Decoding Binocular Vision

Clinical studies on the Neurolens impact to patients and practices
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

Clear and single binocular vision is critical for normal visual behavior. Any inaccuracies in alignment (vergence) would lead to eye deviations which can be broadly classified into three types: heterophoria, fixation disparity, and heterotropia (strabismus). Conditions related to phoria or fixation disparity are clinically referred to as non-strabismic binocular vision disorders. With about 40-80% of American children and adults reporting one or more Digital Vision Syndrome (DVS) symptoms, it is important to evaluate the binocular vision mechanism in these patients and treat them accordingly. The current testing routine involved for phoria estimations is not ideal and has several sources that could potentially cause errors in estimating the binocular function, including the subjective nature of testing, inter-examiner repeatability and the variability and complexity involved in the tests and procedures. The Neurolens Measurement Device, Gen 2 (NMD2) is an accurate, efficient, precise, objective and simple way to diagnose these patients and provide a treatment option (Neurolenses) which can relieve their symptoms.

Neurolens: a comprehensive way to treat Digital (computer) Vision Syndrome

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

Using digital devices regularly for prolonged hours is a common theme in today’s technologically advanced world, and most users experience eye strain or related symptoms after using digital devices, commonly referred to as Digital Vision Syndrome (DVS) or digital eye strain. One of the commonly reported causes of DVS are the non-strabismic binocular vision disorders (accommodation and vergence disorders), which are traditionally corrected using near adds, special coating lenses (for example, blue light filter lenses), prisms and vision therapy. However, these treatment options have limitations. Neurolenses paired with blue light filter coating provide a comprehensive treatment in the sense that they not only provide protection from harmful blue light rays damaging the eyes, but also significantly alleviate DVS symptoms by correcting the eye misalignment using a customizable lens design that incorporates a contoured prism. Patient survey results post 60-day Neurolens wear collected from individual practitioners across the country show that Neurolenses with blue light filter coatings effectively relieve various DVS symptoms in more than 80% of Neurolens wearers.
Can small prism corrections improve visual comfort? Yes! Here is why

by Vivek Labhishetty (BSc Optometry, MSc, PhD)

One of the common misconceptions with binocular vision disorders is that symptomatic patients tend to only exhibit large eye misalignment coupled with other clinical signs. The evidence actually suggests that the magnitude of clinical signs does not correlate with the severity of the symptomology. For instance, a patient with 1PD exophoria and a patient with 10PD exophoria with no other ocular or extraocular problems related to DVS might experience a similar magnitude of eye strain and need to be treated appropriately. Subjective and non-repeatable clinical diagnostic tools limit our ability to accurately detect small eye misalignments which cause DVS symptomology. Small horizontal prism corrections (< 1PD) can provide significant relief in symptomatic patients with DVS.

Neurolens: a game changer for your patients and your bottom line

by Rick Guinotte (CEO, Acquios Advisors/Acquios Alliance)

Over the past few years at Acquios Advisors, we have seen a new technology enter the industry and quickly become a game changer for patients’ quality of life. Evaluating the impact on three newly-implemented Neurolens providers firsthand, I have also seen the dramatic financial impact that adopting Neurolens technology can have on an optometry practice.

Given the impact on patients and practices alike, Neurolens technology has proven that it is—and will continue to be—an effective driver of success for eyecare practices.
Clear and single binocular vision is critical for normal visual behavior. Our eyes focus (accommodation) and align (vergence) to the object of interest in the real world thereby maintaining clear and single binocular vision. Any inaccuracies in the alignment would lead to eye deviations which can be broadly classified into three types: heterophoria, fixation disparity and heterotropia (strabismus). Heterophoria is the relative misalignment of the eyes in the absence of fusion. In other words, it is the eye misalignment measured under dissociated conditions. It can be horizontal, vertical, cyclo deviated or any combination of the above and is typically compensated by the eye’s fusional vergence in the presence of fusion. An inability to compensate this eye misalignment would lead to a manifest deviation called heterotropia or strabismus. Fixation disparity, on the other hand, is the relative misalignment of the eyes in the presence of fusion. This deviation is typically less than the Panum’s fusional area therefore objects in space do not appear double. Conditions related to phoria or fixation disparity are clinically referred to as non-strabismic binocular vision disorders.

Traditionally, a diagnostic vision testing routine involves determination of uncorrected refractive errors which are corrected using lenses that provide the best possible vision. However, comprehensive vision care cannot just be limited to the best monocular and binocular visual acuity that can be provided. In the natural world, our eyes work together to focus and align objects to achieve a clear and single binocular vision. Therefore, to provide the best vision care, it is important to also evaluate how well our patients’ eyes work together. This is especially critical in this modern day and age where we see an increasing trend in our near vision demand associated with viewing digital devices including phones, tablets and computers. This increasing near visual demand increases the load on the accommodation and vergence mechanisms to constantly focus and align objects at closer distances. Recent reports show that, on average, American children and adults spend about 7.5 to 9.7 hours/day on digital platforms with about 40–80% of them reporting one or more Digital Vision Syndrome (DVS) symptoms such as tired eyes, eye strain and discomfort or dry eyes (Rosenfield, 2016). Therefore, it is important to evaluate the binocular vision mechanism in these patients and treat them accordingly.

To evaluate the binocular vision mechanism, clinicians measure the magnitude and the direction of the phoria at distance (6m) and near (40cms). Tests such as cover-uncover, Von Graefe or modified Thorington are typically used to measure phoria. A comprehensive way to measure binocular vision would include testing the limits (NPA/NPC), amplitudes (NFV/PFV, NRA/PRA), accuracy (phoria/fixed disparity, lag/lead of accommodation) and the dynamics (vergence and accommodation facility) of both accommodation and vergence. Prism bars, flippers, RAF rulers, Maddox rods, retinoscopes and phoropters are employed to obtain this information about these two motor mechanisms. Given the unique cross-coupled behavior of the accommodation and vergence mechanism, another important measure would be to determine the strength of the cross-links between the two systems typically quantified as accommodative vergence response (AC/A ratio) and vergence accommodation response (CA/C ratio). CA/C is not commonly measured in a clinical setting. Individual clinical practices typically measure only phoria and limits (NPA/NPC). If the patient with phoria is symptomatic, treatment options aimed at reducing the phoria are traditionally recommended. Currently, several treatment options including lenses, prisms and vision therapy are available and often prescribed based on the information obtained from the above-mentioned tests (Scheiman & Wick, 2014). Given how important it is to evaluate binocular vision in this digital world, it is crucial that we test this mechanism both comprehensively and accurately; however, the current testing routine involved for phoria estimations is not ideal and has several sources that could potentially cause errors in estimating the binocular function. These sources include the subjective nature of testing, inter-examiner repeatability and the variability and complexity involved in the tests and procedures.
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements

Sources of Error

Subjective nature of the tests

Most clinical testing routines for evaluating binocular vision are subjective, depending on either the patient’s attentive response or the clinician’s level of expertise. This subjectivity could cause inaccurate estimates of the phoric posture with poor repeatability. Furthermore, given the subjective nature of testing, these tests will not be suitable for testing young children or individuals that are differently abled where it is difficult to obtain an accurate verbal response.

Inter-examiner repeatability

Most clinical tests, given their subjective nature, are dependent on the clinicians’ ability to perform the test accurately. Although several studies have reported that the level of expertise does not lead to clinically significant differences in phoria estimations, these studies do show that the variability in the estimation is larger with novice examiners (Hrynchak et al., 2010). Another potential source for inter-examiner repeatability would be the difference in the neutralization criterion employed by the clinician. For example, when performing subjective prism cover test, some examiners choose the prism value which neutralizes the eye movement as their end point while others choose the prism which creates an opposite movement of the eye or the point of reversal. Given the steps of prism changes seen in a prism bar, this could potentially lead to a variability of about 2-4PD. A study with a small sample also reported that the smallest phoria value that can be detected by clinicians with varying levels of expertise is about 2-3PD (Fogt et al., 2000). This would mean that any misalignments less than this value would not be detected and may potentially lead to inaccuracies. Finally, while performing tests that depend on the placement of prisms, such as prism cover test or fusional vergence testing, the distance between the prism and eye can impact prism effectivity and can lead to spurious or less reliable estimations.

Tests and procedures

Another crucial aspect to consider is what measurements should be used to calculate the prismatic correction that could be prescribed to your patient. Should you decide the prism value based on dissociated phoria, fixation disparity or both? Is one more effective than the other? Although most clinicians in North America typically prescribe prisms based on the dissociated phoria, there is evidence that fixation disparity could be a better predictor and should be employed for estimating the prism value. These studies argue that fixation disparity tests provide a more natural viewing condition with both eyes viewing similar content which could be fused (Yekta et al., 1989). Others have pointed out that neither of these alignment tests really provide any natural cues with measurements since the subjects view targets in an artificial or abnormal viewing conditions. Previous studies suggested that the practitioners could recommend prisms that make their patients feel most comfortable while viewing objects in real world (Otto et al., 2008). There is also disagreement on effectivity of prism corrections estimated based on either dissociated or associated phoria values (reviewed in Otto et al., 2008).

As mentioned before, several tests including Thorington, cover test and Von Graefe are used to measure phoria. Several studies have reported a significant difference in measured estimates between the tests with a standard deviation of about 4-5PD. One would reasonably expect to see differences between the tests given the difference in the testing procedure, stimuli used, influence of proximal convergence, ability to control accommodation and the nature of subjectivity involved in the test. For example, does the subjective test involve a patient’s response compared to a clinician’s judgement of the deviation? A study looking at the inter-examiner repeatability of different tests reported that only tests such as the Thorington have high inter-examiner repeatability while commonly employed tests such as the Von Graefe have a very low repeatability with differences as large as 3-5PD (Rainey et al., 1998; reviewed in Goss et al., 2010).
Factors contributing to the inaccuracy and lack of repeatability with the traditional subjective heterophoria measurements

Another important difference that could lead to the lack of repeatability and inaccuracies in the estimate is the amount of the time used to dissociate the eyes before taking a measurement. Previous research had reported a dissociation time as long as 5-25 min would be necessary to minimize the influence of vergence adaptation so a more accurate estimate of heterophoria could be obtained (Rosenfield et al., 1997). Unfortunately, this is not possible in a clinical setting and, given the limited ability of an unaided eye to identify and track very small and slow eye motion, it is difficult to say if measurements are indeed obtained after the eye stabilizes in a certain phoric posture under dissociated conditions. This, again, would potentially cause errors in the estimation. Finally, a major complexity associated with binocular vision testing is that the clinician must typically perform a battery of tests to decide on type and magnitude of the corrective option. This is especially challenging in busy individual practices to invest a significant amount of time into performing a battery of tests to estimate an accurate prism correction that can effectively relieve symptoms.

Neurolens Measurement Device, Gen 2 (NMD2)

The Neurolens Measurement Device, Gen 2 (NMD2) is a diagnostic tool that measures binocular vision. It is an objective, efficient, patient-friendly, accurate, precise and simple way to measure eye alignment along with the inter-pupillary distance and AC/A measurements. The NMD2 does not rely on subjective responses, therefore eliminating both clinician and patients’ biases or variabilities. The objective measuring aspect of the NMD2 is achieved by employing an eye tracking system which robustly tracks patients’ eyes in a continuous fashion while the eyes are dissociated. This allows the system to measure the phoria once the eye stabilizes under dissociated conditions leading to an accurate and repeatable estimate of the phoria (Figure 1). The system can identify phoria smaller than 1PD and can detect changes as small as 0.1PD. An internal clinical study done using three different systems on 15 subjects with and without non-strabismic disorders found that the repeatability of the NMD2 was 0.53PD for distance and 0.86PD for near phoria measurements which is significantly lower than 2.5-5PD reported with the traditional methods such as Von Graefe and Thorington. Furthermore, the examiner’s level of expertise or the patient’s responsiveness do not affect the NMD2 measurements. The NMD2 continuously monitors the eye movement and measures both dissociated phoria and fixation disparity at distance and near. To ensure accurate estimates were obtained and the eye movement data was not corrupted with large eye/head movements, the NMD2 also provides a measurement quality index (MQI) which informs the examiner about the quality of measurement obtained (MQI > 0.7 is considered a good measurement with the eye movement having been neutralized within 0.25PD).
The NMD2 is simple in the sense that it employs an iterative procedure which takes the misalignment measurements into account and provides a final Neurolens prism correction (Neurolens value), in units of PD, which the clinicians can readily use to treat their patients. Unlike prescribing guidelines like Sheard’s Criterion, Percival’s Rule or the 1:1 rule, the Neurolens value utilizes a proprietary algorithm that was developed based on patient outcomes across hundreds of thousands of measurements and outcomes. The NMD2 is efficient in that it finishes the basic binocular vision testing, including phoria/fixation disparity and AC/A, and provides a Neurolens correction value within 180 seconds; and, it can be performed by a clinical technician. Finally, it also provides a visual representation of the patient’s misalignment which can be used to explain the problem causing the symptoms along with the solution being recommended to the patient.

Figure 2: Proportion of individuals that reported symptom relief after wearing Neurolens correction for 60 days.

As shown in figure 2, Neurolens correction prescribed based on the Neurolens prism value has proven very successful delivering a very high level of symptom relief for patients with various DVS related symptoms such as headaches, neck pain, discomfort with computer use, etc. Unlike a regular prism, Neurolenses incorporate a contoured prism design which allows clinicians to provide different amounts of prism at distance and near. Overall, approximately 83% of Neurolens wearers reported improvement in the typically reported DVS symptoms including discomfort with computer use (82%), tired eyes (83.8%) and headaches (83.4%). After a 60-day wear of Neurolenses, prescribed based on the neurolens prism value reported by the NMD2, approximately 80% of the symptomatic patients reported that they are willing to recommend Neurolens to their friends and family.

Conclusion

An average American spends about 7-10 hours/day on digital devices of which approximately 40-80% individuals experience some sort of DVS related symptoms including headaches, neck pain and tired eyes. Furthermore, individuals with traumatic brain injury (TBI), post LASIK surgery or young adults with myopia have also been reported to be strongly associated with non-strabismic disorders. It is therefore critical that these individuals are provided with the best possible comprehensive vision care, including an accurate and efficient binocular vision evaluation. The Neurolens Measurement Device, Gen 2 (NMD2) is an accurate, efficient, precise, objective and simple way to diagnose these patients and provide a treatment option (Neurolenses with contoured prism) that can relieve their symptoms, ultimately helping them to lead a symptom-free digital life.
Table 1: Summary of the differences between the traditional subjective methods used to estimate eye misalignment and NMD2.

<table>
<thead>
<tr>
<th>Source of Error</th>
<th>Traditional Methods</th>
<th>NMD2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective nature</td>
<td>Clinicians’ expertise or patient responsiveness</td>
<td>Objective and can be operated by a technician</td>
</tr>
<tr>
<td>Inter-examiner repeatability</td>
<td>Variability with clinical expertise</td>
<td>Yes</td>
</tr>
<tr>
<td>Neutralization criterion</td>
<td>Yes. Does the examiner choose a prism neutralization that induces no eye movement or opposite eye movement (reversal)?</td>
<td>No. The algorithm measures deviation when the eyes stabilize</td>
</tr>
<tr>
<td>Accuracy of the end point</td>
<td>Depending on the test (prism bar) employed, can vary between 2-4 PD</td>
<td>Measurement Quality Index (MQI) &gt; 0.7 would indicate that the end point is within 0.25PD</td>
</tr>
<tr>
<td>Smallest phoria that can be identified</td>
<td>~2-3PD</td>
<td>Misalignment less than 0.1PD would be detected</td>
</tr>
<tr>
<td>Prism effectivity</td>
<td>Depending on where the prisms have been placed relative to the patient’s eyes, prism effectivity can be different</td>
<td>Vertex distance is always kept constant</td>
</tr>
<tr>
<td>Tests and Procedures</td>
<td>Should you decide the prism value based on the dissociated phoria, fixation disparity or both?</td>
<td>Clinicians typically use dissociated phoria</td>
</tr>
<tr>
<td>Repeatability</td>
<td>Depending on the test employed, it can be anywhere between 3-5PD</td>
<td>0.53PD for distance and 0.86PD for near measures</td>
</tr>
<tr>
<td>Dissociation time</td>
<td>Variable depending on the test and is limited by the unaided eye’s ability to track very small and slow eye movements</td>
<td>Eye trackers can accurately track the eye during dissociation and association measures</td>
</tr>
</tbody>
</table>

References

Background

Using digital devices regularly for prolonged hours is a common theme in today’s technologically advanced world, both for personal and professional purposes. This is especially true for young children (~10 hours/day) and adults (~8 hours/day). Most users experience eye strain or related symptoms after using digital devices, commonly referred to as Digital Vision Syndrome (DVS) or digital eye strain (Rosenfield, 2016). It is therefore of the utmost importance that these individuals are provided with an easy-to-use treatment option that alleviates eye strain related symptoms, protects their eyes from harmful radiation and helps them lead a comfortable digital life. One of the commonly reported causes of DVS are the non-strabismic binocular vision disorders (accommodation and vergence disorders). Non-strabismic disorders are traditionally corrected using near adds, special coating lenses (for example, blue light filter lenses), prisms and vision therapy. However, these treatment options have a few limitations. For instance, vision therapy, although effective, does not provide instant relief and is heavily reliant on patient compliance. Most patients with DVS symptoms exhibit different magnitudes of eye misalignment at different viewing distances (Maples et al., 2009). Unfortunately, standard prisms provide a constant correction at different viewing distances and therefore may not be beneficial. Blue light filter coatings, often marketed and prescribed as a treatment option, only protect the eyes from harmful high energy radiation and do not alleviate DVS symptoms (Palavets & Rosenfield, 2019). This is not surprising given that these coatings do not have any impact on the common causes of DVS related symptoms; for instance, eye misalignment. It is also important to remember that digital eye strain due to non-strabismic disorders cannot just be limited to the eyes and is much more complex, involving both binocular and extraocular aspects. Given the near-dominant world we live in, it is increasingly important that clinicians have a comprehensive understanding of the underlying physiology, awareness of the various DVS symptoms, and knowledge of the treatment options that could effectively relieve their patients’ symptoms.

Digital Vision Syndrome: Pathophysiology

There is no unified hypothesis as to why uncorrected refractive errors or non-strabismic disorders, such as convergence insufficiency, cause asthenopia-related symptoms. Several theories have been proposed to explain this association. One widely accepted theory is that the strain on the extraocular muscles (EOM) due to eye misalignment overstimulates the trigeminal nerve causing DVS symptoms, clinically referred to as Trigeminal Dysphoria. In this theory, the pathophysiological pathway involved is similar to the one involved in migraines (Digre, 2018). The trigeminal nerve is the fifth cranial nerve which innervates several parts of the face. The nerve has three branches: ophthalmic, maxillary and mandibular. The first two branches are purely sensory, but the third branch is involved in both sensory and motor functions. It has been previously reported that the ophthalmic branch, which supplies the eye and orbit, also supplies a large portion of the dura. This sensory link between the eye and the central nervous system through the trigeminal nerve is thought to be the causal link. The pathophysiology includes an eye misalignment leading to an increased effort by the visual system to realign to avoid double vision and strabismus. This constant effort to realign causes an overstimulation of the trigeminal nerve, which ultimately leads to an irritated nerve. This irritation then results in a painful stimulation of several parts of the eye, head and neck, leading to symptoms such as headache, neck pain and eye strain. The trigeminal ‘caudalis’ nucleus which relays information between the eyes and the central nervous system extends into the cervical spine in the neck. If the entire trigeminal nucleus is irritated during trigeminal dysphoria, it might explain why problems in the eyes lead to a pain in the neck.

Given the unique cross-linkage between accommodation and vergence, eye misalignments could often be caused due to an altered accommodation behavior. The accommodation system is primarily innervated by the parasympathetic nervous system, particularly the ciliary muscle, which is responsible for accommodation. Previous studies have reported that a dual innervation - meaning both the sympathetic and parasympathetic innervation - is responsible for maintaining the tonic/resting state of accommodation, and any imbalance in this dual innervation leads to an altered accommodation response at near (Bullimore & Gilmartin, 1988; Chen et al., 2003).
This imbalance between the sympathetic and parasympathetic stimulation is another explanation for why disorders in the eyes cause DVS related symptoms such as headaches. Previous studies have reported that increased levels of stress, mental effort or attention lead to enhanced sympathetic and parasympathetic innervation causing an imbalance in the autonomic innervation to the eye. It has been theorized that the increased sympathetic innervation in response to stress or mental effort leads to an overall reduction in the accommodative response at near. This reduced accommodative response leads to a compensatory increase in the parasympathetic innervation to the ciliary muscle, ultimately increasing the accommodative effort. This increased accommodative effort then leads to an eye misalignment because of the increased accommodative-convergence (AC) input. As shown in figure 1, this eye misalignment overstimulates the trigeminal nerve, sending pain impulses to different parts of the face and causing symptoms such as headache, neck pain, etc. Previous studies have reported that an increased load on the ciliary muscle leads to the activation of the trapezius muscle, a large triangular shaped muscle extending over the back of neck and shoulders (Sanchez-Gonzales et al., 2018; Domkin et al., 2019). This activation could explain the association between accommodation disorders and neck/shoulder pain. Other studies have also pointed out that eye misalignments or accommodative (focus) response errors would also lead to postural imbalances that could cause neck and shoulder pain (Sanchez-Gonzales et al., 2019, Ritcher, 2008).

Although the exact function is not totally understood, the sensory receptors of the EOMs provide proprioception (sense of awareness of the position or movement). This afferent proprioceptive signaling provides an extra-retinal signal on the position of the eyes to the visual system (Weir, 2006). As shown in figure 1, this afferent input could signal the visual system about the misalignment, leading to an increased effort to realign ultimately causing an overstimulated trigeminal nerve. When the eyes are misaligned either vertically or horizontally, it might lead to a conflict between the proprioceptive inputs from the vestibular system, neck muscles and the EOMs. This explains why an individual with eye misalignments often experiences symptoms such as nausea and dizziness. The pathophysiology of DVS related symptomology is likely not limited to the eyes and could be much more complex. Therefore, a comprehensive treatment for such a problem cannot be limited to the eyes.
Neurolens

Visible blue light and its impact on the eyes has made blue light protection a popular treatment offered by eye doctors in response to the increased prevalence of symptoms associated with computer and digital device use. Research shows that too much exposure to high energy short wavelength radiation can damage the eyes and skin, and can significantly affect sleep patterns. Increased use of digital devices emitting blue light is thought to increase the risk of blue light induced ocular damage. Accordingly, lenses with coatings that filter blue light have been designed for, and clinicians often prescribe them to, patients with DVS symptoms. As shown in figure 2 (data in blue), recent work shows that these coatings decrease harmful effects of blue light by 10-24% and reduce DVS related symptoms such as eye strain and discomfort in 20-30% of the patients (Leung, 2016).

Neurolenses paired with blue light filter coating provide a comprehensive treatment in the sense that they not only provide protection from harmful blue light rays damaging the eyes, but also significantly alleviate DVS symptoms by correcting the eye misalignment using a customizable lens design that incorporates a contoured prism. Most patients with DVS symptoms exhibit different magnitudes of eye misalignment at different viewing distances. Unlike standard prisms, Neurolens employs a proprietary lens design that seamlessly varies the prismatic correction provided to the eyes at different distances. This allows clinicians to customize the lens correction for each individual patient depending on both patient needs and the clinical findings. As shown in figure 2 (data in orange), patient survey results post 60-day Neurolens wear collected from individual practitioners across the country show that Neurolenses with blue light filter coatings effectively relieve various DVS symptoms in more than 80% of Neurolens wearers. This is significantly more than what was reported in patients who wore standard lenses with blue light filters (~30%). About 83% of the symptomatic patients feel improvement in their headaches post Neurolens wear. About 78% of Neurolens wearers report improvements in neck pain, and 82-84% feel improvement in their eye tiredness or eye discomfort with computer use, which are commonly reported symptoms after prolonged near digital work. Importantly, 80% of symptomatic patients also reported that they would be willing to recommend Neurolenses to their friends and family.
Neurolens®: A comprehensive way to treat digital (computer) vision syndrome

Conclusion

Most individuals experience eye strain or related symptoms after using digital devices, commonly referred to as Digital Vision Syndrome or digital eye strain. A comprehensive treatment should involve both an option to correct the eye focusing and alignment errors along with an option to reduce the exposure to harmful high energy radiation from digital devices. Neurolenses, with customizable contoured prism and choice of blue light filter options, provide a comprehensive intervention to significantly reduce DVS symptoms associated with digital use. This symptom reduction allows individuals to comfortably navigate through their digital life, making digital well-being a real possibility.

References

Digital Vision Syndrome (DVS) is an emerging public health concern where individuals experience a wide range of symptoms including headaches, eye strain, dry eye sensation and neck pain while navigating through their digital lives. Predictably, a growing trend in digital usage in the modern age has led to a steep acceleration of associated DVS symptomology (Rosenfield, 2016); therefore, it is critical to understand, measure and treat this problem appropriately. DVS could be caused by both ocular and extraocular anomalies. While ocular anomalies include uncorrected refractive errors, eye misalignments or dry eyes, extraocular anomalies include muscle strains due to compensating postural changes. Uncorrected refractive errors are typically corrected using prescription lenses, dry eyes are treated with therapeutics, and compensating postural habits are corrected by employing occupational therapy or better ergonomic habits.

An often-overlooked cause of DVS related symptomology is binocular vision disorders (BVD); for example, convergence insufficiency, where the patient typically presents with an eye misalignment (large exophoria at near compared to distance) coupled with other clinical signs such as reduction in near point of convergence (NPC). Typical treatment options for BVD involve prescription lenses, prisms or vision therapy (Scheiman et al., 2008). Lenses—especially plus lenses—are not commonly employed and are reserved for patients with heterophoria associated with a high AC/A. Prescription prism glasses, with horizontal and vertical relieving prisms, are offered to either patients with large phoria or in conjunction with vision therapy. The prism value prescribed is often based on fixation disparity analysis, Sheard’s criterion or Percival’s criterion. These glasses provide a constant prism correction to patients at all distances even though patients often present with varying amounts of misalignment at different distances.

Vision therapy is another commonly employed option for treating eye misalignment. The time course of the therapy and the treatment modality are decided based on the clinical (optometric) findings. The therapy, however, does not provide instant relief and is heavily reliant on the compliance of the patient over an extensive time course. Clinicians typically prescribe these treatment options only to symptomatic patients with large phoria. Clinicians tend to overlook patients with a smaller phoria and instead look for other causes for DVS.

There are several reasons why symptomatic patients with smaller phoria are not prescribed prisms or other corrective modalities to treat eye misalignments. One of the primary reasons is the inability to accurately measure smaller eye misalignments. As a result, only patients with a larger phoric posture are diagnosed and treated while individuals who could benefit from small prismatic corrections (less than 2PD) are overlooked. Clinicians have been testing phorias and fixation disparity subjectively for almost a century now, but it has been virtually impossible to accurately test prism in small increments of 0.10 PD for patients until the advent of the Neurolens Measurement Device (NMD) in 2018. There is a need to recognize the functionality and application of small prism correction. This paper will demonstrate how prescribing small amounts of horizontal prism (less than 2PD) can relieve symptoms commonly related to DVS. So, what do we know about the relationship between small eye misalignments and DVS symptoms?

Eye Misalignment and the Severity of Symptomology

One of the common misconceptions with binocular vision disorders is that symptomatic patients tend to exhibit large phoria or fixation disparity coupled with other clinical signs. The assumption is that these large eye misalignments reflect a breakdown of the binocular vision system, especially the accommodation (focusing) and vergence (aligning) mechanisms. However, several studies have consistently reported evidence contrary to this belief.
Can small prism corrections improve visual comfort? Yes! Here is why.

For example, data from the Convergence Insufficiency Treatment Trial (CITT) study of 221 subjects showed no correlation between the amount of exophoria and the severity of the symptoms of their patients (Bade et al., 2013). The Convergence Insufficiency Symptom Survey (CISS) score was also not correlated with the severity of the clinical signs such as near point of convergence (NPC) or positive fusional vergence limits (PFV). Simply put, the evidence suggests that the magnitude of clinical signs does not correlate with the severity of the symptomology. For instance, a patient with 1PD exophoria and a patient with 10PD exophoria with no other ocular or extraocular problems related to DVS might experience a similar magnitude of eye strain and need to be treated appropriately.

**Diagnostic tools**

Traditionally, eye alignment, i.e., phoria, tropia, or fixation disparity, is typically measured using clinical techniques that are subjective in nature. This results in poor repeatability, limiting a clinician’s ability to measure small eye deviations accurately. Patient attentiveness or the clinician’s level of expertise (Hrynchak et al., 2010) also affect the accuracy and repeatability of the test. For example, a previous study reported that the smallest phoria value that can be detected by clinicians with varying levels of expertise is about 2-3PD (Fogt et al., 2000). This would mean that any smaller misalignments may not be detected at all using traditional methods. The ability to track small and slow dissociated eye movements is also limited with the naked human eye. This introduces discrepancy in the dissociation time, ultimately affecting the accuracy of the misalignment estimation. Simply put, the subjective nature of the procedures limit clinician’s ability to accurately measure small eye misalignments. This would explain why there is no concrete literature on the impact of small eye misalignments on subjective visual comfort and the benefit of correcting them.

**Trigeminal dysphoria**

DVS may not just be limited to the eye and could be much more complex. Although the exact mechanism is unclear, the hypothetical pathophysiology suggests that eye misalignment leads to increased effort by the visual system to realign to avoid double vision and strabismus. This constant effort to realign causes an overstimulation of the trigeminal nerve, which ultimately leads to an irritated nerve. This sensory irritation then results in painful stimulation of several parts of the eye, head and neck, leading to symptoms such as headache, neck pain and eye strain. Therefore, even small prismatic corrections of the misalignment could reduce the overstimulation of the trigeminal nerve and relieve patients’ symptoms, ultimately improving their visual comfort.

**Neurolens: A Better Way to Diagnose and Treat Eye Misalignment**

*Figure 1: Contoured Neurolens design and the Neurolens Measurement Device, Gen 2 or NMD2 (inset).*
Can small prism corrections improve visual comfort? Yes! Here is why.

**Neurolens Measurement Device (NMD2)**

The NMD2 is an objective, accurate, precise, simple and efficient way to measure eye alignment and calculate a patient’s AC/A. The NMD2 does not rely on subjective responses, therefore eliminating both clinician and patients’ biases or variabilities. The objective measuring aspect of the NMD2 is achieved by employing an eye tracking system that robustly tracks patients’ eyes in a continuous fashion while the eyes are being dissociated and associated. The system can identify phoria smaller than 1PD and can detect changes as small as 0.1PD. The repeatability of the NMD2 is 0.53PD for distance and 0.86PD for near phoria measurements, which is significantly lower. This is better than 2.5-5PD reported with the traditional methods such as Von Graefe and modified Thorington (Goss et al., 2010). The NMD2 is simple in the sense that it employs an iterative procedure, which takes the misalignment measurements into account and provides a final Neurolens prism correction (Neurolens value). Unlike prescribing guidelines such as Sheard’s Criterion, Percival’s Rule or the 1:1 rule, the Neurolens value utilizes a proprietary algorithm that was developed based on patient outcomes across hundreds of thousands of measurements and outcomes.

**Neurolenses**

The Neurolens value obtained by the NMD2 is used to prescribe Neurolenses, which provide a proprietary contoured lens design, as shown in Figure 1. This technology seamlessly varies the prismatic correction provided to the eyes at different distances, allowing clinicians to customize the lens correction for each individual patient depending on both patient needs and their clinical findings. The NMD2 provides a Neurolens value at the end of the measurement which corresponds to the distance prism prescription of the patient. Clinicians can readily use this value as a guideline to treat their patients. Unlike a standard prism, the Neurolens contoured prism design allows clinicians to treat their patients with a distance prism correction and additional correction at near.

**Do small Neurolens prism corrections provide any benefit?**

![Figure 2: Proportion of patients who reported improvement in symptoms post wearing less than 1PD Neurolens correction.](image)

Across multiple clinical practices, Neurolens prism corrections of 1PD and 2PD prescribed based on the Neurolens value have proven very successful in delivering a very high level of symptom relief for patients with various DVS related symptoms, such as headaches, neck pain or discomfort with computer use (Lifestyle Index Survey). Patient survey results post 60-day Neurolens wear were collected from individual practitioners across the country.
Can small prism corrections improve visual comfort? Yes! Here is why.

Overall, with a prism correction less than or equal to 1PD, 84% of the symptomatic patients reported improvement in their headaches post 60-day Neurolens wear. About 76% of Neurolens wearers reported improvements in neck pain, and 81% felt improvement in their eye tiredness or eye discomfort with computer use, commonly reported symptoms after prolonged near digital work. Similar symptom score improvements were found with both base in and base out corrections (Figure 2). Also observed were the symptom score improvements with a prism correction less than or equal to 2PD. With a 2PD Neurolens correction, 86% of the symptomatic patients reported improvement in their headaches post Neurolens wear. About 77% of Neurolens wearers reported improvement in neck pain, and 80% reported improvement in eye tiredness and 83% reported improvement in eye discomfort with computer use.

Conclusion

Eye misalignments are one of the most common causes of DVS related symptomology. There is a common misconception that only patients with large phorias or fixation disparity associated with other clinical signs suffer from visual discomfort. However, there is abundant evidence that there is no correlation between the magnitude of phoria and severity of the symptomology. Commercial data collected by Neurolens clearly shows that patients who received small amounts of prism correction reported significant improvements in their DVS symptoms such as headaches, eye strain or fatigue. The Neurolens Measurement Device, Gen 2 (NMD2) and Neurolenses, with customizable contoured prism design, provide a comprehensive way to accurately diagnose and treat Digital Vision Syndrome (DVS), allowing patients to lead a comfortable digital life.

References

**Background**

Over the past few years at Acquios Advisors, we have seen a new technology enter the industry and quickly become a game changer for patients’ quality of life. We have seen firsthand what a change this technology has brought to many offices around the country. That technology comes from Neurolens, an organization that has proven that it is—and will continue to be—an effective driver of success for practices seeking new technology and products to offer their patients.

I have worked with many clients who have invested in Neurolens; and when a client asks me if Neurolens is a good investment, the answer is easy. To drive the point home, I always advise them to begin surveying their existing patients to help them grasp the opportunity, i.e., the number of people that will benefit from this technology. Unquestionably, success with Neurolens technology ultimately rests on the doctor. In my opinion, this is the primary reason that the technology has been—and will continue to be—a sure-fire path to success for a doctor-driven practice. When I speak with clients about how Neurolens technology has impacted their practice, we review their statistics regularly. Over and over, from Connecticut to Texas and everywhere in between, we see one of every 4-5 first pairs of glasses ordered in these practices is a Neurolens. That’s 20-25% of total spectacle lens sales.

To better understand the specific financial impact that Neurolens has on eyecare practices, we took a closer look at a few locations that have adopted the technology in recent years. One has had the technology since March 2018, another since December of 2019 and another invested in October 2020. 

Fundamentally, there are two ways to increase your top line: see more patients or increase your revenue per patient. Our investigation has shown that this technology increases top line as well as bottom line in the most efficient manner possible. Neurolens makes it easy for a practitioner to increase their receipts by seeing the same or fewer patients per day while still increasing their bottom line. Specifically, the practices studied saw their revenue per patient (revenue collected divided by the number of comprehensive patients seen) improve from $476.00, $372.00 and $675.00 to $559.00, $500.00 and $950.00, respectively. Next, we’ll take a deeper look at how this change impacted the practices from a financial standpoint.

---

**Revenue Per Patient Change**

<table>
<thead>
<tr>
<th>Practice 1</th>
<th>Practice 2</th>
<th>Practice 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Neurolens</td>
<td>After Neurolens</td>
<td>After Neurolens</td>
</tr>
<tr>
<td>$500.00</td>
<td>$559.00</td>
<td>$559.00</td>
</tr>
<tr>
<td>$500.00</td>
<td>$500.00</td>
<td>$950.00</td>
</tr>
<tr>
<td>$675.00</td>
<td>$559.00</td>
<td>$950.00</td>
</tr>
<tr>
<td>$476.00</td>
<td>$500.00</td>
<td>$950.00</td>
</tr>
</tbody>
</table>

---

Neurolens®: a game-changer for your patients and your bottom line

Rick Guinotte (CEO, Acquios Advisors/Acquios Alliance)
**Financial Impact Investigation**

One of the many impacts of the pandemic is that it has forced eyecare providers to reduce the number of patients seen per hour and per day. As such, we directed many practices to measure their ROI on the number of vision plans they accepted, and the overall penetration of third party payers in their total book of business. Many optometrists were understandably hesitant to drop less profitable vision care plans for fear that their business would slide backwards. As a non-covered lens option, Neurolens has proven to many practice owners that patients will go outside their third-party plans for life a changing product when educated about the benefits. In fact, the price per transaction for a pair of Neurolenses in these three offices ranged from $650 to $1,000, with an average of $800.

This has an obvious accelerating impact on overall per-patient revenue. As alluded to above, the offices studied had average revenue per patient of $507.88 prior to adopting Neurolens technology. After implementing Neurolens, their average receipts per patient grew to $661.26, an increase of $153.38. To contextualize, a practice servicing 2,500 patients per year—or about 48 per week—while seeing patients four days per week (12/day), will experience revenue growth of $383,425.

Looking at the costs side of the equation, the list price for the neurolens Measurement Device, Gen 2 (nMD2) is $34,900. To put this in perspective, a practice generating $700,000 per year, with a pretax net percentage of 30%, (pretax net being money remaining after paying your Cost of Goods and all operating expenses minus Owner’s compensation), the contribution margin will be about 70%, bringing the breakeven point to about $50,000. Contribution margin, simply put, is the money you need to generate to pay for the device, coupled with the costs of operating the device day-to-day. For example, staff time will need to be allocated to confirming appointments, conducting screenings and measurements, running the optical and so on. Of course, space and utilities used within the practice are part of the equation as well.

Based on the aforementioned average Neurolens transaction of $800, and a breakeven point of $50,000, this equates to 62.5 pair of Neurolenses sold. Conservatively assume one of every five first pairs of glasses sold is a Neurolens; to achieve the breakeven you only need to see 312.5 patients.

Neurolenses are also financially risk-free for patients, as the company extends a guarantee on their technology that providers are empowered to extend to their patients. If a patient is unhappy and/or dissatisfied with the product, the patient and practice are out zero dollars. This satisfaction guarantee not only protects the practice and patient from financial risk, it also demonstrates the level of confidence Neurolens has in the effectiveness of the technology.
Of note, the number of refunds reported by the offices reviewed in this study were minimal and did not negatively impact the results or the ROI realized with this technology. In fact, several of the few patients who did elect to be refunded and refitted in traditional lenses later reported that they, in fact, did experience better visual clarity and comfort with Neurolenses than with the traditional lenses they were subsequently dispensed.

The practices studied also found that marketing Neurolens technology was simple and cost-effective. While marketing costs obviously vary by market, the offices studied reported that their marketing/advertising budgets were in the 2-4.5% range. Networking with medical professionals in the area is obviously a key opportunity for Neurolens providers. From headache clinics to neurologists to general practice MDs, building effective referral networks is especially important when you are implementing technology in your practice that provides an optical solution to a medical problem. Practices also found that direct-to-patient outreach through email, direct mail, social media, radio and newspapers effectively helped drive patients’ interest in the Neurolens solution. This stands to reason given the high prevalence of related symptomology among the general population. By far the most successful marketing tactic employed is leveraging platforms such as social media to share testimonials from patients who explained how their overall quality of life has improved; not only through better vision, but also through the reduction—or even elimination—of frequent symptoms such as headaches.

Conclusion

Bottom line: Neurolens is a game changer. It’s a rare thing when an investment can have a dramatic impact on your top and bottom line while also delivering proven patient outcomes and bringing new awareness and appreciation for the optometric profession. I have seen many practices—old and new, big and small—invest in Neurolens technology with great success. This technology is not only for the million-dollar businesses, but for all optometry practices. Your patients want to feel better, and they will invest in you and your practice if you provide solutions that help them do so.

Neurolens®: A game changer for your patients and your bottom line
If you have any questions about Neurolens, please contact us

1-888-236-2219
accountmanagement@neurolenses.com