YZ ET AL. VERNIER ACUITY CARDS: EXAMINATION OF DEVELOPMENT AND SCREENING VALIDITY. OPTOM VIS SCI 2010;87:E806-E812.

Vernier acuity the detection of the finest misalignment between two lines/gratings, utilizes spatial localization to determine the relative position of elements in a visual stimulus. Because it is five to ten times more sensitive than the intercone spacing on the fovea, it is commonly known as “hyperacuity.” This study was designed to assess the use of vernier acuity cards as a screening tool to detect amblyopia in infants and toddlers.

Ninety-eight (98) children and eighteen (18) adults with normal vision ranging between ages 2.8 months to 35.8 years were compared to the developmental time course between vernier acuity and grating acuity. In addition, both vernier and grating acuities were measured in forty-three (43) children (age 3-17 years) with unilateral amblyopia and thirty non-amblyopic children who had amblyogenic conditions. All patients were tested monocularly. Vernier acuity was measured with vernier acuity cards, where each card had a misalignment in stripe position that formed a symmetrical shape, and grating acuity was measured with Teller Acuity Cards (TAC). Optotype visual acuity was also measured monocularly in every participant using an HOTV test or an ETDRS test. Vernier and grating acuity were then classified as normal/abnormal by comparing it to the age normative data.

The results of this study show that vernier acuity is initially poorer than grating acuity and is adult like by age 8. Vernier acuity possessed a higher sensitivity (81% vs. 44%) than similar specificity (73% vs. 93%) to grating acuity. Vernier acuity was superior to grating acuity in all subtypes of amblyopia except anisometropic amblyopia. Vernier acuity appears to be a valid screening tool for amblyopia in infants and toddlers.

## VISION AND AGING

WOOD J, CHAPARRO A, ANSTEY K, ET. AL. SIMULATED VISUAL IMPAIRMENT LEADS TO COGNITIVE SLOWING IN OLDER ADULTS. OPTOMETRY VISION SCIENCE. 2010; 87:1037-1043.

Subjects included adults, 65 years of age and older. All were free of neurological conditions, ocular disease, and were not taking any medication. Age-related cataracts were simulated using 2 different levels of Vistech light scattering filters. The purpose of the filters was to cause an increase in intraocular light scatter and glare sensitivity. During the study, patients were tested under three conditions: no filter, one filter (88% light transmission), and two filters (75% light transmission). For each condition, visual acuities were taken using a logMAR chart and a Pelli-Robinson chart and contrast sensitivity was assessed with a Pelli-Robinson chart. Cognitive testing for each of the conditions included that of standard pen-and-paper tests, a Digit Symbol Substitution Test (DSST), a Trial Making Test (TMT), and the Stroop Color Word Test.

The results of this study showed that both visual acuity and contrast sensitivity did in fact decline when a subject had on the Vistech filters, most drastically in the 2 filters condition. Near visual acuity was four times greater than the visual requirements for the cognitive tests.

Performance on all cognitive tests worsened when more filters were added. The filters had a greater effect on visual and cognitive in the older subjects. The decrease in cognitive function was greater than expected by visual deterioration. Contrast sensitivity, and not visual acuity, was a better predictor of decrements in cognitive test performance.

## VISUAL MOTOR INTEGRATION

KOSLOWE, K. BIENENFELD, N. TANAMAI, S. SHNEOR, E. THE RELATIONSHIP BETWEEN HETEROPHORIA AND VISUAL ORGANIZATION IN FIRST AND SECOND GRADE CHILDREN ON THE GESELL COPY FORM TEST. OPTOM VIS DEV. 2010; 41: 33-37.

Heterophorias are an integral element of Behavioral Optometry, not as just an ocular phenomenon but also as a component of an individual's perception of space. This study was designed to determine if there is a potential connection between a subject's heterophoria and their performance on a visual form copying test (Winterhaven/Gesell Copy Form Test (GCFT)).

78 elementary school children (17 girls and 61 boys), in a public school grades 1 and 2 were administered the GCFT. The age range was 6.1-8.9. Inclusion criteria included a near visual acuity of 20/20, stereopsis of 600 seconds of arc using the Titmus Stereofly, and no strabismus. Before taking the GCFT, the subjects were divided into three groups based on the results of the cover test: exophoria (n=13), esophoria (n=23), and normal (N=42). For the purposes of this study, normal phoria were 1-6 exophoria, esophoria was orthophoria or any esophoria and exophoria was greater than 6 exophoria.

Upon the conclusion of the testing, only the first 3 of 7 figures were able to be evaluated due to inconsistencies in drawing the more difficult figures. Based on those 3 figures, spacing between the cross and square was significant ( $p=0.018$ ) when comparing the esophoric group to the exophoric group. The standard error of the means was 0.72 for the esophoric group and 1.16 for the exophoric group. These errors express the great variation in copying shapes for children of these ages.

The data suggest that the cross and square could be the most reliable indicators of the perceptual aspects of a subject's heterophoria. Due to difficulties in copying figures, the authors felt that it might be worthwhile to repeat this study with an older population. Additionally, the authors note that the quality of binocular vision, other visual conditions that could have affected the children's performance, and the use of Ritalin were not evaluated in this study.

The significant spacing difference seen between the esophoric and exophoric groups on the cross and square figures support the theory that an individual's heterophoria is a spatial phenomenon. As predicted, the esophoric subjects "crowded" their shapes while the exophoric subjects stretched the space between the shapes and thus "expanded" their visual perceptual space world.

## VISION PERCEPTION

BURR D, BANKS MS, MORRONE MC. AUDITORY DOMINANCE OVER VISION IN THE PERCEPTION OF INTERVAL DURATION. EXP BRAIN RES 2009;198:49-57

The purpose of this study was to evaluate quantitatively the contribution of visual and auditory stimuli on temporal localization.

The experiment was designed as a temporal bisection task in which three stimuli were presented over the course of two experiments. The stimuli were either visual, auditory (high frequency at 1,700 Hz or low frequency at 200Hz) or both. A total of 10 subjects participated in the study; three of the ten were the authors and the remaining seven were independent participants. The subjects' tasks were to identify whether the central stimulus was closer in time to the first or third stimulus over the course of 800ms.

During the experiment, 15 different conditions were tested in random order including vision only, auditory tones only and 13 two-cue conditions.

Data were graphed for each of the three testing conditions, and the point of subjective equality was measured to determine the average time the second stimulus appeared to bisect the first and third stimuli. For no-conflict tests, the center stimulus was perceived about 60ms closer to the first stimulus instead of at the physical midpoint. For visual-auditory combinations, when the auditory stimulus was presented before the visual stimulus, the center stimulus was perceived at an earlier time. When the visual stimulus was presented first, the center stimulus was perceived at a later time. In both situations, the perception of the middle stimulus appeared to follow the auditory stimulus demonstrating that audition is more dominant than vision.

The authors also tested whether degradation of the auditory stimulus (decreased frequency or increased time constant) would now cause vision to dominate. Based on the data collected, when the sound source was degraded, vision became more dominant.

The study shows that auditory stimuli tend to dominate visual, but not totally; individual variations exist.

CENSOR N, BONNEH Y, ARIELI A, SEGI D. EARLY-VISION BRAIN RESPONSES WHICH PREDICT HUMAN VISUAL SEGMENTATION AND LEARNING. J VISION 2009;9: 1-9

The purpose of this study was to determine if, and how much, early vision processing predicts behavioral texture discrimination performance and learning by evaluating electrophysiological brain responses. Researchers measured perceptual threshold of participants and recorded event-related potentials, before and after learning a visual discrimination task.

Four subjects were a part of the main study and 3 additional subjects completed a single session. All sessions consisted of subjects' viewing a textured stimuli for 40 ms followed by a patterned mask, shown for 100 ms. Subjects viewed a central fixation target and had to determine if an array of 3 diagonal bars embedded in an array of horizontal bars were horizontal or vertical. Multiple presentations of the target and mask stimuli with varying time separation between the target stimuli and the mask stimuli, known as stimulus onset asynchrony (SOA) were presented.

During the sessions, event-related potentials or EEG signals were recorded. Individual visual evoked potentials (VEPs) were averaged across trials. Psychometric curves and the mask's neurometric curve were calculated.

Researchers found and confirmed that when the SOA decreased, performance of the subject also decreased. All subjects improved between training sessions. Psychophysical threshold decreased between sessions and ERP mask response thresholds decreased, suggesting that practice seems to decrease the temporal interactions between the target and the mask. Researchers were able to calculate neuronal threshold of mask event-related potentials and found that it correlated with performance level in a visual discrimination task. On the contrary, researchers used these neural thresholds and compared them to the behavioral thresholds, found that both thresholds closely matched and were able to predict a person's behavioral threshold.

OP DEBEECK H, BAKER CI. THE NEURAL BASIS OF VISUAL OBJECT LEARNING. TRENDS COG SCI. 2009;14:22-30.

Most studies on learning how focused on the IT cortex, which includes the lateral occipital, occipitotemporal, and inferior temporal cortices. Op deBeeck and Baker review the evidence and hypotheses of visual object learning in the IT cortex. Individual neurons and sub regions of the IT cortex are selective for more difficult stimuli. The stimulus selectivity of the IT neurons and its modulation by learning will be discussed.

### Theoretical considerations

At a single neuron level, learning may increase or decrease selectivity of the optimal stimulus and/or it may change the dimensions encoded by that neuron. For example, there could be a decreased response to the non-preferred stimulus or an increased response to the preferred stimulus. Computational modeling emphasizes that tuning at the neuron level of a moderately complex object may be due to an optimal compromise between bottom-up statistics and the top-down information. At the population level of IT neurons, learning could modify a small or large number of neurons or affect the clustering (grouping) of neurons. The neurons that will be modified by learning may depend on the responsiveness of a subset of neurons, face-selective neurons, or modifications of tuning neurons that are most informative for object learning.

### Empirical Considerations

Monkey and human studies have shown that there is an increase in selectivity for trained versus untrained objects at the single neuron level. However, differences between relevant and irrelevant dimension seem more difficult to detect. Studies are conflicting as to whether or not there is an association component in object learning. Studies of humans, using functional MRI (fMRI), have shown training changes that are not fully distributed among neurons.

The prevailing view is that the IT cortex is plastic, however, there is limited evidence to support this. Future studies could investigate the properties of neurons to determine those that will be targeted by learning. Studies should examine the responsiveness of neurons over days or weeks.

ROELFSEMA PR, VAN OOYEN A, WATANABE T. PERCEPTUAL LEARNING RULES BASED ON REINFORCERS AND ATTENTION. TRENDS IN COGNITIVE SCIENCES. 2009; 14: 64-71.

Practice improves visual perception. With training in a laboratory, visual perception for a particular task can be improved with a few hundred trials per day over a few days and effects can last from months to years. The learning effects are often very specific, to orientation, motion direction, contrast, and/or location in the visual field and do not generate to other areas.

Neuronally, imaging studies have found an increase in neuronal activity in the area of the visual trained, particularly in area V1. Higher visual areas, V1, the IT cortex, area LIP and prefrontal cortex, also show changes. There is evidence that global neuromodulatory systems create learning by signaling relationships between stimuli and rewards. Dopamine neurons have been shown to code deviations from award expectancy and respond to stimuli that predict rewards. Acetylcholine has also been associated with synaptic plasticity.

A variety of studies have showcased the effects of selective attention on improvement in perceptual learning. When study subjects are instructed to attend to a particular feature of stimuli during training, their visual perception for that feature improves. Some studies have shown that if stimuli have paired features, such as color and shape, improved perception only occurs for the attended to feature. Other studies have demonstrated that learning can occur without attention. Subthreshold stimuli, too weak to be perceived, can be learned, if paired with the detection of another stimulus.

One theory to explain these changes proposes that synaptic changes only occur where dictated by the attentional feedback system. Only the sensory neurons involved in the perceptual task and subsequent behavior change their tuning.

This review aligns two seemingly contradictory theories explaining the role of attention in the mechanism for learning. The authors propose that the attentional feedback signal blocks the plasticity of irrelevant features in addition to enhancing plasticity of relevant features in the visual cortex. Subthreshold stimuli can be learned when paired with a neuromodulatory signal. The authors propose that there are 2 signals: a global, neuromodulatory signal, involved with rewards, and an attentional credit assessment signal involved with restricting plasticity.

JORDAN TR, PATERSON KB, STACHURSKI M. RE-EVALUATING SPLIT-FOVEA PROCESSING IN WORD RECOGNITION: EFFECTS OF WORD LENGTH. CORTEX. 2009; 45: 495-505.

Research is being conducted to gain a better understanding of how words are recognized and processed. One theory is known as the “split-fovea” theory of word recognition. This theory proposes that the fovea is split down the vertical meridian such that letters presented to the left of this fixation point are processed by the right hemisphere, while letters presented to the right of fixation are processed by the left hemisphere. Previously, Lavidor M, et al. conducted a study which found that increasing the number of letters to the left of fixation (projecting the right hemisphere) impaired lexical decision making, but increasing the number of letters to the right of fixation did not.

In the current study Jordan et al. conducted three separate experiments to re-evaluate this claim. The first experiment was set up using the same stimuli as Lavidor M, et al. After presentation of the fixation point for 400ms, both word and non-word stimuli of 5 to 8 characters were presented to a participant for 150ms. The number of letters to the left and right of the fixation point were varied. No eye tracker was used. Participants were asked to respond to whether the stimulus presented was a word or non-word. Reaction time and response accuracy were recorded. The results found that varying the number of letters in a word to the left of fixation did not affect word recognition.

A second experiment was then conducted by Jordan et al. using larger stimuli and an eye-tracker to monitor fixation. Word and non-word stimuli were again presented as in experiment one. Results were again similar to the first experiment. Because the eye tracker was used to monitor fixation, researchers found that there was accurate fixation by participants in only 52% of trials. Fixation fell between 2 to 8 letters from the fixation point.

A third experiment was conducted to ensure fixation was accurate at a fixation point. To ensure accurate fixation, presentation of the stimulus was delayed until the participant accurately held fixation for 400 ms. Again, there was no evidence to support the split-fovea theory.

ALBRECHT , T. ET AL. INDIVIDUAL DIFFERENCES IN METACONTRAST MASKING ARE ENHANCED BY PERCEPTUAL LEARNING. CONSCIOUSNESS AND COGNITION 2010; 19: 656-66.

This study used a series of 4 metacontrast masking experiments to examine differences in perceptual learning between 16 young adults with normal vision. Each experiment contained 13 blocks of 48 trials which were analyzed for learning trends. The target stimulus was presented before the masking stimulus and the stimulus onset asynchrony (SOA) varied between 24-84 ms.

In experiment 1, the subject identified the shape of the target stimulus via a forced choice method. Subjects fell into distinct Type A and Type B masking patterns within the first 3 blocks of trials, and these differences were enhanced with practice. Performance improved at long SOA in a Type A masking pattern, while performance improved at short SOA in a Type B masking pattern. Type A subjects did better than Type B. In experiment 2, subjects identified the shape of the masking stimulus in a speeded forced choice method to examine if the learning trends displayed in experiment 1 could be applied to a different task. No significant difference was found in the priming effect between type A and type B groups, indicating that the learning trends are task specific. Experiment 3 was run on an average of 105 days after experiment 1 and used the same methods to examine the stability of the learning trends. Five (5) type A and 5 Type B subjects exhibited the same Type A or B masking behaviors, indicating that learning is not changed between experiments. Experiment 4 used short SOA(24 ms) vs. long SOA (72 ms) to test if subjects could convert to the other masking pattern. Subjects improved with conditions in which they performed well previously, but did not improve in the previously poor conditions. Subjects followed their original Type A and Type B patterns.

These results suggest individuals may differ in how they interpret visual cues, and these differences may be due to prior experience. Further research is needed to examine what causes

initial bias towards Type A or B masking patterns. The results of this study may be used to examine the relationship between perceptual learning and conscious perception.

HOUTKAP R, ROELFSEMA PR. MATCHING OF VISUAL INPUT TO ONLY ONE ITEM AT ANY ONE TIME. PSYCH RES 2009;73:317-26.

This study focuses on whether the visual processing system allows an individual to search for multiple objects at the same time.

Previous studies have found that the human visual system performs best when only a single visual matching process is at work and loses efficiency when numerous visual searches occur at the same time. This experiment tested subjects' ability to recognize and find a target amongst a stream of objects. The first experiment required subjects' to find the shape amongst a number of other shapes; the second require the subjects to find a specific color; and the third required a combination of shape and color simultaneously. Performance greatly decreased when subjects' were told to find two targets amongst a search template compared to finding one target.

This study found that performance was poorer when subjects had to identify 2 items compared to a single item. Additionally, the study found that the visual processing system is not able to efficiently execute multiple matching processes simultaneously even if features of targets are from different categories, in this case shapes and colors. Memory allows us to memorize more than one stimulus, but only one of those stimuli is able to be affectedly compared to our working memory at a time. Concurrent matching processes result in poorer performance when compared to a single process.

## VISION SCREENING

VIP STUDY GROUP. EFFECT OF AGE USING LEA SYMBOLS OR HOTV FOR PRESCHOOL VISION SCREENING. OPTOM VIS SCI. 2010; 87

The purpose of this study was to "compare the effectiveness of the Lea Symbols and the HOTV distance visual acuity tests...as vision screening tests to identify three- to five-year old children in need of eye care."

This study enrolled 1,142 children in the Head Start program. The children were divided into 4 groups according to age (3, younger 4, older 4, and 5). Each child's VA was tested monocularly at 3 m using the linear, crowded Lea Symbols distance VA test, and linear, crowded HOTV distance VA test. The optotypes used in the measurements were 10/100, 10/32, 10/25, and 10/20 for the three year olds. The optotypes used in the measurement for the four year olds were 10/100, 10/25, 10/20, and 10/16. Testing continued from larger to smaller optotypes until the child could not identify or match  $\frac{3}{4}$  optotypes on a line. A distance and near cover test, and cycloplegic retinoscopy were measured on each child. Targeted conditions included amblyopia, strabismus, significant refractive error, and unexplained reduced VA. Group one conditions included a constant unilateral strabismus, specific VA levels for presumed/suspected amblyopia

and specific values for refractive error. The sensitivity and specificity of the Lea Symbols distance VA tests and HOTV distance VA tests in detecting one or more targeted disorder was then calculated for each age level.

The results of the study found that 95% of children completed both tests. Children in the youngest group had an easier time with Lea symbols than with HOTV testing. There was no statistically significant difference for all age groups, three through five in the Lea symbol or HOTV test to detect one or more targeted condition or any group one condition.

MARSH-TOOTLE WL, FUNKHOUSER E, FRAZIER MG, CRENSHAW K, WALL TC. KNOWLEDGE, ATTITUDES, AND ENVIRONMENT: WHAT PRIMARY CARE PROVIDERS SAY ABOUT PRE-SCHOOL VISION SCREENING. OPTOM VIS SCI 2010; 87: 104-111.

This study examines how knowledge, attitude, and environmental factors play a role in the delivery of pre-school vision screenings (PVS) by primary care providers. The stated goals of the study were to (1) describe responses from providers to questions about knowledge, attitudes, and practice environment related to PVS and (2) to consider a framework to understand factors associated with desirable PVS behaviors.

The study group designed a case-based, provider-targeted educational website to ask various questions about knowledge (mainly about amblyopia), attitudes, and practice environment related to PVS, with case questions involving a healthy 4 year old child. Participants were selected from a large pool of Medicaid providers in Alabama, Illinois, and South Carolina, and agreed to join in the study by returning faxes and answering the survey online. The 53 providers (primarily pediatricians) that completed the study were asked to report their PVS behavior and were asked questions about amblyopia knowledge, their attitude towards vision screening, and their vision screening environment. Good PVS behaviors were defined as: (1) screen acuity at all well child visits beginning at age 3, (2) refer a hypothetical 4-year-old child who cannot pass the 20/40 targets with each eye tested separately, and (3) perform additional tests of alignment as well as examining the external and internal eye for abnormalities.

The results of the study found that behaviors were consistent with the American Academy of Pediatrics (AAP) guidelines, but there were caveats. Most providers did not perform all AAP-recommended screening procedures, and only 40% report routinely beginning acuity testing at age 3. The idea that "PVS interrupts patient flow" is an attitude that was significantly associated with reduced odds (OR= 0.2; p=0.05) of being in the "good" behavior category. Interestingly, "attitudes" was the only category where scores were significantly associated (adjusted OR= 6.9; p=0.03) with a higher probability of reporting "good" PVS behavior. There was a trend between the number of "good" scores on knowledge, attitude, and behavior and being placed in the "good" PVS behavior category.

This study found that most provider begin screening for amblyopia at age 4 using visual acuity screening tests, although the knowledge scores indicated that many PCPs do not have a basic knowledge of amblyopia. In the future, emphasis needs to be placed on the fact that physical exam alone will miss the majority of amblyopia cases. In the future, work to improve PVS should include emphasizing (1) asymptomatic children are at risk for amblyopia (i.e. greater than 30% of 4 year olds do not have signs of amblyopia); thus routine physical exam is not sufficient to detect most

cases, (2) specific evidence-based tests have high testability and sensitivity for amblyopia in pre-school children, and (3) new tests (i.e. 5 m test distance, photoscreeners/autorefractors) minimize interruptions to patient flow.

REGISTER SJ. VISUAL ACUITY AND STEREOPSIS SCREENING RESULTS IN AN UNDERSERVED COMMUNITY. OPTOMETRY 2010;81:200-4.

New England College of Optometry's New England Eye Institute (NEEI) partnered with The Boys and Girls Clubs of Boston to provide vision screenings to disadvantaged youth in the Boston area. These screenings involved testing of stereopsis (Random Dot E stereotest) as well as of visual acuity (Lea Symbol, Snellen or HOTV).

Between October 2005 and February 2006, NEEI provided screening for 252 children at 5 Boys and Girls Clubs. The children ranged in age from 5-17 years old (average age 9.7) and were from various racial and ethnic backgrounds. Passing criteria included: distance VA better than 20/40 and any stereo vision. There was a mean failure rate of 37.4%. Of those referred, 48% were referred because of reduced VA and stereo, 23.7% because of reduced VA, 24.2% due to reduced stereo. Follow-up letters recommending a comprehensive eye examination were sent to parents whose children did not pass. The Boys and Girls Club offered a van to help facilitate follow up care via "field trips" to NEEI. Financial coverage for the full exam was supplied by personal insurance, VSP's Sight for Students, or the Affordable Eye Care Program at NEEI. Follow-up data was not gathered as some children elected to receive care elsewhere.

Other studies have demonstrated high failure rates in vision screenings, depending on age, method of testing, type of clinical administering the screening, and other variable. However, the consensus of these studies is clear; cooperation within a community and willingness to educate the public on the need for screenings are significant public health initiatives. Proper screening will help to identify children with visual problems that may lead to underperformance in school.