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Australian Orthoptic Journal

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Contents:

Orthoptic Landmarks into the 21st century

This edition of the Australian Orthoptic Journal celebrates two tremendous landmarks in the development of orthoptics in this country. Following closely on the heels of the 50th anniversary of the OAA are two works of distinction that involve both clinical and research developments. The first is the invention by Australian orthoptist, Zoran Georgievski, of the Torsionometer, the second is the first establishment of normative data for long wavelength perimetry by Australian orthoptists, Josephine Piraino and Helen Goodacre.

The Torsionometer is currently being marketed world-wide by the producers, Clement Clarke International Ltd. This invention has received accolades from our European and North American counterparts and from ophthalmologists renowned in the field of strabismus. Congratulations are extended to Zoran who began with the clinical observations that symptomatic torsion needed to be accurately measured before and after intervention. It was observed that existing tests were limited either by capacity, fixidity of gaze or artifical space. Discussions with colleagues determined that colour dissociation on a white background would prove to have the elements of high contrast and allow best levels of understanding for patients. The ease of use of the Torsionometer for both the patient and clinican is one of the key features of this new instrument. Perhaps the most outstanding feature, is the ability to measure the amount of torsion in various positions of gaze - most commonly, primary position and the depressed positions. These measures are gathered in free-space with minimal binocular dissociation and therefore approximate the level of torsion experienced by the patient in daily life. Having worked from his clinical observations to the development of a prototype, Zoran then conducted reliability and validity testing and research. One such study is published in this edition. This work has been inspiring and will continue to contribute to our understanding of torsion. Feedback from users is invited through letters to the editor or directly to the author.

A second torsion paper in this edition tackles the objective/subjective method of blind spot mapping. The very interesting results of Cornell and co-workers show partial compensation mechanisms of cyclotorsion in response to set rotations of the head. These positions were static by nature of the apparatus. The most significant finding was that intorsion mechanisms were 30% more effective than extorsion mechanisms and were larger in amplitude. This would suggest a confirmation of the superior oblique muscle as the active torter by way of anatomy and physiology. Is there a corresponding sensory asymmetry to this motor asymmetry and how would this affect the binocular state? Your comments are invited on this paper also.

Perimetric testing featured in the previous edition and the second landmark contribution this year concerns perimetry with long wavelength stimuli, the red field. The significance of the study by Piraino and Goodacre is that it goes a long way towards solving the quandary of utilizing the red field as a diagnostic tool. White field interpretation is aided by comparisons to norms incorporated in the Statpac programme of the Humphrey automated perimeters. Deviations from these norms can be interpreted as pathology in conjunction with other diagnostic tools such as symmetry. Comparison of a red field against norms can now be performed as normative red field data has been collected and analysed by these authors. Ideally this will be incorporated into the Statpac database and red field perimetry will gain the diagnostic credence it deserves as a sensitive long wavelength low illumination target. The ideal early detector of pathology. These authors have recognised the need to eliminate possible error sources in clinical interpretation and establishing the norm is a critical step in the scientific process. More research into colour perimetry is eagerly awaited.

Monocular visual assessment is addressed twice in this edition, as a letter to the editor and in a study by Duyshart on test design, test features, age and repeated measures. Many more questions are raised than are answered with respect to screening for the detection of amblyopia versus clinical assessment of the visual system. It is about time that these issues were resolved. Send your comments.

Orthoptist have argued long and well that the services that are provided in the arena of ophthalmic assistance are ones of intelligent data gathering and interpretation as opposed to proforma technical activities. Many diagnostic dilemnas have been solved by orthoptists employing deductive testing procedures. The need for complete and sensitive investigations has been well highlighted in the case study by Ryan and Kelly. Internuclear ophthalmoplegia is a subtle yet clear and distinctive clinical sign localised to the brainstem. Its sequelae is well known as is its association with vascular disease, and bilaterally, with multiple sclerosis. The case presented highlights the significance of the detection of unilateral INO in association with optic neuritis and decreased monocular function and symptomatic interruption of binocular functions.

The extensive head injury review by Apostolou is a reminder of the full visual and ocular motility workup required to establish the usually multiple lesion sites of ocular problems in these instances. The pathophysiology is updated with the exception of the comments on divergence paralysis. Clinicans and researchers alike continue to describe the occurrence of divergence paralysis. The site of defect has even been suggested to be at the level of the VI CN nucleus in the region of the pontine paramedian reticular formation. This makes no sense at all. A reduction or absence of divergence ability is invariably accompanied by a reduction or absence of convergence ability. The patient has decompensation of an exophoria for near and an esophoria for distance fixation. The point of binocular single vision is at 120 cm which is the average resting vergence or tonic vergence position, for an IPD of 6 cm.

This defect of both convergence and divergence ability can be easily localised to the dorsal midbrain, 1-2 mm from the III CN nucleus, as this is the region of groups of phasic and tonic cells that fire in response to approaching and receding targets. Nowhere near the pons. Again, a full binocular vision workup leads to localisation and answers to pathophysiology. It was reassuring in this head trauma paper to see the term 'skew' deviation applied to brainstem anomalies in which a disturbing disruption to vertical alignment and management of the horizontal meridan occurs. (Vertical vergence or vestibulo-ocular brainstem pathways may possibly have been disrupted.) This is mainly seen in comatosed patients. It has recently become fashionable to adopt the term 'skew' for the yet to be explained minor incomitant hyperphorias/tropias of L/R in left gaze and R/L in right gaze. Suspicions lie with sloping insertions of the lateral recti, only evident in extreme dextro and laevodepression. The inferior recti anatomy could also be considered if there is an accompanying A exotropia. Certainly no brainstem anomalies. Diagnostic terms are designed to relate to underlying pathophysiological mechanisms and should be used as such.

Research on Visual Acuity Tests: A Need for a Functional Perspective.

In response to the article "Comparison of crowded single optotypes with linear acuities in amblyopes" by Williams et al., published in AOJ 1995, Vol.31: 21—27, I would like to comment on which test should be used to identify amblyopia. The debate is a double edged sword as it can be discussed in reference to either screening or diagnostic protocols. These protocols should consider different aims and mean age of acuity assessment, which are reflective of the population groups examined. The confusion generally results when attempting to debate such a topic because the above factors are not addressed simultaneously.

The aim of screening is to detect and reduce the incidence of visual anomalies. Amblyopia is thought to be the most common visual anomaly in children, hence, many vision screening programmes are aimed at its detection. Screening involves a non repeated measure that often occurs during the preschool years. Consequently, screening visual acuity tests should have a high sensitivity and specificity for three and a half year olds in order to detect amblyopia. It may be argued that acuity tests used for screening are not chosen to be used in isolation and therefore do not need a high sensitivity and specificity. However, a greater emphasis is placed on acuity test results for referral purposes by those who are not familiar with the overall characteristics of amblyopia and its influence on the visual system.

The implementation of Single optotype tests as a screening tool is commonly debated in the literature. Their use is advocated on the basis of short test duration times and high reliability [1]. However, it must be remembered that Single optotype tests were originally chosen as a screening tool because it was the only reliable alternative in paediatric assessment of visual acuity in the early seventies [2]. Its use as a screening tool has since been debated because it overestimates acuity in amblyopes and its absence of adjacent contours is thought to induce the crowding phenomenon [3,4,5]. Since the 1970's there have been several new paediatric test designs that incorporate form and spatial perception as well as contour interaction. However, validations of test types have generally been conducted with a small sample size, varying types of amblyopia and often have a diverse subject age range. Consequently, results are difficult to extrapolate to specific population groups, in particular which test type to choose in a screening program or clinical setting. For example, although the study conducted by Williams et al. [6] concluded that the LM test provides a stimulus that detects amblyopia and its acuity measurements equate to those measured by a Snellen Chart, the findings are limited to any further interpretation. Williams' et al [6] results could have had greater clinical significance if their subjects were between three and five years of age, included test-retest reliability with inter-test correlations, and analysed anisometropic and strabismic amblyopia results separately.

Can the use of single optotypes in a screening program be substantiated with the development of other test designs? The question can only be partly answered and debated if large studies are conducted to determine the characteristics and incidence of amblyopia in preschool children, as it is these characteristics which will influence the design specifications of future screening tests.

Screening is aimed at eliminating a disease and the method employed is dependent on the prevalence and characteristics of the disease. Therefore, by definition, if a screening program has been successful, the test used to detect a disease should continually change in accordance with the changing prevalence and characteristics of the disease. It is logical then to argue that the screening tests used 25 years ago are not appropriate as screening tools for today.

Single optotype VA tests, however, are still a clinically valid VA test. Why? In a clinical environment acuity measurements can be conducted repetitively over time and the choice of test is largely up to the discretion of the clinician, who can determine which test type to implement, dependent upon the aim of the investigation, child's age and cognitive function. When diagnosing and monitoring amblyopia, there is sufficient time to make comparisons between eyes, with repeated measures, and between single and multiple optotype tests, as well as in conjunction with other ocular motility and binocular function tests. This enables the use of clinical judgement to overcome the inherent problems associated with the use of Single optotypes.

In conclusion, it is important for clinicians to recognise the different aims and mean age groups in studies when reviewing the literature, to determine whether Single optotypes are a valid test to use in the detection of amblyopia. Specifically, clinicians need to be aware to not extrapolate information from studies which are not stringent in design and subject criteria in conjunction with its aim. Furthermore this letter addresses the importance for researchers to design studies that have clinical significance.

Rebekah Duyshart

Ed: Some excellent points have been made in this letter concerning the testing of visual acuity. Replies are welcome on any or all of the above issues.

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Evaluating Torsion with the Torsionometer, Synoptophore, Double Maddox Rod Test and Maddox Wing: A Reliability Study

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Abstract

This paper reports a reliablity study which compared a new test for the measurement of torsion, the Torsionometer, and three standard clinical methods: the synoptophore, double Maddox rod test and Maddox wing. Measurements on the four tests correlated well, however there were significant discrepencies between different tests on several occasions. Such variation is clinically important and it is therefore recommended that clinicians evaluate torsion with more than one test.

Key Words:
torsion, ocular torsion, cyclotropia, strabismus, Torsionometer, synoptophore, double Maddox rod test, Maddox wing.

Introduction

In his 1984 Costenbader lecture, Gunter von Noorden asked " Why has cyclotropia been a stepchild of clinical investigation for so long?"[1]. Without doubt, part of the neglect in this field of strabismology has been due to the complexity of the measurement procedure of some tests. This is probably compounded by the fact that surgery for torsion has only been widely practiced for a relatively short time. Little over twenty years ago, in fact, orthoptists were taught never to mention torsional diplopia to patients as there was nothing that could be done about it! Today, the measurement of torsion is recognised as a intergral part of the ocular motility examination, since its presence and extent are important factors in planning treatment.

Various instruments and tests can be employed to assess torsion in cyclovertical deviations. These 'measurement' methods can be inexact and often need to be supplemented by a second or even third test. They are subjective and, unlike measuring horizontal and vertical deviations, challenge the patient to align two lines parallel to each other. The concept of parallelism is difficult which complicates the measurement of torsion. This paper reports the results of a reliability study which statistically compared four methods of measuring torsion [2], one of which is a new test from Clement Clarke International Ltd., called the Torsionometer [3].

The Torsionometer

The Torsionometer (Figure 1) offers the advantages of portability, speed and ease of use for both patient and examiner. The device consists of a red plate with a vertical line beside a green one, which the patient rotates using a dial (Figure 2). The patient's view of the test has been designed so that there are minimal cues about objective parallelism. On the back of the test plate is a measurement scale corresponding to the orientation of the green line relative to the red line. This enables the examiner alone to read the amount of torsion present. The test is carried out in free-space with the patient wearing a pair of reversible complementary red and green goggles, so each eye is presented with a different line image. However, the test plate and its surrounds are visible to both eyes so that sensory cyclofusion, a most effective compensatory mechanism in cyclodeviations,[4] is not precluded.

Measurement is relatively quick and uncomplicated (Figure 3). The test plate is positioned at a 40cm viewing distance, perpendicular to the patient's line of sight. To begin testing, the green line is rotated maximally in one direction and the patient attempts to make it subjectively parallel with the red line. Up to 25° of excyclo– or incylcotorsion can be read off the scale. Torsion can also be measured in other positions of gaze, for example in downgaze, where it is often greater and causes most problems in cases such as bilateral fourth nerve palsy [5,6]. The goggles that come with the Torsionometer enable unrestricted measurement in the reading position or extreme downgaze.

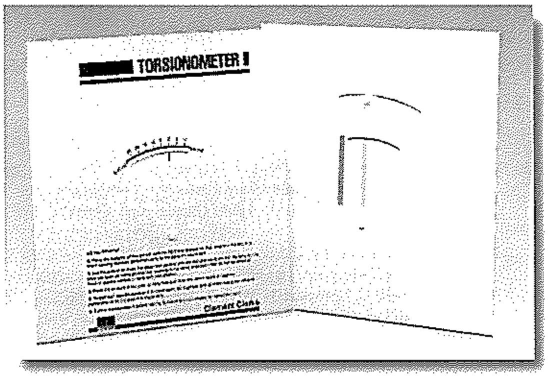

Figure 1

The Torsionometer: Front and Rear Views.

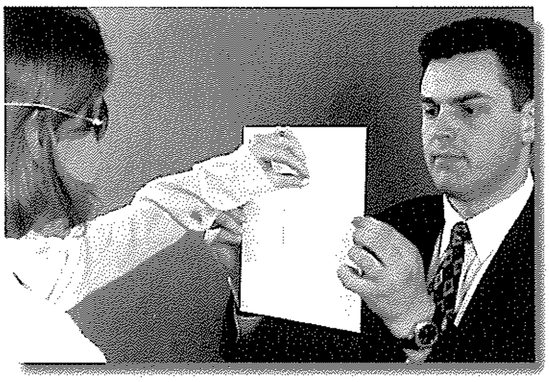

Figure 2

The Torsionometer: Alignment by the patient.

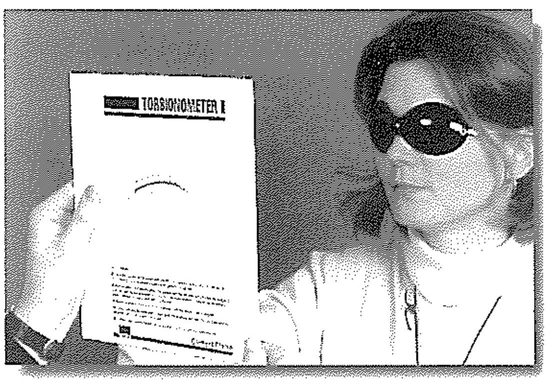

Figure 3

The Torsionometer: Measurement Scale.

Method

Patients

Patients were obtained from the Ocular Motility Clinic, Royal Victorian Eye and Ear Hospital, Melbourne. Thirty-three (n=33) adult patients who were aware of a torsional component to their diplopia underwent torsional measurement.

Apparatus

Torsion was measured with the following: the Torsiononmeter, synoptophore (Major Synoptophore Model 2053, Clement Clarke International Ltd.), double Maddox rod test (DMR) and Maddox wing (MW). To improve precision, the synoptophore slides (simultaneous perception, G35 & 36) were modified with horizontal straight lines. Also, the Maddox rods were marked to indicate the axis in the trial frames (Oculus).

Procedure

The four tests were performed in a conventional manner and presented in random order. In certain situations, measurements could not be obtained with all tests, for example, the MW could not be used with large amounts of torsion. All patients had their torsion measured in the primary position, some also in the secondary position, usually depression, and many were assessed on review visits when the torsion may have changed either spontaneously or following treatment. Comparisons were made between measurements obtained at the same visit and in the same position of gaze.

Statistical Analysis

In total, 68 sets of measurements were analysed using the one–way ANOVA intraclass correlation coefficient, or ICC [7,8]. This is a statistic used in clinical reliability studies and test relationships similar to Pearson's r test, except that it takes into consideration variance components due to error or absolute differences in the data [7]. The level of significance, alpha, was set at 0.05.

Results

As evident in the correlation matrix (Table 1), there were moderately high to very high correlations between measurements of the four tests, the strongest correlation being between the Torsionometer and DMR test (ICC: R=0.93). This is also shown in Figure 4.

The overall correlation between all four tests was moderately high(R=0.74) and strengthened only when the MW data were excluded from the analysis (R=0.90). It would seem that the highest correlation was between the Torsionometer, Synoptophore and DMR test. On closer inspection, however, it was found that this is related to the larger measurement range of these three tests. Repeat analysis that was confined to measurements of 10° and less on all tests showed that when the MW data was excluded, the correlation actually dropped slightly (from R=0.74, as above, to R=0.70).

It was found that the DMR test generally revealed greater amounts of torsion than the other tests. This was statistically significant against the Torsionometer (ANOVA:$F1$, 56 = 5.76, p=0.020) and synoptophore ($F1$, 56=9.66, p=0.003), except when the analysis was confined to 10° and less when all four tests were included ($F3$, 102=1.24, p=0.298). In other words, the DMR test revealed significantly greater amounts of torsion, but only when the amount of torsion exceeded 10°. Furthermore, it was determined that the tests in order of decreasing dissociation tendency after the DMR test were the Torsionometer, synoptophore and MW, although there were no statistically significant differences between the measurements obtained with the latter three tests ($F2$, 74=0.09, p=0.912.)

Despite the strong agreement between the four tests, the mean difference between the highest and lowest torsion value for each measurement set was only 2.4° (sd= 1.7°, mode =2°).

However, the difference between the two extreme values was at least 5° for 7 (10.3%) of the 68 measurement sets, the maximum being 8° for one patient. These differences were encountered in measurements obtained from six patients and across different tests, so that no particular test was consistently responsible for the variation.

Discussion

The results demonstrate that the Torsionometer is a valid test for the measurements of torsion. They also confirm the validity of the standard testing methods when they are modified as described. The MW is an equally reliable device, but is limited in application by its small measurement scale.

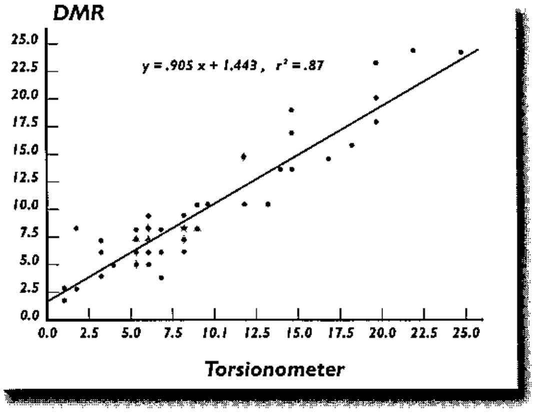

Figure 4

Strongest Correlation seen between Torsionometer and DMR

	Tor	Syn	DMR	MW
Torsionometer	1.00	0.90	0.93	0.81
Synoptophore	0.90	1.00	0.87	0.76
Dbl Maddox Rod	0.93	0.87	1.00	0.76
Maddox Wing	0.81	0.76	0.76	1.00

Table 1

Correlation Matrix

It is generally believed that different tests reveal varying amounts of torsion depending on the level of dissociation provided. For example, measurement with the Bagolini striated glasses would be expected to show less torsion than the DMR test because the former allows cyclofusion [4,9]. In the present study, it was also found that the DMR test generally revealed greater amounts of torsion than the other methods, but this was only statistically significant when the amount of torsion exceeded 10°.

It is difficult to explain why the synoptophore and MW revealed lesser amounts of torsion than the DMR test as all three are haploscopic tests. The Torsionometer, on the other hand, uses complementary colour dissociation, is performed in free space and does not preclude sensory cyclofusion, yet ranked second after the DMR test in dissociation tendency.

In a subsequent statistical analysis of tabular data published by Pratt–Johnson and Tillson in 1987 [10], it was found that there was no signifcant difference between the torsion measurements obtained by DMR and Bagolini striated glasses testing in 10 patients with bilateral fourth nerve palsy (ANOVA: $F1$,9=1.91, p=0.164), which is contrary to the conclusion made by these authors.

In light of these findings, it is probable that a torsion test's dissociation tendency is not particularly important when cyclotropia is associated with vertical and horizontal strabismus, as it usually is, and fusion is not possible even peripherally. This is supported by a further analysis of Pratt–Johnson and Tillson's [10] data. In their small series, torsion was measured on the synoptophore using simultaneous perception and fusion slides, although these were not modified for the purposes of measuring torsion specifically. The measurements obtained with the simultaneous perception slides were significantly greater (ANOVA: $F1,9=7.22$, $p=0.002$), presumably because fusion was suspended.

In the present study, a small but significant number of patients demonstrated quite a variation between the highest and lowest torsion value in a measurement set. There are important clinical implications if different testing methods elicit such different torsion measurements in one patient, in one position of gaze, and in one measurement sitting. Indeed how much torsion does the patient have? One implication is that it becomes more difficult to determine if the patient's symptoms are attributable to the torsion. Also, using the amount of torsion as an indicator of bilateral involvement in fourth nerve palsy becomes even more problematic.

It is therefore important that torsion be measured with more than one test, particularly when the patient is aware of it and describes it as a component of the diplopia. The author routinely uses at least two methods to evaluate torsion in such cases and recommends that each test be repeated to verify the measurement. This proceedure adds negligible time to the ocular motility examination and is therefore more than worthwhile.

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Evaluation of Compensatory Torsion by Blind Spot Mapping.

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Abstract

Blind spot mapping is a non contact and relatively simple method to evaluate rotation of the eye in response to head tilt. Any displacement of the blind spot during head tilt indicates the concurrent rotation of the eye, ie that which has not been compensated by a torsional movement.

This method was used to evaluate the extent of intorsion and extorsion induced by head rotation from 0° to 30° in 22 normal subjects. Results confirm previous studies that full compensation to head tilt does not occur, even at small degrees of head tilt. The mean responses of compensatory intorsion ranged from 32% to 41% and those of compensatory extorsion from 20% to 25%. This difference between intorsion and extorsion (ie, a more effective intorsion response) was statistically significant ($p<0.00001$) at each position of head tilt. This unequal response must be accompanied by a sensory and/or motor cyclofusion to prevent torsional diplopia from occurring. Although these results do not directly contradict the theoretical basis of the Head Tilt Test, they do suggest that a negative or inconclusive result may be due to poor cyclotorsion.

Keywords:
cyclofusion, intorsion, extorsion, head tilt, counter torsion.

Introduction

Ocular torsion is defined as rotation of the eye around the Y axis of Fick. It needs to be differentiated from 'false torsion' which routinely occurs when the eye moves to a tertiary, or oblique position, moving around an axis on Listing's plane, but without rotation around the Y axis [1] (see Figure 1).

Most commonly normal torsion occurs as a vestibular response to tilting of the head (counter torsion or counter rolling [2]), supposedly to maintain the correct horizontal retinal meridian [1] (although Jampel [2] argues that this does not occur). In this context, responses initiated by static tilt and dynamic head movements are often differentiated [2,3].

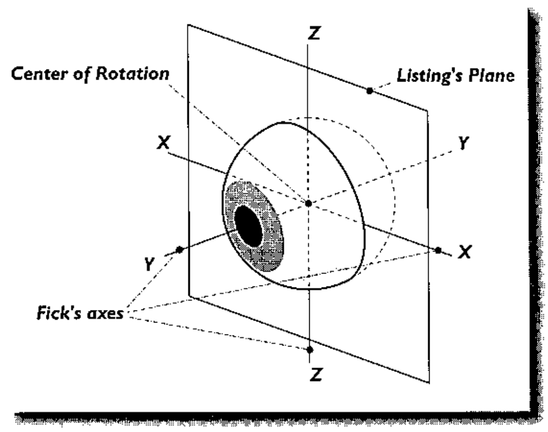

Figure 1
Fick's Axes and Listing's Plane. (from Adler's Physiology of the Eye, 7th Ed 1981 CV Mosby)

Subjective and objective torsion

Rotation of the eye around the Y axis is now defined as objective, or anatomical torsion, as many studies have shown [4,5,6,7,8] that the perception of a tilted image (subjective torsion) does not always accompany, or is much less than, that which would be predicted from the anatomical position of the eye. For example, Guyton [8] has shown that subjective torsion is rarely experienced in cases of congenital cyclovertical muscle anomalies, yet considerable objective torsion may be demonstrated by observation of the fundus.

Assessment of Torsion

Evaluation of torsion dates back at least 200 years. Subjective methods have included blindspot mapping [8,9,10] the use of an after image [9,11], the Maddox Rod [11,12], the Maddox Wing [12], the Maddox Double Prism [11], the Synoptophore [11,12] and the recently developed Torsionometer (Georgievski) [12,13].

Subjective torsion, whilst perhaps being a good indication of a patient's symptoms, does not necessarily indicate the full amount of anatomical torsion. For this reason, objective methods are now usually used as a measure of anatomical torsion. These methods include direct viewing of external landmarks of the eye [2,4,9], special contact lenses [4,11,12], evaluation of fundal torsion by fundus photography [8,10,11] or indirect ophthalmoscopy [8,11], infra red video oculography [15,16] and the scleral search coil [3,4,17]. Blindspot mapping (see description below), whilst being essentially a subjective method, reflects the detection of an anatomical landmark and is not influenced by perception of a normal environment. It is therefore more likely to reflect the true anatomical position of the eye.

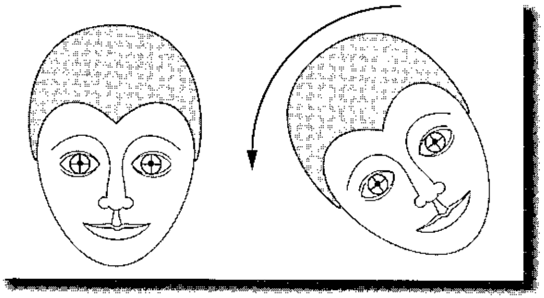

Figure 2

No compensation is occurring, eyes (and optic discs) passively rotate with head tilt.

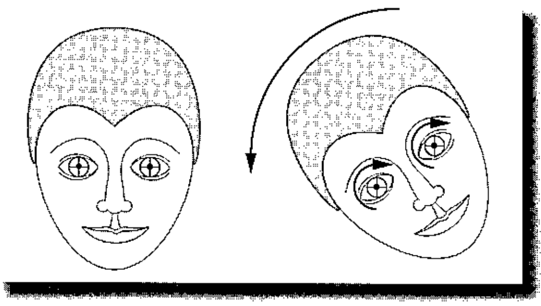

Figure 3

Full compensation is occurring, eyes rotate against head tilt, optic discs remain on horizontal plane.

Effectivity of countertorsion

Studies of the effectivity of counter torsion to passive head tilt have yielded varying values, but tend to show that the response is usually much less than the actual amount of head tilt (see Table 1). The fact that a perception of an upright image is still maintained when the head is tilted, despite the relative motor response, is a further example of the differences between subjective and objective torsion.

On head tilt to the right the right eye is said to intort, whilst the left eye extorts [1]. This, of course forms the theoretical basis of the Bielschowsky Head Tilt Test. However some authors (see Table 1 [2,10]) argue that this counter rolling does not occur, and Levine [10] therefore questions the validity of the basis this test.

According to Hering's Law, any response which does occur should be equal. However Linwong and Herman have shown a difference in the intorsion and extorsion responses to passive head tilt, (see Table 1). As torsional diplopia is not perceived in this situation it is likely that subjective cyclofusion (a sensory, rather than a motor response) is occurring allowing perception of a single upright image in the presence of torsional disparity [5,6,7].

As few other studies have reported on the relative input of intorsion and extorsion in this situation, this study was undertaken to further evaluate the responses of each eye to passive head tilt in normal subjects by using the simple method of blind spot mapping.

Method

Twenty two normal subjects were evaluated, the only criteria for selection being that they had 6/6 (equivalent) visual acuity at the distance of the test (2m), normal binocular vision and no ocular motility problem.

Blind Spot Mapping:

The head position was maintained by a special apparatus incorporating a bite bar which could be rotated to fixed positions in either direction.

With the head thus stabilized, the position of the blind spot was carefully plotted and its long axis recorded. This was carried out with the head tilted from 0° to 30° in both direc-

Table 1

Previous studies on intorsion and extorsion responses to passive head tilt.

Researchers	Year	Method	Extent of Response
Levine [10]	*1969*	*Fundus Photography / Blind Spot Mapping*	*Little or none*
Linwong & Herman [1]	*1971*	*Fundus Photography / Blind Spot Mapping*	*Intorsion 16% / Extorsion 22%*
Petrov & Zenkin [13]	*1973*	*Contact Lens / Light*	*Approximately 25%*
Collewijn et al [3]	*1985*	*Scleral Search Coil*	*10%*
Vieville & Masse [16]	*1987*	*Infra-Red Video*	*(not tested)*
Jampel [2]	*1987*	*Iris Markings*	*None*
Cheung et al [17]	*1992*	*Scleral Search Coil*	*16%*

tions (5 degree steps). An examination of both intorsion and extorsion of one eye therefore involved plotting 14 blind spots during fixed head tilt.

Any displacement of the blind spot during head tilt indicated concurrent rotation of the eye, ie that which has not been compensated by a torsional movement. Conversely, if the blind spot did not move, full compensation was occurring, (ie, a counter torsional movement equal and opposite to the head tilt) (see Figures 2 & 3).

The coordinates of the upper and lower limits of the long axis of the blind spot were recorded, and were calculated as degrees of rotation of the eye, allowing for the original position and tilt of the disc.

The order of testing was randomised. Fourteen subjects had only one eye tested (7 right eye, 7 left eye). Eight subjects had the procedure carried out on each eye, and, in these cases the tests were done on different days, due to the time consuming nature of the assessment.

Results

Figures 4 & 5 show typical responses from two different subjects. The Y axis represents the calculated torsional response (not the plotted rotation of the disc) and the X axis the amount of head tilt. Therefore, if it was a full compensation for the head tilt, the response would follow the dashed line. Incomplete responses would fall below this line. In Figure 4 it can be seen that there is a good (although incomplete) response of intorsion, at least up to 25° of head tilt, whilst, overall, the extorsion response is much poorer. In Figure 5 both intorsion and extorsion responses are poor, with, at the most, only 1 degree of response for each 5° of head tilt.

The mean values and standard deviations of the total group are shown in Table 2 and Figure 6. The difference between intorsion and extorsion (ie, a more effective intorsion response) was statistically significant ($p < 0.00001$) at each position of head tilt.

The effectivity of these responses are shown in Figure 7, which shows a 32% to 41% response for intorsion, and 20% to 25% response for extorsion, with decreasing efficiency at the head tilt increases.

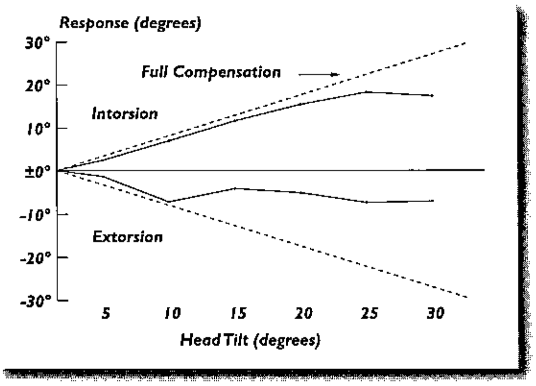

Figure 4

Responses from subject PE. The X-axis represents the amount of head tilt, the Y-axis represents the torsion response. Responses falling on the dashed line would represent full torsional compensation to the head tilt. In this subject there is an almost full intorsion response to 25° of head tilt, but an overall poor extorsion response.

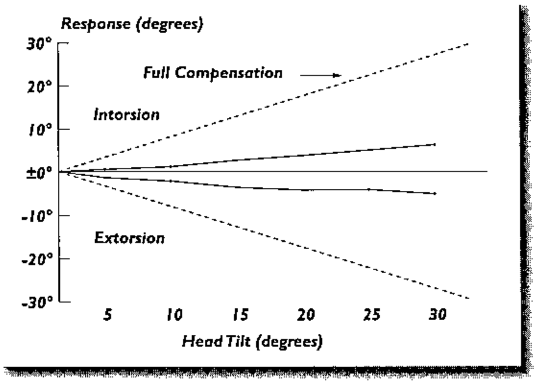

Figure 5

Responses from subject RH. The X-axis represents the amount of head tilt, the Y-axis represents the torsion response. Responses falling on the dashed line would represent full torsional compensation to the head tilt. In this subject there is approximately only one degree of response for each ten degrees of head tilt.

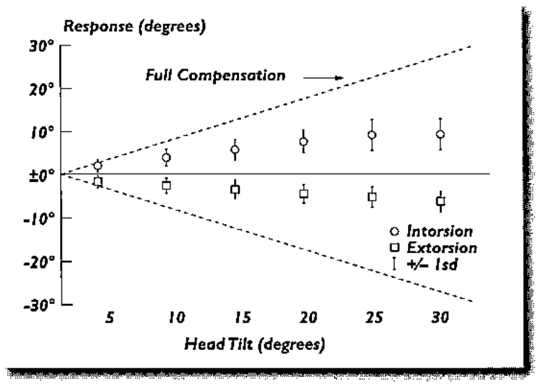

Figure 6

Mean values and one standard deviation for the whole group at each position of head tilt. The X-axis represents the amount of head tilt, the Y-axis represents the torsion response. The dashed line represents full torsional compensation to the head tilt.

Head Tilt	Intorsion Mean	Intorsion SD	Extorsion Mean	Extorsion SD
5°	2.05°	1.42°	1.23°	1.02°
10°	4.08°	1.92°	2.45°	1.75°
15°	5.85°	2.41°	3.28°	2.16°
20°	7.64°	2.71°	4.35°	2.17°
25°	9.24°	3.53°	5.10°	2.36°
30°	9.52°	3.44°	6.00°	2.49°

Table 2

Intorsion and extorsion responses to passive head tilt

It was noted that in many cases that the amount of tilt of the blind spot was not always consistent with its measured rotation, frequently the disc appeared to be more tilted than that which would be predicted from the amount of rotation in the eye. It is difficult to imagine how this might happen if foveal fixation was maintained, as rotation must occur around the visual axis, and is probably due to testing artefacts from the elevation or depression of the eye caused by the head tilt.

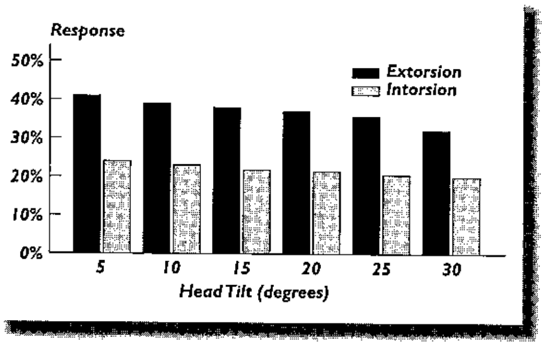

Figure 7

Effectivity of the torsional response. The X-axis represents the amount of head tilt, the Y-axis the percentage of response.

Discussion

These results are consistent with previous studies in so far as the torsional response to head tilt is not complete, however they do indicate a greater response than many previous studies. They also indicate a significantly better intorsion response over extorsion (approximately 30%), which differs from Linwong and Hermann's findings of a greater extorsion response [18]. The reasons for this are not apparent, however, Sullivan and Kertesz [19], in studying the motor cyclofusional response to torsional disparity, did find that intorsion was more effective than extorsion.

Blind spot mapping does not permit measurement of both eyes at the same time, and, in the eight cases where both eyes were assessed, these were done on different days, so one must be careful in drawing conclusions regarding the contribution of each eye to the binocular response. However, as there were equal numbers of intorsion and extorsion recordings, the overall superiority of the intorsion response does indicate that, on tilting the head to one side, there must be resulting torsional disparity. This would need to be overcome either by a motor cyclofusion response, or, more likely (according to Kertsz [5]), sensory cyclofusion.

Although these results do not directly contradict the theoretical basis of the Head Tilt Test, the inefficiency of the torsional response to head tilt in some cases may explain why this test does not always give clear results.

A negative or inconclusive result may be due to poor cyclotorsion, rather than paresis of a cyclovertical muscle.

Summary

Results indicate that the counter torsional response to passive head tilt is around 32%—41% for intorsion and 20%—25% for extorsion. These values are higher than previous studies, but confirm that the response is, at best, much less than that required to maintain the horizontal retinal meridian. The superiority of the intorsion response suggests that motor or, more likely, sensory cyclofusion is acting to prevent torsional diplopia. It is possible that the relative inefficiency of the torsional response may affect the results of the Head Tilt Test in some cases.

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Normal Threshold Values for Red Targets in the Central 10 Degree Visual Field

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Abstract

Automated perimetry is widely used in ophthalmic practices to monitor changes in a patient's visual threshold across the visual field. White stimuli are usually used and sophisticated statistical analysis is obtained comparing the patient's data to normal age matched results. Red stimuli can be used to monitor early effects of drugs in the visual field yet no comparative data is available.

The central visual field was examined with a 10–2 visual programme on the Humphrey Visual Field Analyser using red and white targets to establish normal perimetic data for red fields.

Red and white fields for 53 subjects (70 eyes) were obtained, age range 15–57 years. The fields were analysed using quadrant totals of decibel (db) threshold values. Then totals for superior and inferior fields, as well as nasal and temporal fields and then the whole fields were calculated. The decibel values were significantly reduced when the red thresholds were compared with white thresholds irrespective of the area of field tested. The means and standard deviations of each test location were calculated for the red fields. It was found that the visual threshold for red fields with the 10–2 program ranged from 21.1 dB with standard deviation + 1.73dB peripherally, to 26.6 dB with standard deviation + 1.83dB centrally. Three of the seventy eyes examined showed significant field defects (both clinically and statisically) when tested with the red target compared to a normal field with the white target.

Key Words:
visual threshold, computerised perimetry, central visual field, colour perimetry.

Introduction

Prior to the advent of automated static perimetry, coloured targets were used as an adjunct to kinetic perimetry [1,2]. Most commonly a red target was employed in these tests as the luminance contrast between the background and the target was significantly altered [3]. Some authors believe that red visual fields should only be performed in cases of optic nerve disease, supra– and infra chiasmal lesions, minute foveal legions, cone degeneration, diabetes, glaucoma, or toxic amblyopia, as these pathologies selectively affect colour vision mechanisms (cone photoreceptors and subsequent pathways) often before any ophthalmoscopic or visual acuity changes [4,5].

The exact explanation for why coloured targets may be useful is controversial. Perhaps retinal ganglion cells receive and convey information from different portions of the spectrum and thus coloured targets will reveal defects before other testing techniques. Others postulate that red targets only function as dull white targets and therefore defects found with coloured targets will always be demonstrated with white targets of reduced illumination[4]. A number of criticisms have been raised concerning the use of colour thresholds in perimetry [4,6]. The most serious criticism of colour perimetry is the lack of quantative evidence that colour provides any additional information compared to achromatic perimetry [7].

With the advent of automated perimetry the use of coloured targets has decreased due to the fact that much duller achromatic stimuli can be produced with this form of static perimetry. Consequently, colour perimetry is now used primarily to detect defects caused by drug toxicity. Medications that have been reported to affect colour vision mechanisms include Chloroquine, Plaquenil and Ethambutol [8].

In a study performed by Easterbrook and co–workers [9], patients with the risk of retinopathy from chloroquine therapy were examined on the Humphrey 10–2 program using both white and red targets and the Amsler Grid. They found that red targets revealed abnormalities that were not present with the white targets. Overall when the effectiveness of red and white targets was assessed by comparing their results with Amsler testing, they found that red targets yielded 91% sensitivity and 58% specificity and white targets 78% sensitivity and 84% specificity. The low specificity for red targets may have been due to the fact that the Humphrey visual field test is not as specific as the Amsler or perhaps more likely, the Humphrey visual field test using red targets was able to detect field defects not normally detected with Amsler testing.

The quantitative nature of the data from automated perimetry and the opportunity for computer analysis have stimulated interest in the development of statistical methods to describe the probability that a given set of measurements represent normality or abnormality, or that sequentially obtained field represent stability or change [10].

At present the clinician attempts to answer these important questions by simply inspecting the visual field display and looking for irregularities in the contour of the hill of vision. When a patient is tested for the first time three comparisons are commonly made:

The patients results are compared with expected normal values, the fields of the patient's two eyes are compared for symmetry, and possibly abnormal areas of the field of one eye are compared with other unaffected areas in the same field.

In order to determine if a patient's test is normal or abnormal, one thus needs information about the result of the same test in normal subjects. Very little has been published on expected normal values for any perimetric instrument.

One of the limitations of using coloured targets with the automated perimeter is the fact that there are no normal values for coloured targets. There is one study by Flanagan and Hovis [11] where threshold was measured on the Humphrey perimeter using white, red, green and blue targets.

The testing strategy used was firstly a macular threshold test where the central 4° was tested and secondly one meridian (5° to 195°) of the central 30°. The coloured targets showed reduced threshold values but when the luminance difference for each of the targets was compensated there was little difference in threshold values between each of these targets and white targets. Normative data for the complete central visual field has not been determined, and Easterbrook [9] stated that age – matched control data for the 10–2 program would assist in the evaluation of patients receiving chloroquine therapy.

The purpose of this study was to determine normal values for the 10–2 program using a red target on the Humphrey visual field analyser and to consider the question of whether a red target can detect defects that a white target cannot.

Method

Subjects:

A total of 53 subjects (70 eyes) recruited from the staff and students of the university and acquaintances participated in this study. All subjects had a screening eye examination prior to visual field testing consisting of relevant history questions and assessment of their visual acuity.

The criteria essential for subject participation included:

1. distance visual acuity of 6/6 Snellen's linear or better (with optical correction if required);

2. no known ocular pathology or systemic disease that might cause a visual field loss;

3. no previous ocular treatment such as surgery, laser treatment, eye medication or occlusion;

4. no use of medications such as tranquillisers that might affect their test performance or medications such as Plaquenil, that might affect their visual field;

5. pupil size greater than 2.5mm;

6. no media opacities or known retinal disease;

7. willingness to undergo the visual field test.

The age range of the subjects examined was 15 to 57 years with the average age being 20.9 years.

Forty one females and 29 males participated in this study.

Testing Procedure:

The visual field tests were done on the Humphrey field analyser using a 10–2 program where thresholds were determined at 68 locations within the central 10 degrees of field using a repeated, up and down staircase procedure to determine threshold levels [12]. Two different tests were performed, one using the standard white stimulus and another using a red stimulus (Hoya R62). Each stimulus subtends a visual angle of 0.43, equivalent to Goldmann size III [13]. Therefore each subject could have a maximum of 4 visual field tests: a white and red stimulus on each eye. All subjects were examined by one examiner (JP).

The subjects were all given standard instructions prior to commencement of the field test. All eyes were tested in randomized order and the stimulus colour to be used first was also randomized to ensure that any learning effect would not influence the results. All were tested with the iris and the ciliary muscles in their natural state. A correcting lens was worn when neccesary and the appropriate age add if needed. A demonstration of the 10–2 programme using the one minute practice test available on the field analyser was employed. The 10–2 programme was then run with either the red or white target and repeated with the colour that hadn't been examined. Subjects were given a break during the testing procedure at about five or six minutes, and between fields. The eye monitor was on so that the subject's fixation could be monitored at all times and constant encouragement was given to the subjects throughout the field test. The average pupillary diameter measured 3.5mm.

Since the aims of this study were to obtain normal values for the red test target and to observe whether the red test target detects defects before a white test target, the white field can be considered the control for each eye of each subject.

Results

From the 70 eyes examined on the Humphrey visual field analyser, 70 white fields and 70 red fields were obtained. All subjects were considered reliable according to the specifications of the Humphrey field analyser (<33% False Negatives & False Positives).

As expected when the red stimulus was used the decibel (dB) levels recorded were observed to be considerably decreased compared to the white decibel levels.

Mean Values for Red and White Targets:

The usual method of statistically analysing the decibel levels of each field (known as Statpac) could not be employed in this study as it relies on making comparisons between the field recorded and normal age matched populations. There are no normal values for red stimuli using this testing strategy. In order to compare the red fields in this study with the white fields for each subject another printout was used known as a 3 in 1 format. This provides a grey scale, defect depth, and decibel levels printout with quadrant totals for each quadrant of the field. With this in mind the following comparisons were made:

a) Mean values and standard deviations were tabulated for each quadrant in the white field. (White superior nasal – WSN; White superior temporal – WST; White inferior nasal – WIN; White inferior temporal –WIT.) The same values were recorded for the red field. (Red superior nasal – RSN; Red superior temporal – RST; Red inferior nasal– RIN; Red inferior temporal, – RIT.)

b) Secondly a comparison between the superior half of the fields and inferior half was made for both white and red stimuli. (White superior –WS, Red superior RS, White inferior WI, Red inferior RI).

c) Thirdly a comparison between the nasal and temporal fields was recorded for red and white stimuli. (W–field, R–field).

These comparisons were made to see if the field was reduced in any of these quadrants or half fields more so than others.

d) Lastly, an overall mean value and standard deviation was recorded for each field.

As each quadrant tests 17 threshold points the mean quadrant totals calculated were divided by the number of points in each sector examined so that the values presented relate to dB values that appear on the printout in common practice. From these values MANOVA– Multivariate analysis of variance (repeated measures analysis) was calculated showing that the difference in dB levels for white and red targets was statistically significant. Table 1 and Figure 1 depict these results. From Table 1 we can see that red scores were significantly lower than white scores. A similar difference was evident in all quadrants tested. It is also evident that the statistical level of significance did not alter depending on whether quadrants were tested, half fields analysed, or whole field analysed. The quadrant totals for each quadrant are listed in Table 2 so that clinicians can compare quadrant totals to the calculated normal range from this population.

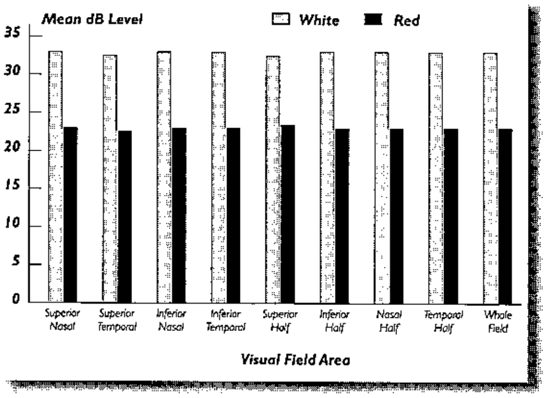

Figure 1

Histogram comparing mean dB levels for red and white stimuli for each area of field analysed.

Correlation between corresponding red and white fields:

Given that there were large mean differences between the red and white decibel threshold levels obtained, correlations were calculated (including all 70 subjects) to see if subjects who had performed best with white targets also performed best with red targets. Table 3 does show moderate positive correlations however it cannot be concluded that subjects who perform best on the red field will always perform best on the white field and vice-versa.

Normal Values for Red 10/2 Test:

The normal threshold values (mean and standard deviation) for each test location on the red field 10–2 test have been calculated and depicted in Figure 2. It was found that the visual threshold for red fields ranged from 21.1 dB with standard deviation ±1.73 more peripherally to 26.2 dB with standard deviation ± 1.83 at central fixation. In this study age appeared to make no difference to the threshold level recorded. That this, sensitivity was not decreased significantly in the older subjects when compared to the younger subjects, however there were only 3 subjects in the older age group (aged 48, 55 and 57).

Abnormal fields with red target not detected by white target:

In order to identify any abnormal field results from this series of subjects any fields that had a quadrant total more than one standard deviation outside the range of values indicated above were considered abnormal. Of the 70 subjects examined 3 subjects showed a field defect when examined with the red stimulus, but no defect when examined with the white stimulus. Removing these from the results of Tables 1&2 produced very similar means which have not been included in this report. In addition removing the 3 abnormal fields produced similar correlations to those shown in Table 3.

The three " abnormal" fields showed no defect with a white target but definite abnormality with a red target. All the abnormal fields on red testing had excellent reliability and low short–term fluctuation. The defective areas were always in the superior field.

A calculation similar to that used by Statpac for white fields to determine the likelihood of the area of the field being defective was employed.

Each abnormal field showed a z score indicating that 95% to 99% of the population would get a better score in the defective

Table 1

Mean dB levels and standard deviation recorded for red and white stimuli for each area of visual field analysed (n=70).

Field Area Averaged	White		Red			
	mean dB	sd	mean dB	sd	F	p
Superior Nasal Quadrant	32.27	1.14	23.46	1.09	7372.82	<0.001
Superior Temporal Quadrant	31.93	1.17	23.18	1.20	5551.60	<0.001
Inferior Nasal Quadrant	32.37	0.98	23.50	0.99	7654.31	<0.001
Inferior Temporal Quadrant	32.42	0.93	23.61	0.94	8558.81	<0.001
Superior Half	32.10	1.11	23.32	1.10	7446.52	<0.001
Inferior Half	32.39	0.92	23.56	0.92	9694.65	<0.00
Nasal Half	32.32	1.02	23.48	0.97	9203.64	<0.001
Temporal Half	32.18	0.99	23.40	1.01	7877.11	<0.001
Whole Field	32.25	0.98	23.44	0.97	9385.14	<0.001

quadrant. This is similar to the statistical results provided on the Total Deviation plots of the usual Statpac analysis.

Two of the three red abnormal fields were both from the same subject. The results for this subject for the left eye with the white target and for the red target had an almost complete superior field defect with the superior temporal and superior nasal quadrants equally affected. Z–test shows that 99.92 % of the population scores better than 337 in the temporal quadrant and 99.95% of the population scores a better result than 346 for the superior nasal quadrant. Other tests performed on this subject showed normal colour vision but borderline contrast sensitivity.

Discussion

The results of this study provide standard values for the Humphrey perimeter against which the results of visual field tests in individual patients can be assessed. Most importantly, the 10° field with a red target was tested so that future fields examined by this technique can be compared with these normal values obtained.

It was found that regardless of the area of the field examined, the threshold levels measured in decibels, were considerably reduced for the red fields when compared to the white fields. These reduced decibel levels suggest that a brighter red target is needed in order to reach the same visual threshold obtained with the white target.

The threshold values for red targets obtained by Flanagan and Hovis [11] compare well with the results of this study. The subjects aged 20 to 30 years in their study achieved a 20dB level for most points in the Macular Threshold test (central 4°) compared with a level of 24 to 26dB for this study. Levels for the 5° to 195° meridian ranged from 24dB centrally to 18dB at 10°; also similar but slightly lower than those obtained from this study. Threshold values for all points tested with their standard deviations were not reported in the study by Flanagan and Hovis [11].

The reason for the difference in dB levels recorded by the Humphrey perimeter for red and white targets is due to the luminance properties of these targets. If we consider the visible solar spectrum we know that white light consists of the whole visible spectrum, whereas red light represents only part of the colour spectrum (i.e. 590nm to approx. 660nm). Hence luminance of the red test target is not the same as luminance of the white test target, therefore the red decibel level will be lower. This has been confirmed experimentally by Flanagan and Hovis[11] who calibrated for the luminance changes with coloured targets and found that dB levels obtained with red were virtually identical to those of white.

Field Area Quadrant Totals

	White		Red	
	mean dB	sd	mean dB	sd
Sup. Nasal	548.5	19.3	398.8	18.5
Sup. Temporal	542.8	19.8	394.1	20.4
Inf. Nasal	550.3	16.7	399.6	16.8
Inf. Temporal	551.1	15.7	401.4	16.0

Table 2

Mean quadrant totals and standard deviation for red and white stimuli (n=70).

Correlation of Field Segments

White/Red Sup. Nasal	0.7036
White/Red Sup. Temporal	0.6560
White/Red Inf. Nasal	0.6308
White/Red Inf. Temporal	0.6362
White/Red Sup.	0.7050
White/Red Inf.	0.6660
White/Red Nasal	0.6995
White/Red Temporal	0.6601
White/Red Total Field	0.6958

Table 3

Correlation of Field Segments.

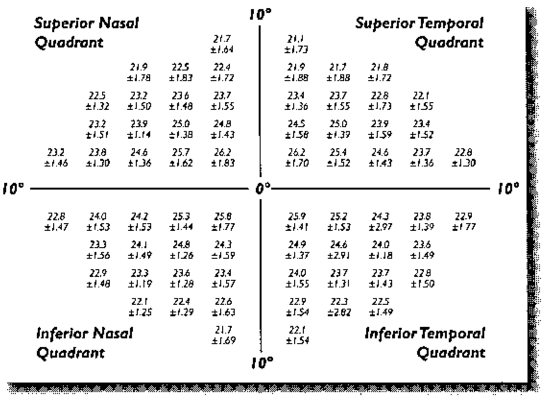

Figure 2

Normal threshold values and standard deviation for a red stimulus for each test location of the 10–2 program.

If we consider contrast between the red target and white background it was interesting to note that most subjects reported the red target easier to see than the white test target. One would expect this to hold true as a red target on a white background has greater colour contrast than a white target on a white background. Mullen [14] found there was a steeper decline in colour contrast sensitivity than luminance contrast sensitivity across the visual field of each spatial frequency, resulting in a continuous decline in colour contrast sensitivity relative to luminance contrast sensitivity. This suggests that there is a greater confinement of post–receptoral chromatic mechanisms than luminance sensitive mechanisms to the central visual field and that the central visual field has a greater degree of specialisation for colour contrast detection.

The reduction in perimetric sensitivity with age is well known. That is, as the subject's age increases the sensitivity decreases. The effect of age on threshold values has been found to be most obvious in the peripheral areas of the visual field beyond 27 degrees from fixation [15,16,17]. In this study, however, little difference in decibel levels were noticed between the younger and older subjects, although there were only 3 subjects of the 53 examined that were in the older age group.

Unexpectedly, of the 70 eyes examined, 3 were found to be "abnormal" both clinically and statistically when examined with a red target, but perfectly normal when examined with the white target. This suggests that the red target is sensitive to very subtle field changes and may not simply be acting as a dim white target as has been previously suggested [18,19].

Physiological evidence suggests that different retinal ganglion cells receive and convey information from different portions of the visual spectrum. The visual pathways, from the ganglion cells to the cortex, are composed of nerve fibres predominantly from the cone receptors. Since the majority of cones appreciate the red wavelengths, early defects in the visual pathways were thought to be more detectable with red stimuli [2,3].

Hedin and Verriest [6] suggest that colour may be selectively affected in generalised cone dysfunction; dysfunction of an isolated cone type; and when there is damage to colour opponent processes. Further studies are required in this area using both coloured and white targets on people with such abnormalities. Red fields may then play a part in early detection of disease caused by a variety of factors such as drug toxicity, defects in the visual pathway, cone dysfunction/degeneration and chiasmal lesions.

As normal data is now available for red targets, visual field testing employing a red test target can be performed with more confidence and knowledge of what the expected outcome should be. This may lead to earlier detection, hence quicker prevention of various ocular problems.

Conclusion

Normal threshold values for the 10–2 program using a red target on the Humphrey Visual Field Analsyer (Model 610) were measured from the fovea to 10° on 67 normal eyes. The data help to establish the range of normal threshold values for red size III targets on the Humphrey perimeter.

Regardless of the area of field examined, the threshold levels were considerably reduced for the red fields compared to the white fields, reinforcing the fact that red targets have lower luminance than white targets. However, three abnormal fields were found with the red target that weren't detected with the white target suggesting that the red target is sensitive to very subtle field changes and may not just act as a dim white target.

Acknowledgments

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The Influence of Uncontrolled Variables in Paediatric Assessment of Visual Acuity: Do we only Measure Visual Acuity?

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Abstract

This paper aims to acknowledge the influence of test design features on visual acuity measurements in normal preschool children and to recognise this as an uncontrolled variable in research. Visual acuity and test duration time were measured and evaluated for three different visual acuity test types; Cambridge Singles, Cambridge Crowding Cards and the logMAR chart. Each test type has varying design features including the number of optotypes presented. The results indicate that the mean acuity decreased with the increased number of optotypes displayed. The design specifications and testing procedure were considered to be influential in these results as the age of the subject and test type influenced test duration time. This may imply that the acuity means are not solely reflective of the integrity of the visual system but the psychological processes used for each test type and these vary with age. However, test design and examination procedure become only uncontrolled variables when not acknowledged in comparisons made between tests in children of the same age or between age groups using the same test type.

Key words:
design specifications, test performance, psychology.

Introduction

Westheimer [1] considered that with the examination of any sensory threshold several intractable problems exist. These being the design specifications of the instruments used, other sensory/motor and cognitive functions, the scale of measurement and the technique of obtaining threshold values. From a research perspective, these "intractable problems" could simply be classed as "uncontrolled variables", which derive from the test stimulus and method of measurement that inturn influences the psychological functions used in the process of visual acuity (VA) assessment.

It may be questioned why these uncontrolled variables have not been addressed more often in the literature, particularly within paediatric research. Unfortunately, research conducted to validate test design has generally used "normal" adults and/or older children as subjects [2,3]. Therefore, researchers have generally not had the opportunity to observe these uncontrolled variables in the population for which the test has been designed [2]. Validity of VA tests on an older population may be explained and justified on the basis of their high compliance and reliability in comparison with preschool children's variable and poor reliability [2,4]. However, this assumes that adult acuity is in agreement with preschool children's acuity and that the methodology of examination and test performance is identical for both age groups.

Fern [2] and Simons [5] suggested that the level of visual acuity recorded per age group was reflective of the developmental tasks stipulated by test design rather than acuity itself. Design specification should be influenced by the type of acuity the test aims to measure and the age group for which the test is to be used. Yet design specifications are dependent upon which aspect of acuity is affected by particular anomalies, and the developmental stages of visual and cognitive function. To acquire such information is dependent upon the design characteristics of the objective test. Hence, the dichotomy that explains why infant's and preschool children's true visual capacity is underestimated and inadequately assessed, which highlights the difficulty in trying to correlate age to level of visual function. Sonsken[6] mentions that there has been little appreciation of the developmental factors associated with test design. It is important to consider then, that what is thought to be measured may not necessarily be reflected in the measurement itself. Instead, the measurement is an index of the design characteristics and the method of assessment, which in turn may reflect the psychological development of the child examined. It can then be asked, do we only measure acuity? This paper is aimed at specifically acknowledging the influence of test design features on VA measurements in normal preschool children and to recognise this as an uncontrolled variable in research.

Method

Subjects:

Forty-three subjects, 21 males and 22 females between the ages of three and five years were recruited from two preschools.

Apparatus:

The three visual acuity tests used were: the Cambridge Singles (the Cambridge Singles is part of the Cambridge Crowding Card Kit and is similar to the Sheridan and Gardiner Single Letter Test); Cambridge Crowding Cards; and the logMAR Chart. The matching board used for the Cambridge Singles and Crowding Cards was also used with the logMAR Chart. Detachable adhesive letter plates were constructed for the letters F, P, E, D, R, N, U, Z (which were specific to the logMAR Chart) in a similar fashion to those used in the Cambridge Singles and Crowding Card Kit. Letters were placed on the matching board in an identical and non–linear arrangement for each test.

Procedure:

A pre-examination training session was conducted for all visual acuity tests per subject, to ensure that the subjects were able to comprehend the process of identification by matching and were familiar with the letter optotypes and testing procedure. An attempt was made not to point to the letters during the examination, however, with the logMAR chart only, each letter was pointed to throughout the assessment of acuity. Care was taken to be consistent and to minimise occlusion of the blank area beneath each letter. Three and four year old children were classed by age into Categories 1 and 2, respectively. Test and eye orders were randomized. Acuity tests were conducted at a distance of three metres. Re-tests occurred two weeks later at the same time of day under identical examination conditions. The lighting level in each examination room was recorded to be equal to or greater than 350lux. For each visual acuity measurement, test duration time was recorded. The criterion for establishing test duration time was from the beginning of the pre-examination teaching session to the level of threshold acuity recorded. For each visual acuity test the ability with which the subjects could perform the test was observed.

Design analysis: The principal aim was to ascertain the influence of test features and subject age on intra-test agreement. The dependent variables measured were visual acuity and time. The mean acuity and test duration times were calculated for each test type. Time was recorded on an interval scale and was also analysed by a two factor ANOVA. Analysis could then determine whether the age and test type influenced visual acuity measurements and whether interaction between these independent variables existed.

Results

Visual Acuity:

The mean VA of the Cambridge Crowding Cards was between that of the Singles and logMAR Chart (Table 1). On retesting the mean acuity for each test type did not change (Table 1).

Time:

The mean duration time for each test type decreased on second examination and was longest for both first and second examinations with an increase in the number of optotypes displayed (Table 2). Intraclass Correlation Coefficient (ICC) value for the first examination (0.03) and second examination (0.12) indicates that the test performance increases are equivalent across all three VA tests.The two factor repeated measures ANOVA indicated that the main effects for age (first exam F=4.70, df=1,41 p=0.036; second exam F=23.65, df=1,43 p=0.0001) and test type (first exam F=131.20, df=2,82 p=0.0001, second exam F=172.07, df=2,86 p=0.0001) were significant on 1st and 2nd

Table 1

Mean Visual Acuity for each VA Test Type; 1st & 2nd Exam

Singles		Crowding Cards		Chart	
first	second	first	second	first	second
6/5	6/5	6/9	6/9	6/12	6/12

examination (Table 3). Thus, the age of the subject and the type of VA test used did influence test duration time on first and second examination. However, there was no interaction between age and test type on either first (F=0.31, df=2,82 p=0.879) or second examination (F=2.70, df=2,86 p=0.0721) (Table 3). Therefore, the effect of age did not influence the effect of test type with the test duration time.

Observations:

Subjects examined with the logMAR Chart commented that they did not like the smaller letters because they were more difficult to see and seemed further away. With the Cambridge Crowding Cards subjects frequently had to have test instructions repeated throughout the examination and visually scanned all letters on the test display card. Half of the subjects excluded from the study were three years of age and could not complete the Cambridge Crowding Card VA test.

Discussion

The influence of psychological functions in visual assessment is not often acknowledged within the ophthalmic and orthoptic literature. This may have resulted from Duke-Elder's opinion that behavioural concepts of perception would eventually be discredited [7]. However, some authors have begun to acknowledge its importance [2,5,8,9] giving specific attention to the influence of test design on test performance.

Test performance can be evaluated in terms of test duration and Ehrlich [10] suggested that it may reflect the degree to which psychological processes are used. Tables 1 and 2 illustrate that as the number of optotypes displayed increased, the mean acuity decreased, whereas the test duration time increased. This may imply that the psychological processes used with the logMAR chart differ to those used with the Cambridge Crowding Cards, which inturn differ to those used with the Single letters. The varying test duration times per VA test type were found to be age related, which suggests that these processes are developmental and could be learnt as test duration time decreases on second examination. Furthermore, the interaction p values between age and test type differ greatly between first and second examination, which suggests a significant learning effect (Table 3). This implies that the acuity means do not solely reflect the integrity of the visual system but also the psychological processes used for each test type. Interestingly, the low ICC values indicate that not one test type can be favoured over another in terms of test performance. The learning effect was of the same degree for each VA test type. This is important in relation to test selection for clinical evaluation of VA and supports an argument for test selection not to be solely based on test performance. For example, clinicians may prefer the administration of Single letters because it is quick and easy to administer. However, the results may be questionable in relation to the detection of amblyopia and the learning effect between first and second examination would be similar to that associated with a VA chart, which is a better test for the detection of amblyopia [10].

Time Means of VA Tests (sec)

	first Exam	second Exam
Singles		
Ages 3—4	135.0	118.2
Ages 4—5	116.4	95.4
All Ages	125.7	106.8
Crowding Cards		
Ages 3—4	192.6	169.8
Ages 4—5	168.6	117.6
All Ages	180.6	143.7
Chart		
Ages 3—4	335.4	118.2
Ages 4—5	304.2	217.8
All Ages	319.8	245.4

Table 2

Mean Time of VA Tests in seconds

The observation of test performance is commonly thought to be factored into the interpretation of acuity measurements in a clinical environment under the umbrella of clinical judgment. However, in studies where different acuity test types are compared, particularly in the validation of test types, emphasis on observations of test performance has been minimal in comparison to acuity statistical analysis. It is not important clinically to know exactly what type of psychological functions are involved when acuity is

Age and Test Type 'p' values of Time

	first Exam	second Exam
Age (A)	0.036	0.0001
Test Type (T)	0.0001	0.0001
A.T. Interaction	0.879	0.0721

Table 3

Age and Test Types

examined but to be aware of any perceptual anomalies that may exist with particular test designs.

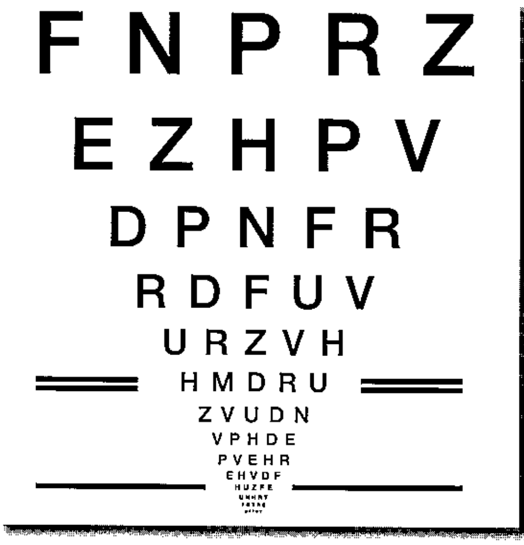

Figure 1

LogMAR Chart

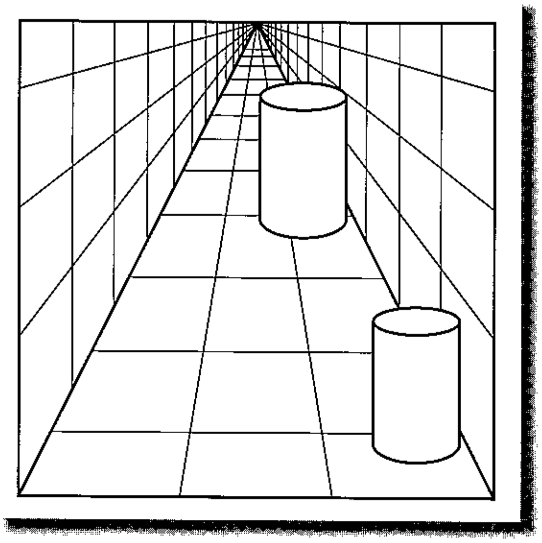

Figure 2

Corridor Illusion

With the logMAR chart, subjects often made the comparison of letter sizes between visual acuity levels and often commented that they did not like the smaller letters because they were more difficult to see and seemed further away than the larger letters. The perception of distance influences image size and the further away the image is perceived the smaller the image is thought to be [11]. This perception anomaly was most likely to have been invoked by the logarithmic scaling of letter size and an equal number of letters per acuity level, which has created an inverted passage to infinity (Figures 1 & 2). Richards [12] describes this as the "Corridor Illusion" where two identical objects of the same size are located separately in a passage to infinity and appear to be at different distances. It may be hypothesised that when comparisons are made between VA levels and perceived letter size, the subjects may be less inclined to attempt to resolve the smaller letters because they are thought to be smaller than they actually are. This psychological phenomenon associated with the logMAR chart may then partly account for its low acuity mean and suggests its measurements may not reflect threshold acuity. The observation of letter size comparison when acuity was measured with the chart would support the use of flip over acuity tests with preschool children, which have been incorporated into more recent designs such as the Sonsken-Silver Acuity System [9] and the Glasgow Acuity Cards [4]. In particular, it may further explain the results in the study by Jayatunga [13] where threshold acuity for the Sonsken-Silver Acuity System was 6/6 while on the MK2 Chart it was 6/9 despite both having a linear display with equal and standard spacing between optotypes.

The surrounding letters displayed in the Cambridge Crowding Card test are, in theory, to be ignored in the process of resolution and recognition of the centre letter. The designers used different surrounding letters from those displayed on the answer board to avoid confusion in the process of identification and matching of the central letter displayed [14]. However, it was considered that the display presentation was visually confusing and conceptually difficult for preschool children which may explain why half of the excluded subjects (all three years old) could not complete the Cambridge Crowding Card test on first examination. The Cambridge Crowding test card and answer board each displayed a total of five letters and although the configuration of letters was different, opposing mental processes were required in the matching strategy when the subject fixated between the Cambridge Crowding Card display and the answer board. That is, the subject was instructed to only look at the centre optotype on the Cambridge Crowding Card display yet asked to visually search all five letters on the answer board to identify "the same" central letter.

It may be considered that the poor reliability and test ability of preschool children is possibly a reflection of the design specifications that inturn influence the psychological aspects of visual function. Clinicians need to be aware of the research background of acuity tests in order to interpret their results appropriately. McDonald [3] emphasises that any new VA test should be supported with examination times, estimates of reliability, preliminary norms and percentage success rates but most importantly these statistics should be specific for various age groups.

Conclusion

The design specifications of visual acuity tests only become uncontrolled variables when comparisons are made between tests when subjects are of the same age group or between age groups when acuity is measured with the same test type. If the same test type is clinically used sequentially to monitor vision in a subject then the design specifications are not considered uncontrolled variables, but are still thought to influence the measurement of vision. With paediatric assessment of acuity, each clinician should ask whether the acuity measured is reflective of acuity itself and/or other factors. It is important not to assume that an acuity measured with one test will be the same when measured with another acuity test due to each test having a different design specification and testing procedure. These and other uncontrolled variables need to be specifically addressed in further research into the examination of acuity in preschool children. Until this occurs the distinction between what is thought to be assessed and what has been measured will remain undifferentiated.

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Ocular Sequelae Following Head Trauma: A Review

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Abstract

To date there have been numerous studies which have investigated the nature of ocular abnormalities as a result of head injuries. However few have presented a full spectrum of disorders that can occur. Orthoptists are skilled in the diagnosis and treatment of trauma victims who have visual disturbance as a result of orbital fractures, cranial neuropathies, brainstem damage, cerebral lesions and soft tissue injuries.

Key Words:
head trauma, ocular, injuries, orthoptics.

Introduction

Head trauma may produce a myriad of visual and visually related disturbances. Rehabilitation of the head injured patient is aimed at developing new skills that will permit the patient to optimally function as a viable and independent member of society. Many visual complaints of the head injured patient however, are sometimes ignored, and visual disturbances are misdiagnosed for long periods of time [1,2]; thus hampering long term neurological and vocational rehabilitation efforts [3].

Orthoptic evaluation of the head injured patient should therefore be carried out routinely as part of the multi-disciplinary team approach to rehabilitation. The role of the orthoptist firstly being diagnostic, and secondly, therapeutic [4].

Orthoptic assessment can also be a valuable resource for monitoring the recovery rate of head injured patients, as changes in eye movements can provide a measure of the recovery or deterioration during the acute stage [5,6].

Epidemiology

Motor vehicle accidents tend to be the most common cause of head injuries [7,8,9,10]. Other causes include direct trauma to the head, injuries sustained from a fall, or as a result of work or recreational activities. In 1991, it was estimated that there were 10,000-12,000 Victorians with head injuries; and this number was growing by 2,000 per year. Head injuries are responsible for 5,000 hospital admissions per year, two thirds of these being under 25 years of age and 71% being males. This figure is comparable throughout many industrialised nations [2]. Approximately 75% of patients who survive head trauma require rehabilitation.

Patho-physiology Of Head Injury

The term 'head injury', for the purpose of this review, will encompass open and closed head injuries, as well as open and closed facial trauma. Open head trauma is defined as direct invasion through the skull, and closed head trauma occurring when there is no direct pathway from the environment to the soft tissue and injury site. The effects of head injuries may result via several mechanisms. The major forces being 'contact' injuries and/or 'deceleration/acceleration' injuries.

With a blow to the head, contusion of the brain occurs as the bone at the site of impact indents and damages the brain surface. Contact injuries also include epidural or subdural haematomas and skull fractures including blow-out fractures of orbital bones [8].

Acceleration/deceleration injuries are related to the movement of the brain in relation to the skull. Such movements may be in anterior-posterior and superior-inferior directions. Consequences of such movements include the tearing of veins bridging the space between the skull and the brain; disruption of cranial nerves and contré coup injuries.

Evaluation of the Head Injured Patient

Examination techniques will be varied, depending on the level of consciousness and the symptoms of each individual [5]. Evaluation of each head injured patient should be aimed at describing the ocular deficits and localising lesions attributable to the head injury. It is therefore imperative that where possible, a general and ocular history be ascertained prior to examination. This will aid in identifying the presence of disease processes which may have ocular involvement, i.e. diabetes mellitus, thyroid eye disease etc.

Clinical Categories

1. Orbital Injuries.

Motor vehicles, heavy machinery, physical confrontations and sports injuries are responsible for an ever increasing accident rate. The eye and orbit are commonly involved in middle third facial injuries. Trauma to the orbit is commonly caused by a blunt blow to the face ie. a squash ball or a fist; or through the patient making contact with a hard surface, as is the case in motor vehicle accidents, ie. the face striking the dashboard.

The effects of orbital trauma may result in soft tissue injuries which cause swelling and haemorrhage leading to limitations in eye movements. Such injuries usually resolve spontaneously. Orbital floor fractures occur when the contents of the orbit are compressed by the blow resulting in the floor, medial wall, lateral wall or roof of the orbit being fractured.

Orbital fractures may be pure, where the orbital rim remains intact, and the fracture affects the floor (antral blow-out fracture) or less commonly the medial wall (ethmoid blow-out fracture); each of which consists of bone 0.5-1.0 mm thick [19]. An impure blow-out fracture involves orbital wall fracture in association with a fracture of the body of the zygoma or the rim of the orbit.

The patient may present with a variety of signs and symptoms which include:

- Limitation of ocular movement due to oedema, haemorrhage, incarceration of tissue within the fracture; or herniation of the orbital contents into the antrum.

- Displacement of the globe backwards, commonly referred to as enophthalmos. The enophthalmos is due to the contents of the orbit prolapsing into the fracture, with the displacement progressively worsening.

- Facial asymmetry usually evident in impure blow out fractures, where there is damage to the zygoma.

- Retraction of the globe when the eyes move in the direction opposite to the entrapment site.[23]

- Infra orbital anaesthesia causing loss of sensation on the skin just below the lower eyelid; resultant from damage to the infra-orbital nerve.[23]

- Pain which is most obvious when the patient looks away from the site of the lesion, ie. on up gaze in antral blowout fractures.

- Visual symptoms which are dependant on the amount of damage to the optic nerve [21]. There may be immediate and permanent blindness, or a field deficit which usually affects the inferior half of the visual field [19].

- Diplopia, which may not be initially evident due to the considerable amount of periorbital haemotoma. The excessive oedema will not allow the eyelids to be opened, and only once this oedema subsides, does the diplopia become evident. The type of diplopia will depend on the site of the fracture. In an antral blow out fracture, where there may be incarceration of the inferior oblique and/or the inferior rectus (this may include entrapment of muscle sheaths or fat), vertical diplopia occurs . Ethmoid blowout fractures result in horizontal diplopia due to entrapment of the medial rectus; also causing limitation of abduction [19]. Displacement of the body of zygoma will also cause horizontal diplopia due to lateral rectus muscle weakness [19]. It should also be noted that horizontal diplopia may become evident in antral blowout fractures as the horizontally acting muscles have connective tissue septa which extend to the orbital floor . Finally, supra orbital fractures may cause vertical diplopia due to involvement of superior oblique or superior rectus muscles [19]. Usually this type of muscle imbalance resolves spontaneously [23].

The incidence of diplopia (in the primary position) has been reported as high as 86% , and as low as 36% in orbital floor fractures. More than one third of all orbital blow out fractures have an associated ethmoid fracture, although isolated medial wall fractures are rare.

Management of patients with orbital fractures is usually conducted by facio maxillary surgeons with ophthalmic and orthoptic intervention being crucial in assessment of the trauma and diagnosis of the injury[25]. It is the orthoptist's role to check the visual acuity; chart the size of the deviation in all positions of gaze; and measure the field of binocular single vision. Surgery should then be considered if there is persistent diplopia; or incarceration or herniation of tissue into the fracture; which shows no sign of spontaneous recovery, and in cases of cosmetically unacceptable enophthalmos [25].

2. Soft Tissue Injuries.

Avulsed extra ocular muscles are another manifestation of head injuries and are categorised as soft tissue injuries [5]. This type of injury is usually the result of a penetrating wound. The medial rectus is the most commonly avulsed muscle followed by the inferior rectus, the superior rectus, lateral rectus and the obliques. Clinical features of the lacerated muscle include limitation of movement of the affected eye, incomitant strabismus and reduced saccadic velocity in the field of action of the injured muscle [5]. Management of the injured muscle involves re-insertion to the sclera, or rejoining of the lacerated muscle ends.

3. Refractive Errors.

(a)Traumatic Cataract.

Cataracts are usually the result of blunt trauma to the eyeball or from a foreign body injury . The lens usually becomes opaque shortly after entry of the foreign body, as the aqueous and at times, the vitreous penetrate the lens structure . The patient's immediate complaints are that of blurred vision, and redness of the affected eye. There may also be intraocular haemorrhage. It is possible that the eye may become soft if the vitreous or aqueous escapes from the eyeball. Complications may include infection, uveitis, retinal detachment and glaucoma [37].

(b) Lens Dislocation.

A contusion injury, such as a blow to the eye with a fist may cause partial or complete lens dislocation. The patient may not complain of any symptoms if the dislocation is partial, however if the dislocation is complete and the lens is floating in the vitreous, the patient may experience blurring of vision. Iridodonesis, a quivering of the iris on eye movement may also become evident - this is a common sign of lens dislocation, and is due to the lack of support to the lens.

(c)Traumatic Myopia.

The most common ocular complaint elicited from head injured patients was that of decreased vision[1]. This can be explained by the fact that many had either incorrect refraction or no refraction at all. Although diplopia is sometimes misinterpreted as blurred vision by the patient, Sabates et al 1991, suggests that most common complaints of blurred or decreased vision can be cured with a sometimes difficult, but accurate refraction. The occurrence of myopia after concussion injuries has been recognised since 1870 following the original observation by Kugel . The extent of the myopia varies from 1 to 6 dioptres. In most cases, the condition is transient although many cases show considerably long duration. The cause of the myopia is not clear, although two causes postulated are that of ciliary spasm, and weakening or rupture of the zonule. Spasm of accommodation initiated by the trauma is the most common etiologic factor. Characteristics of such spasm is associated with a loss of accommodative amplitude, and miosis, and disappears under the influence of atropine [41].

4. Traumatic Maculopathy.

Blunt trauma to the anterior segment of the eye may cause a contré coup injury to the macula called commotio retinae [39]. Retinal whitening occurs primarily in the outer retina, and this whitening may be confined to the macula area or conversely involve more extensive areas of the peripheral retina. The resultant impairment of central vision may be temporary as the whitening may clear completely; or it may be permanent, usually associated with a pigmented scar or macula hole.

5. Cranial Neuropathies.

(a)Neurogenic Paralytic Strabismus.

Typically, traumatic palsies of cranial nerves are caused by closed head injuries [7]. Traumatic damage of cranial nerves may be caused by tearing of the nerves, contusion, or compression. Resultant abnormalities might include varied disturbances of fusion (strabismus and diplopia), ptosis, pupil abnormalities and corneal anaesthesia; arising from damage to the ophthalmic branch of the trigeminal nerve (CNV). Ocular motility defects may occur when the cranial nerves controlling the extra ocular muscles are affected. Except for the facial nerve (CNVII), the abducens nerve (CNVI), oculomotor nerve (CNIII) and trochlear nerve (CNIV) are the most commonly affected nerves in that order. As with any other motor nerve injury, weakness may be complete (paralysis), or partial (paresis) [5].

Deficits associated with oculomotor nerve damage, may include superior rectus and levator palperbrae superioris weakness (superior division of CNIII); medial rectus, inferior rectus and inferior oblique weakness (inferior division of CNIII), as well as damage to the pupillary fibres. As the third nerve controls so many muscles (intra ocular and extra ocular), a third nerve palsy may be complete or incomplete.

A complete third nerve palsy will result in paresis or paralysis of the medial, inferior and superior recti, the inferior oblique and sphincter pupillae; the ciliary muscle and the levator palpebrae superioris. The resultant ocular posture is that of an intorted, hypotropic and exotropic eye, with a dilated pupil and ptosis [24].

In an incomplete third nerve palsy, there may be damage to: superior or inferior divisions of the nerve, single muscle palsies, double elevator palsies, paresis of the extra ocular muscles supplied by CNIII with sparing of the intra ocular muscles [24].

As a consequence of complete third nerve palsies, a new pattern of abnormal movements may occur. This is a result of aberrant regeneration during the re-growth phase of the third nerve , where the regenerating autonomic and voluntary nerve fibres are misdirected. Clinical signs of aberrant regeneration include:

- elevation of the upper eyelid on down gaze [48,49],
- retraction of the globe on elevation and/or depression,
- constriction of the pupil on attempted adduction [24], however there is no reaction (or poor reaction) of the pupil to light stimulation [49],
- poor vertical responses to monocular vertical optokinetic testing [51].

Although the least commonly affected of the ocular nerves [48], the trochlear nerve (CNIV) may be damaged through trauma, resulting in superior oblique weakness, leading to symptoms including diplopia (torsional and horizontal) as well as V-pattern esotropias. Trauma is the most common aetiology of acquired fourth nerve paresis. The troclear nerve may be damaged anywhere along its course by direct orbital trauma, frontal trauma, or an oblique blow to the head [5]. The patient often assumes a compensatory head posture with the head tilted and face turned to the side of the unaffected eye, and the chin is depressed, so as to overcome the symptoms of diplopia and torsion.

Abducens nerve (CNVI) paresis, like trochlear nerve paresis, occurs frequently in head trauma [5], with the deviation usually being larger. Damage of the sixth nerve nucleus results in paresis or paralysis of the lateral rectus muscle, and therefore paralysis of ipsilateral horizontal gaze . Lesions to the sixth nerve are usually found where the nerve leaves the pons and passes through the subarachnoid space. Ocular posture of sixth nerve lesions is that of an esotropic eye (the deviation being more marked for distance fixation); and a compensatory head posture where the face is turned to the affected side [24].

(b) Visual Field Deficits.

Traumatic optic neuropathy has been described by many authors. The optic nerve is commonly injured following closed head trauma. Jeanet et al 1981 described an incidence of up to 13% of survivors of severe head injury. The most common area of injury sustained by the nerve is the intra nuclear portion, where the nerve is tethered to the dura and is relatively immobile [1]. Should a basal skull fracture occur and extend through the optic canal, it could readily damage the optic nerve, as the nerve occupies the entire canal space. Chiasmal damage is also possible when there is a blow to the frontal or parietal region. Lesions of the chiasm occur as a result of jarring to the head and sudden displacement of moveable parts of the brain, with the consequent ruptures of small blood vessels which enter the chiasm [60].

Optic nerve damage may result in transient visual loss, and visual field loss. This loss may be unilateral, bilateral and/or altitudinal. Such field losses may be mirrored by damage to the occipital lobe region. As in circulatory disturbances, trauma destroys masses of brain tissue at once. Portions of the visual pathway included in the lesions are likely to be totally interrupted.

Visual deficits following closed head injuries are not uncommon. Sabates et al 1991 described an incidence of 35% in their series of patients, with functional (tunnel) fields being the most common. The most severe extent of damage was that of cortical blindness. Other types of field deficits included:

- arcuate field anomalies (optic nerve damage),
- quadrantinopia
- bitemporal hemianopia
- homonymous hemianopia
- infero temporal island.

6. Cerebral Lesions.

The occipital cortex is comprised primarily of the parieto occipital visual association areas, which play a role in the control of smooth pursuit movements, and the primary visual cortex (area 17), which is the sensory cortex for sight. A lesion in the occipital lobe may result in visual field deficits, as described in section 5(b), but it may in turn, also cause disruptions to eye movements. Such disruptions are apparent in patients with hemianopic field deficits, which result in cogwheeling eye movements instead of smooth eye movements, as well as saccadic dysfunction. However this is an adaptation and not an ocular motor defect in the true sense.

The purpose of smooth pursuit movements is to maintain a clear image of a moving target (ie. maintaining foveal stimulation [24]). The areas of the cerebral cortex which initiate and co-ordinate smooth pursuit movements are many and varied. Generally, control over smooth pursuit movements is primarily in the parieto occipital visual association areas; with control being ipsilateral ie. left occipital cortex controlling movements to the left. Hence any damage to the parieto occipital area may lead to anomalous pursuit movements. Damage to the cerebellum may also impair smooth pursuit function as the cerebellum plays a role in the co-ordination of eye movement and fine motor control.

Saccadic movements are described as voluntary rapid eye movements between two points. The speed of this movement is usually between 200 and 400 degrees per second, having a peak velocity of 700 degrees per second [67]. Control of horizontal saccades is via the frontal eye fields (Brodman's area 8) for voluntarily directed saccades; and the superior colliculi for re-orienting gaze to novel stimuli. The cerebellum is also responsible for controlling saccades, by monitoring pulse size and aiding accurate and co-ordinated eye movement.

Damage to one frontal lobe produces a conjugate deviation of the eyes to the side of the injury and an inability to look towards the side opposite the lesion [5]. This sort of disturbance is usually transient. Bilateral lesions of the frontal lobes can produce ocular motor apraxia, a quite marked eye movement disorder, where there is an inability to voluntarily direct horizontal saccades to both sides.

7. Intra Axial Brainstem Damage.

Mid brain lesions, and brainstem damage can lead to the disruption of conjugate gaze movements, accommodation convergence relationships, nystagmus and a variety of disturbances of resting fixation, ie. skew deviation or Parinaud's Syndrome. A horizontal gaze palsy may result from an ipsilateral pontine lesion or a contra lateral frontal lobe lesion. Unilateral lesions produce ipsilateral conjugate gaze paresis, and bilateral lesions (at the level of the abducens nucleus) may cause paralysis of all horizontal eye movements [5]. Vertical gaze palsies are indicative of pretectal damage. As vertical eye movements are under bilateral hemispheric and mid brain control, vertical gaze palsies due to isolated cerebral lesions do not occur [24]. In trauma, it is likely that up gaze paresis may be associated with other signs of dorsal mid brain damage. These include light near dissociation of the pupils, limited convergence, eyelid retraction and skew deviation.

Lesions in the pretectal mid brain, rostral to the third nerve nucleus may cause paralysis of convergence. Divergence insufficiency has also been reported after trauma, as a lesion in the area of the sixth nerve nucleus can produce paralysis of divergence. Paralysis of accommodation following head trauma has also been described [77,78], with the deficiency usually being temporary, although recovery may be incomplete. Baker and Epstein 1991, suggest that it is not uncommon for the condition to be mistaken for inattention, lack of effort or alexia [5]. The simple prescription of convex lenses may compensate for the paralysis.

Vestibular dysfunction is also possible in the head injured patient. Symptoms include vertigo and oscillopsia; although due to diffuse representation of the vestibular system in the brainstem, makes isolated lesions unlikely [5].

Central lesions are usually accompanied by other signs of brainstem dysfunction.

8. Glaucoma Secondary to Trauma.

Head trauma and specifically contusion injuries of the globe may be associated with an early rise in intra-ocular pressure. This rise in ocular pressure is due to hyphema. The presence of free blood in the anterior chamber blocks the trabecular meshwork which is rendered oedematous by the injury. Management of the condition is initially medical, and surgery may be necessary if the pressure remains elevated [39].

Visual Deficits and their Implications.

The orthoptist is capable of making a significant contribution to evaluation of the visual status and level of function of the head injured patient, thereby aiding the rehabilitation process. It is important that all therapists are made aware of any visual deficiencies the head injured patient may possess, as many ocular anomalies may interfere with treatment regimes being initiated by any member of the rehabilitation team. Such anomalies may range from the easily correctable blurring of vision to the complex gaze anomalies and the chronic head postures adopted by patients to overcome symptoms of diplopia and pain of ocular movements. Orthoptic findings can aid effective therapy.

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Vision and Functional Capacities of Older People in the Community

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Abstract

Population studies indicate that sight loss is a problem of increased incidence for the aged. Previous studies have shown that sight loss can reduce people's ability to live independently, and that some independence can be regained through effective rehabilitation strategies.

To provide effective rehabilitation an orthoptist must be aware of older persons' perceptions of their functional capabilities. The data presented in this paper represents selected findings from the Health Status of Older People Project, a socio–medical survey of 1000 older people living in the community. Variables selected for presentation include self rated eyesight, measured eyesight, perceived ability to perform certain daily tasks and ability to use public transport.

In addition, respondents who reported poor or worse vision were asked to comment on specific aspects of visual function. Analysis indicated good response between self rated and measured vision. This preliminary analysis of data suggests that a number of areas of daily activity are compromised at least in part due to sight loss.

Key Words:
sight loss, daily living activities, self rated vision, measured vision.

Introduction

Older people generally view health as a resource which enables them to remain independent and feel well [1]. Vision, however, is an aspect of health which is likely to decline from middle age onward. When vision has declined with age then rehabilitation strategies and optical aids can be effective in ameliorating the effects of sight loss and assisting people to maintain their usual activities. Orthoptists are becoming increasingly involved in the process of visual rehabilitation. To be effective in this role orthoptists must gain an awareness of older people's own views of their visual capacities and how vision influences their functional capabilites.

This article presents baseline information on reports on vision from respondents in the Health Status of Older People (HSOP) survey conducted in Melbourne 1994. The socio–medical HSOP study, unlike clinical studies, included representative groups of older people in the community. It extends beyond national health surveys, such as the Australian Bureau of Statistics (ABS)[2] by gathering the data on measured vision as well as self rated vision.

After reviewing related literature and the study methods, this article presents findings on perceived and objective measures of vision and functional capacities of older people with visual impairment. This article concludes by considering how representative population data on the daily living problems experienced by visually impaired older persons can be applied in providing effective and efficient rehabilitation programs.

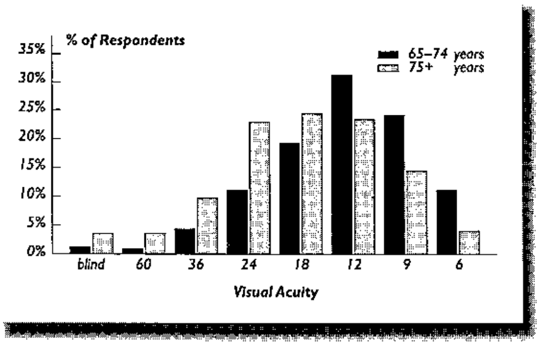
The Australian Bureau of Statistics' figures indicate that 9% of Australians have a sightloss [2]. Sight loss is a sensory impairment which is known to increase in incidence with age,[3-5] a trend supported by the Australian Bureau of Statistics figures which show incidence increasing from 0.4% under 15 years to 14% over 75 years [2]. The impact of sight loss on an individual's ability to perform daily tasks as well as their well–being, has become an area of interest to researchers, particularly given financial stringencies limiting government support. As the aged have an increased incidence of sight loss the impact of limited services is of particular significance to this group.

Poor vision for many older people means a loss of independence. Aged people with visual impairments in the community report unmet needs with household tasks such as shopping, housekeeping [6] and with mobility both walking and using public transport [7,8]. In addition, visual impairment increases the risk of falls with consequent injury [9]. Loss of independence is compounded for aged people who are visually impaired and living in nursing homes. Marx and co workers found visually impaired nursing home residents were more dependent for daily needs such as bathing and toiletting, than non visually impaired residents [10].

Figure 1

Snellen visual acuity by age group.

(Functionally or Totally Blind (n=7). None of these respondents were asked to attempt the Snellen acuity test)



Visual impairment also impacts on the emotional well being of older people. Those with poor eyesight have lower morale than non visually impaired people and are more likely to have feelings of uselessness and to believe that life is unpleasant [7]. A number of authors have reported on the isolation associated with visual impairment [6,11,12]. Social isolation can be further compounded when dual sensory loss occurs [13,14]. This situation arises overwhelmingly among older people as the incidence of both hearing and vision loss increases greatly with age [8,13-15]. The emotional losses associated with sight loss in the aged can be misdiagnosed as a loss of mental faculty, with consequent inappropriate institutionalisation and compromised quality of life [15-17].

With increased awareness of sight loss, researchers also have begun to consider its impact in terms of cost to the community. These costs extend from welfare payments [18] to increased work loads and stress of nursing home staff [10].

The effects of sight loss in many cases can be ameliorated with appropriate assistance such as the use of optical aids [19,20] and the use of rehabilitation strategies such as eccentric viewing [21-25]. Providers of rehabilitation services for the visually impaired should be fully cognisant of the functional problems experianced with sight loss, both emotional and physical, to ensure that those in need of rehabilitation are identified and that the appropriate strategies are employed. Evaluation of rehabilitation must reflect the purpose of increasing functional capacities and hence requires accurate functional assessments to establish baseline and progress data [26].

Method

Data were gathered in a survey conducted by the Health Status of Older People project (HSOP) in Melbourne from May to November 1994. The sample, drawn from electoral rolls, consisted of 1000 people aged 65 years and over living in private households and capable of answering the questions in English. At the end of the interview averaging 90 minutes in length, respondents were asked to participate in brief physical examinations. Finally, they were asked to fill in and return a self completed questionnaire.

The HSOP survey achieved a 70 percent response rate for the personal interviews and, of those interviewed, 84 percent also returned the self completion questionnaire. Overall, the sample was broadly representative of older people in Melbourne, although it slightly over–represented men and those who were married and relatively healthy [27]. Information was collected on respondents' health conditions, health related behaviours, functional capacities, well–being, attitudes, recent life experiences, and basic demographic and social characteristics. This article reports data on

Table 1

Self reported sight and Snellen Acuity

(Functionally or totally blind (n=7). None of these respondents were asked to attempt the Snellen acuity test.)

There are some missing values representing respondents who attempted the Snellen test but where unable to read any line correctly.

Self reported eyesight by measured Snellen acuity N=986

	6/60	6/36	6/24	6/18	6/12	6/9	6/6	Total (n)
Excellent	0%	2%	10%	21%	25%	29%	12%	165
Good	0%	0%	4%	14%	21%	30%	22%	567
Fair	3%	10%	20%	24%	27%	12%	3%	201
Poor	15%	22%	22%	9%	20%	7%	0%	46
Blind	• • •	• • •	• • •	• • •	• • •	• • •	• • •	7

measured vision using Snellen charts, self rated eye sight following the Australian Bureau of Statistics format [2], and well–validated measures of functional capacities [28].

The findings presented below describe the distribution of visual impairment across a community sample of older people and show associations between self rated eyesight, measured eyesight and functional capacities. It should be appreciated that these associations are not necessarily causal, for example, older people with poor eyesight typically also have other difficulties which also limit their functional capacities. Further, the findings are subject to sampling error, particularly for small subsets of the population.

Results

Data from general population surveys such as the ABS surveys usually measure self reported vision and exclude objective measures of visual acuity. The HSOP study, however, collected both self reported and measured visual data, thus enabling comparison of perceived to measured acuity. Figure 1 provides a summary of measured visual acuity by age group for the survey population. As expected the figure shows that visual acuity is significantly better for the younger group of respondents.

Table 1 provides a comparison of measured visual acuity by self rated eyesight for rating from poor to excellent. Respondents who were registered legally or totally blind were not tested objectively and a small number of other respondents were unable to complete the object test and have been omitted from this table. Of respondents self rating their vision as fair to excellent, 79% had a measured acuity of 6/18 or better, which is consistent with the WHO classification of slight to moderate impairment. Of respondents who self rated their vision as poor, 67% had a measured acuity of 6/18 to 6/60 which is consistent with the WHO severe low vision category.

Of the respondents who self rated their eyesight as fair to worse, 47% agreed (when asked) that their problems with eyesight made it difficult to do the things they wanted to do. The proportions agreeing that vision limited their activities was 38% for those who rated their eyesight as fair, 78% for those with self rated poor eyesight and 86% for the few respondents who were classified as legally or totally blind.

Figure 2 shows kinds of difficulties experianced by people who self rated their eyesight as fair or worse. The most frequently experienced problems were reading small print, adjusting to dim light, and handling lights/glare.

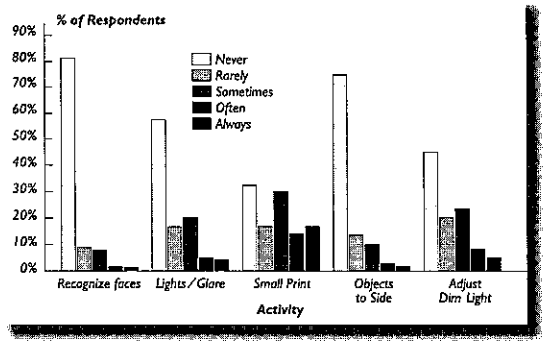


Figure 2

Responses of Subjects with self rated poor vision and task difficulties.

	Self Rated Eyesight	
	fair–excellent	poor–blind
Males		
65–74:	91% (n=307)	57% (n= 9)
75+:	78% (n=138)	54% (n=13)
Females		
65–74:	54% (n=315)	46% (n= 9)
75+:	33% (n=181)	9% (n=13)

Table 2

Proportions of respondents who drove a car in the last month, by age, gender and eyesight (n=996).

For example, the upper left hand cell shows that 91% of men in the age group of 65–74 years with fair to excellent eyesight had driven a car in the last month.

A small number of respondents experienced problems with seeing objects to the side or recognising faces. It should be noted that these difficulties were only reported by those who completed the self completion questionnaire. A signficant number of respondents who rated their vision as poor or worse did not complete the self completion questionnaire. All respondents were asked if they could perform certain household tasks on their own, with assistance or not at all. Figure 3 shows that across all the activities, those with relativley poor eyesight are much less likely to be fully independent. The activity of taking care of one's appearance and eating were performed without assistance across all eyesight categories. Difficulties were most likely in the areas of gardening/minor house repair and doing housework across all sight categories, and more women than men needed help to shop and prepare meals in the fair/excellent and poor eyesight categories.

The ways in which eyesight relates to driving is shown in Table 2. For both men and women in both age groups the proportions who drive is substantially lower among those with poor or worse eyesight. While the numbers with poor sight are small, comparatively poor vision has a particulary strong association with not driving among men of the younger age group and women of the older age group.

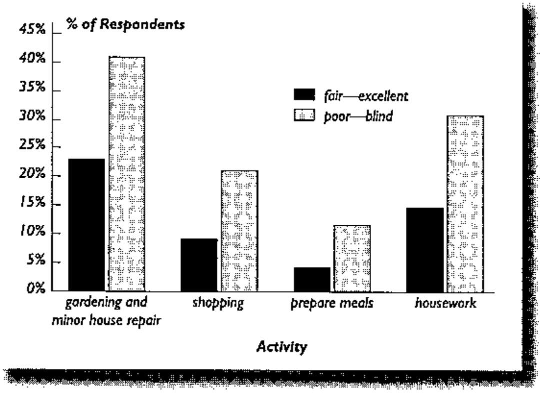


Figure 3

Need for assistance or inability to perform household tasks by self reported eyesight. (N=993)

People who had not driven in the last month (N=363) were asked if they had any difficulty using public transport. Within this group of non drivers, 36% of those with fair or better eyesight reported difficulty using public transport as compared to 48% of those with poor or worse eyesight. Relatively more women than men, and older than younger people reported difficulty using public transport across all eyesight groups. Those who reported difficulty using public transport were asked to state the reasons for this difficulty (N=137). The single greatest difficulty was getting on and off public transport reported by 74% of the fair to excellent sight group; 81% with poor eyesight and 100% of the few who were legally or totally blind.

A similar question was asked regarding difficulty using taxis. Of this same group of people who had not driven in the last month, only 11% of those with excellent to fair sight reported problems as compared to 24% for those with poor to worse sight. For those reporting difficulties, the most frequently reported reasons were expense, getting in and out, and safety concerns. The patterns of these reasons varied little between those with fair or better sight as compared to those with poor sight, with the exception that all of the few people in the blind group reported getting in and out as the greatest difficulty.

Discussion

Overall, the Health Status of Older People (HSOP) findings indicate good agreement between self rated and clinical measures of eyesight. A majority of respondents' self ratings equated with the WHO sight impairment category as determined by measured visual acuity. Yet some respondents appeared to underestimate vision capacities (26% of those self rated fair/excellent) while others appeared to over estimate capacities (21% of those self rated poor). Interestingly, 7 respondents (only 1%) rated their vision as fair to excellent but had a measured acuity of 6/60, an acuity level which borders on legal blindness.

These comparisons are important because most studies of functional disabilities and vision loss rely on self rated vision. Some researchers argue the need for caution when interpreting self rated vision data because of the tendency to understate the degree of visual impairment on self report [12]. Other studies indicate that the elderly visually impaired tend to under report the existence of visual impairment [6,29,30]. The disparity in the findings suggest the importance of taking both self rated vision and measured capacities into account when making functional assessments of individuals.

Consistent with other studies [6,7,8] nearly half of the respondents with fair or worse vision indicated that vision loss limited their activities. Areas of activity in which significant numbers of people were able to undertake or needed assistance included gardening, housework, shopping and meal preparation. Whilst respondents from all eyesight categories reported difficulties with these activities, a greater proportion of respondents who were blind or self rated their sight as poor reported such difficulty. The data also indicates that respondents with poor sight are more likely to require more assistance with minor house repair and grooming. Whilst the association between sight loss and unmet needs for shopping and housekeeping have been reported in other sudies [6] , the association of sight loss with difficulties with gardening and minor house repair have not been reported previously and are areas that warrant further study. Even when sight is not the sole cause of these limitations, it remains an important factor to take into account when assessing the benefits of improved sight when delivering community services.

A large proportion of respondents in the poor or funtionally/legally blind categories indicated a number of household tasks which they were unable to do alone (gardening, shopping, prepare meals and housework). These tasks indicate areas to be targeted by the visual rehabilitation practitioner. Eccentric viewing training has been shown to be effective in improving near vision performance [26, 31, 32]. This technique may assist with aspects of shopping and meal preparation. Eccentric viewing is also reported to assist people with sight loss due to macular degeneration to perform household tasks of cleaning, cooking, washing dishes and shopping [32].

Data from this study support previous findings that elderly persons with self reported sight loss have difficulty using public transport [7]. Among those with relatively poor sight, as well as the rest of the elderly population, generally the older groups of women rather than men were more likely to indicate difficulty. The main problem encountered in using public transport was entering and alighting. A smaller proportion of respondents reported difficulty using taxis and, of those who did, major reasons given were expense and entering and alighting. Age and gender do not appear to be major factors in difficulty of taxi use. Inability to use public transport or taxis will severely limit mobility options, a contributing factor to isolation and impacting on emotional well being [6,7,11].

In summary, these preliminary analyses of data from the Heath Status of Older Persons Study indicate that a number of areas of daily activity are compromised at least in part due to sight loss. Whilst some of these activities such as shopping and housekeeping have been reported in previous studies, additional areas of need identified by this study include activities such as gardening and minor home maintenance. Further analyses controlling for general health and physical disability, will reveal the full extent of the impact of sight loss alone on these activities. The activities of daily living which are compromised by sight loss must be further explored to increase efficiency of training and to develop appropriate functional measures to apply to the evaluation of visual rehabilitation programs. Baseline data on older people in the community will assist in developing and delivering rehabilitation programs which enhance individual independence and limit the need for costly services. Clinicians also have a wider responsibility to advocate for, and ensure the 'user friendliness' of, public transport and other aspects of local environments which enhance independence of older people living with vision impairments.

Acknowledgement.

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Internuclear Ophthalmoplegia as a Presenting Neuro-Ophthalmic Manifestation in a Case of Multiple Sclerosis

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Abstract

Multiple Sclerosis is a disease which has well documented neuro-ophthalmic manifestations of optic neuritis and internuclear ophthalmoplegia. Optic neuritis is characterised by subacute painful visual loss, reduced colour vision, contrast sensitivity and visual field loss. A case history of multiple sclerosis in a 25 year old female is presented. The presenting symptoms were blurred vision and dizziness on laevoversion and tingling in the left foot. Examination of ocular movements demonstrated limitation of right adduction and left abduction nystagmus with diplopia on laevoversion, consistent with unilateral right internuclear ophthalmoplegia. Although a diagnosis of optic neuritis was eventually made, this was not consistent with the presenting symptoms. This case highlights the importance of a full orthoptic investigation of neuro–ophthalmic patients.

Key Words:
multiple sclerosis, internuclear ophthalmoplegia, optic neuritis, orthoptic investigation.

Multiple Sclerosis

Multiple sclerosis (MS) is the most common idiopathic inflammatory disease of the central nervous system [1]. According to Weinshenker [1], MS 'begins as a relapsing–remitting disease and evolves secondarily into a progressive neurological illness in 60% of patients'. Optic neuritis and eye movement control defects, particularly internuclear ophthalmoplegia are common in MS [2].

Optic Neuritis

Optic Neuritis is a frequent forerunner of MS and is characterised according to Warner and Lessells [2], by 'subacute painful visual loss, with disproportionate loss of colour and contrast sensitivity, central or caecocentral scotoma, and an afferent pupillary defect'.

These "classic" visual field defects have been challenged by the recent Optic Neuritis Treatment Trial conducted in the USA, which reported that only 8% of patients showed central or caecocentral scotomas [3].

Arcuate, altitudinal or nasal step defects were found in 20%, and diffuse (nonfocal) depressions were present in 48% of patients.

Abnormalities in contrast sensitivity in patients with optic neuritis in the Treatment Trial, were reported to be as high as 98% [3].

Beck et al [4] state that even when visual acuity returns to normal, abnormalities of other visual functions such as visual field, colour vision and contrast sensitivity defects persist.

Internuclear Ophthalmoplegia

Patients with internuclear ophthalmoplegia (INO) are usually asymptomatic and rarely complain of diplopia. Symptoms of oscillopsia and a sudden onset of heteronymous diplopia on side gaze are reported by some patients [5,6,7].

Internuclear ophthalmoplegia may be unilateral or bilateral, more commonly reported to be bilateral and is characterised by the presence of several features:

1. limitation of adduction of one eye (on the side of the lesion) or of both eyes;

2. jerky horizontal nystagmus of the contralateral eye or eyes on abduction, with the fast phase in the direction of gaze.

Duane [5] reports that nystagmus of much smaller amplitude is is always present in the paretic adducting eye, but may require oculography for detection.

3. retention of convergence in most cases [5,6,8,9].

In addition, bilateral INO is often associated with gaze evoked vertical nystagmus and impaired vertical pursuit [6,7]. The ocular movement abnormalities seen in INO are present regardless of the stimuli, be it for smooth pursuit, saccadic or vestibulo-ocular reflex movement.

Brainstem Control of Ocular Movement

Excitatory impulses from the horizontal gaze centre within the paramedian pontine reticular formation (PPRF) of the pons, synapse in the ipsilateral abducens (VI) cranial nerve nucleus. Internuclear axons then cross and ascend via the contralateral medial longitudinal fasciculus (MLF) to the oculomotor (III) cranial nerve nucleus at the level of the midbrain [5,6]. The MLF axons convey saccadic, vestibulo-ocular and pursuit signals in this manner [5] (see Figure 1).

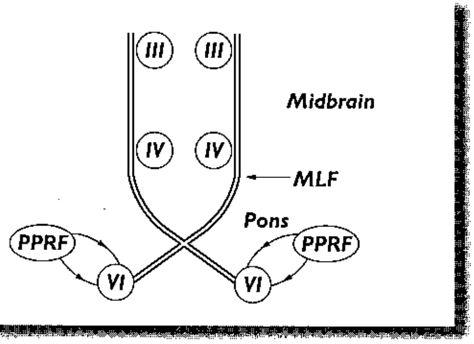

Figure 1
Schemmatic representation of brainstem ocular control.

Unilateral interruption of the MLF between the mid-pons and the III cranial nerve nucleus, disconnects the ipsilateral medial rectus subnucleus, resulting in failure of adduction during horizontal gaze. However, the same medial rectus subnucleus usually functions for convergence. Under the constraints of Herring's Law of equal innervation, excessive signals are supplied to the contralateral lateral rectus yoke muscle, which is the probable cause of the dissociated nystagmus seen in INO [6,9].

According to Duane [6], any process that structurally or functionally interrupts conduction in the MLF may potentially result in an INO.

Case History

The following case highlights the importance of ocular motility assessment in combination with other ophthalmic investigations.

MN a 25 year old Asian female lawyer presented complaining of a two week history of slightly blurred left vision on laevoversion and dizziness on laevoversion. In addition, she reported a tingling sensation in the left foot. These symptoms had increased in severity during this period.

Initial ophthalmic assessment showed:

- Visual acuity (uncorrected):
  Right: 6/12 +2 Left: 6/12 −1
  ph: 6/6 −2 6/9 +2
- Visual fields:
  Full on confrontation.
- Anterior segments, media and fundi were all within normal limits. A mild degree of bilateral myopia was diagnosed.
- Intraocular pressures were 12mmHg right, 16mmHg left.
- Some colour desaturation was reported by the patient.
- There was no evidence of relative afferent pupillary defect (RAPD).

A Bjerrum visual field test was requested on the following day and the result showed a slight enlargement of the blindspot superiorly and temporally on the right and a moderate enlargement of the blindspot inferiorly on the left.

Contrast sensitivity and colour vision testing were requested at a fortnightly follow up visit.

Contrast Sensitivity

Contrast sensitivity was assessed using the Pelli-Robson Chart. The Pelli-Robson Chart is quick and easy to administer. It is most appropriate as a screening device for contrast sensitivity but must be recognised as not being designed to be sensitive to retinal image quality [10].

Contrast sensitivity expresses the ability of the visual system to detect spatial contrast, and thus is really a measure of visual sensitivity [10,11]. The Pelli-Robson Chart uses letters of constant size (low spatial frequency), rather than gratings that decrease in size. Hence the test gives a single measure of contrast sensitivity (known as peak contrast sensitivity) rather than a contrast sensitivity function curve. The test uses Sloan letters which appear in triplets on the chart, each triplet having letters of the same contrast. The lowest contrast 'triplet' in which two out of three letters are named correctly is recorded.

The contrast threshold is recorded as the log of the reciprocal of contrast sensitivity [10].

Normal standards are 1.80 log units or above for a person younger than fifty years and 1.65 log units or above for a person older than fifty years [10].

- The Pelli-Robson Chart log unit scores for MN were:
  Right: 1.80 – normal
  Left: 1.50 – reduced

Colour Vision

Colour vision was tested using the Roth 28 Hue Test. This test is based on the Farnsworth Munsell 100 Hue. This test is sensitive to acquired dischromatopsia and may detect congenital colour vision abnormalities [12]. For this case it was the test of choice as it is easy to perform and relatively quick.

- Results: (see Figures 2a & 2b)
  Right: Few errors, indicating a mild acquired colour vision defect.
  Left: Many errors, but no axonal pattern, indicating a significant acquired colour vision deficit.

Orthoptic Assessment

- Cover Test:
  Near and distance–exophoria with good recovery.
- Stereoacuity (Titmus):
  100 secs of arc
- Ocular Movements:
  Marked limitation of right adduction on laevoversion with left abducting nystagmus with blurred vision on left gaze and vague diplopia (see Figure 3).
- Convergence:
  Intact with a near point of 5cms
- Goldmann visual fields :
  Right: Depressed field superiorly
  Left: Significant enlargement of the blindspot.

MN was referred to a neuro-ophthalmologist who diagnosed an internuclear ophthalmoplegia and left optic neuritis consistent with a demyelinating condition.

Neuro–ophthalmological investigation included Magnetic Resonance Imaging (MRI) and VERs. The MRI showed multiple areas of unidentified bright objects (UBOs) and the VERs showed the central field response as being delayed from the left eye and absent from the right eye.

The diagnosis of MS was made.

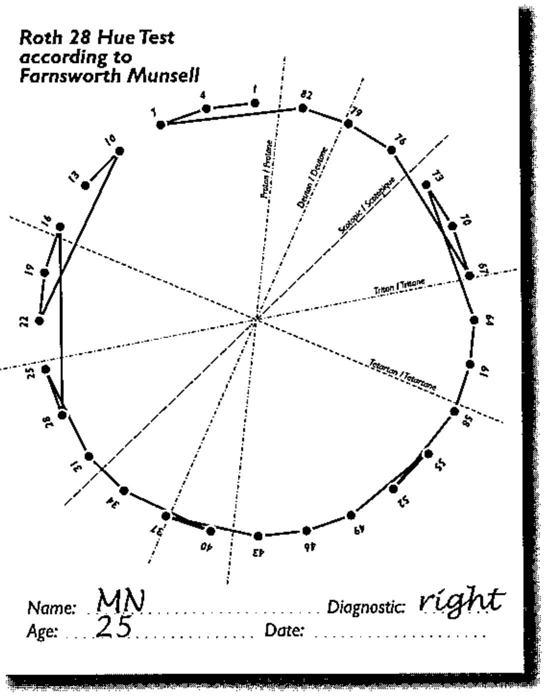

Figure 2a

Roth 28 Hue Test
Right Eye

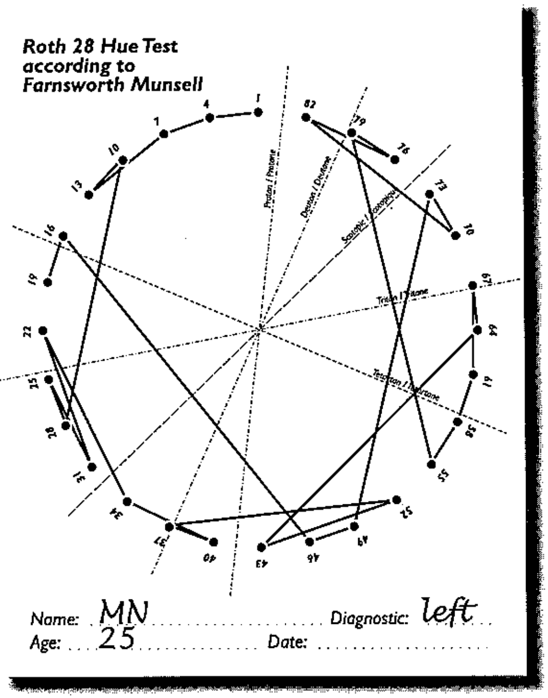

Figure 2b

Roth 28 Hue Test
Left Eye

MN was administered with 500mg of intravenous methyl prednisolone for 4 consecutive days and with oral prednisone 75mg per day for 7 days.

MN was asymptomatic for 24 hours after the onset of treatment and on subsequent visits continues to be symptom free.

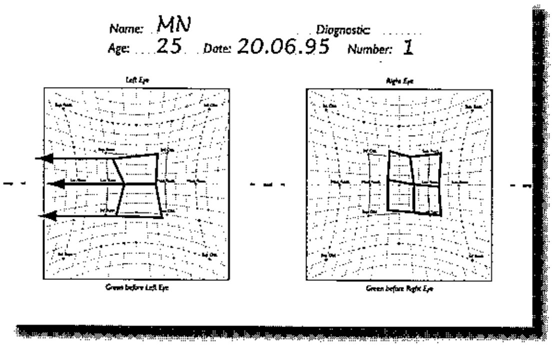

Figure 3

Hess Chart showing limitation of adduction Right Eye

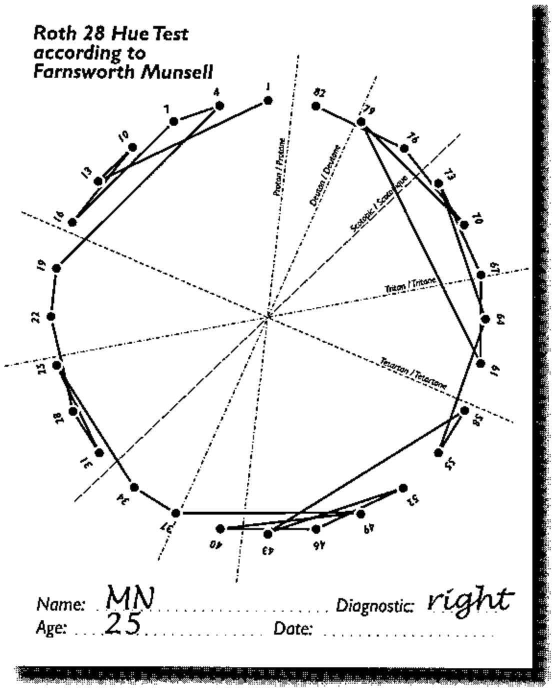

Figure 4a

Roth 28 Hue Test Right Eye

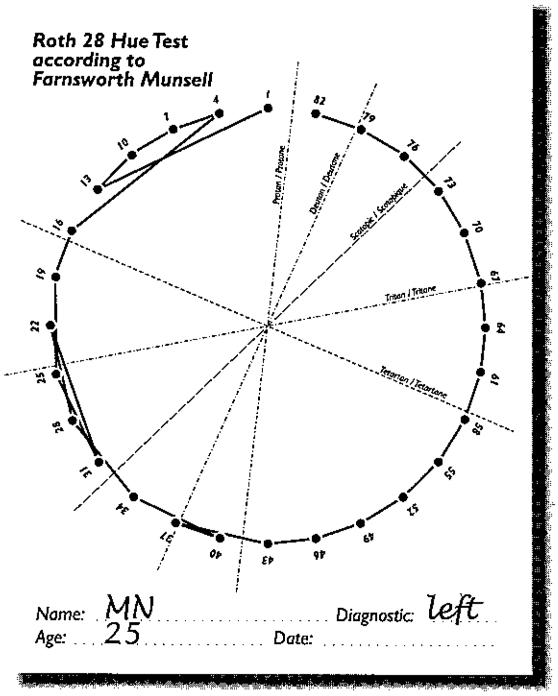

Figure 4b

Roth 28 Hue Test Left Eye

The patient is to be followed up by the neuro-ophthalmologist and to have repeat MRI scans.

1st Follow–Up Orthoptic Assessment; 17 Days Later

- Cover test–near and distance:
  Small exophoria with rapid recovery
- Convergence:
  7cm left eye failed with diplopia
- Ocular Movements:
  No limitation of movement
- Contrast sensitivity: Pelli-Robson Chart
  Right 1.65 log units
  Left 1.50 log units
- Colour vision with the
  Roth 28 Hue Test (see Figures 4a & 4b):
  Right: multiple errors indicating a deterioration in colour discrimination.
  Left: minimal errors, showing a marked improvement in colour discrimination.

2nd Follow–Up Orthoptic Assessment; 1 Month Later

- Visual Acuity (uncorrected):
  R 6/18 L 6/18
  ph 6/6 pt ph 6/12
- Ocular Movements : no limitation of movement. Normal horizontal and vertical saccades.
- Contrast sensitivity scores were unchanged from the previous assessment.
  Pelli-Robson Chart
  Right 1.65 log units
  Left 1.50 log units

Colour vision with Roth 28 Hue Test
Right and left showed an increased error pattern indicating a further deterioration in colour discrimination(see Figures 5a & 5b).

Goldmann visual fields showed bilateral enlargement of the blind spots.

Discussion

Review of the current literature suggests that the patient who may ultimately be assigned a diagnosis of MS, presents because of loss of vision which may vary in severity from a slight deficit in the field of vision to complete loss of light perception [4].

Although the diagnosis of MS was eventually made in this patient, she did not present with the classical symptoms associated with optic neuritis, (ie sudden loss of vision associated with pain on eye movements and a relative afferent pupillary defect) [13]. MN presented complaining of symptoms related to the INO. Symptoms of blurred vision on laevoversion and dizziness on laevoversion prompted MN to seek medical investigation.

Examination of ocular movements revealed a right INO which was an obvious clinical sign in this patient. Although the INO was easily recognised in MN, Muri and Weinburg [9] showed that the disjunction of horizontal saccades has proved to be a most sensitive diagnostic criterion of INO. In their study of 34 patients with MS, mild forms of INO (internuclear ophthamoparesis) were diagnosed with slowing of adduction saccades as the only clinical sign that could be detected. Duane [6] states that assessment of OKN may also disclose a subtle form of INO. This relies on demonstration of impairment of innervation of the medial rectus compared with its yoke and contralateral lateral rectus during horizontal saccades. Therefore, as clinicians it is essential that we routinely include saccadic eye movement testing in addition to assessment of versions so as to ensure that subtle signs of INO are detected.

The reduction of visual acuity at the initial and subsequent visits was only minimal in MN, however, this reduction in vision may have been complicated by the fact that MN had mild uncorrected myopia. The abnormalities in the visual fields, contrast sensitivity and colour vision present at the initial visit were the clinical indicators which led to a subsequent diagnosis of left optic neuritis.

Fleischman et al [14] and Saunders et al [15] state that these functions of vision are 'more sensitive indicators of optic nerve function than is visual acuity'.

At the follow up visits there was no evidence of the INO and the optic neuritis was thought to have resolved. However, the visual field, contrast sensitivity and colour vision results continued to show abnormalities. These findings are consistent with those reported by Beck et al [4] who state that, 'most patients have lasting symptoms of impairment of visual function and even when visual acuity returns to normal, abnormalities are common in other aspects of visual function such as visual field, colour vision and contrast sensitivity'.

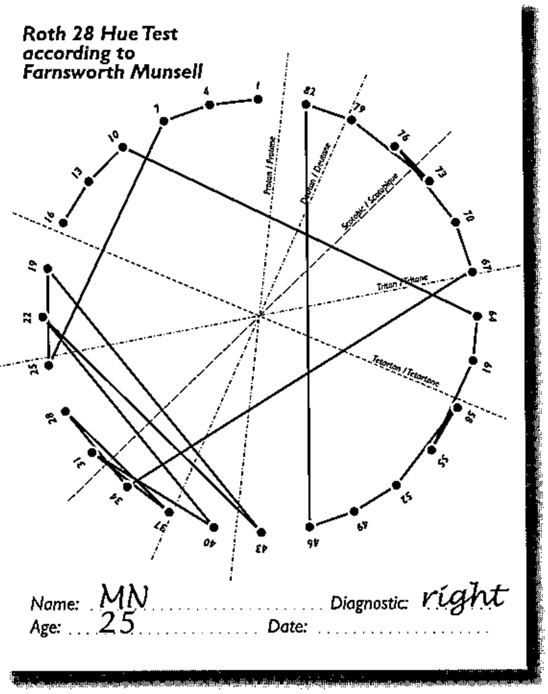

Figure 5a

Roth 28 Hue Test Right Eye

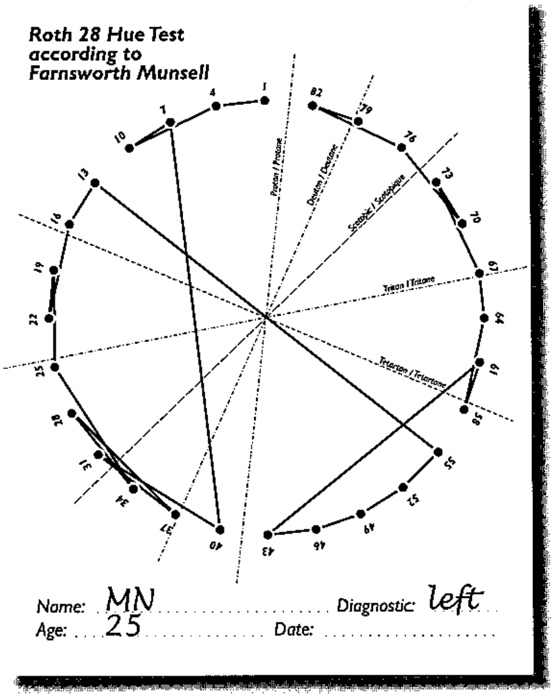

Figure 5b

Roth 28 Hue Test Left Eye

The defect in the visual field and colour vision present in the fellow (right) eye in MN at the initial assessment has increased in severity at subsequent testing along with a slight reduction in contrast sensitivity. Beck et al [16] looked at the abnormalities in the fellow eye and reported that 'abnormalities were found on measurement of visual acuity in 13.8%, contrast sensitivity in 15.4%, colour vision approximately 21% and visual fields in approximately 48% of patients'. However, they also stated that ' the majority of the fellow eye deficits resolved over several months' [16]. These authors also reported, that the improvement of many of the visual deficits indicates that visual abnormalities detected in the fellow eye at the onset of unilateral optic neuritis may not represent pre-existing optic nerve demyelination, but rather acute loss concomitant with the symptomatic involvement of the fellow eye [16].

In a patient who presents with an attack of optic neuritis or INO which are indicative of demyelinating disease, MRI scanning is essential. The MRI clearly identifies areas of focal high white signal aberration, often reffered to as UBOs in periventricular cerebral regions [3]. The Optic Neuritis Treatment Trial, a multi-centre study conducted in the USA showed that MRI was the strongest predictor of the development of MS. Patients found to have two or more periventricular cerebral signal abnormalities had a 36% chance of developing MS after 2 years; patients with scans showing one signal abnormality had a 17% chance of developing MS; and those whose scans lacked these abnormalities had only a 3% chance [3]. The diagnosis of a demyelinating disease was confirmed in the case of MN following MRI which showed 'multiple UBOs'.

Corticosteroids have been widely used in the treatment of optic neuritis, however no properly controlled studies had ever evaluated the treatment. The Optic Neuritis Treatment Trial, (ONTT) was conducted to investigate the value of corticosteroids as treatment for optic neuritis.

The research consisted of three groups:

1. the oral prednisone
2. intravenous methylprednisolone followed by oral prednisone and
3. placebo.

The most significant conclusions to be drawn from the ONTT are:

1. That treatment with intravenous methylprednisolone followed by oral prednisone has no effect on visual function at least 1 year post treatment, but it reduced by more than 50% the 2 year rate of developing MS. This protective effect which began to wane at 2 years, was especially evident in those patients whose MRI scans manifested multiple signal abnormalities typical of MS.
2. Treatment with oral prednisone alone had no affect on visual recovery, and in fact increased the number of recurrences of optic neurtis [3].

Conclusion

This case history demonstrates the need to heed the patient's reported symptoms and the importance of a full orthoptic assessment in combination with ophthalmic investigation. Ocular motility assessment provided the diagnosis of the right INO which was causing the principal presenting symptoms. Having made the diagnosis of INO, the results of contrast sensitivity, visual field and colour vision testing aided a diagnosis of left optic neuritis. The clinical picture now more complete, prompted MRI which provided evidence of demyelinating disease and the requirement of intravenous corticosteroid treatment.

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Named Lectures, Prizes and Awards of the Orthoptic Association of Australia Inc.

The Patricia Lance Lecture

1988	Elaine Cornell (Inaugural)
1989	Alison Pitt
1990	Anne Fitzgerald
1992	Carolyn Calcutt
1993	Assoc. Professor Judy Seaber
1995	Dr David Mackey

The Emmie Russell Prize

1957	Margaret Kirkland	Aspects of vertical deviation
1959	Marion Carroll	Monocular stimulation in the treatment of amblyopia exanopsia
1960	Ann Macfarlane	A study of patients at The Children's Hospital
1961	Ann Macfarlane	Case history: "V" Syndrome
1961	Margaret Kirkland	Post operative diplopia in an adult
1962	Adrienne Rona	A survey of patients at the Far West Children's Health Scheme, Manly
1963	Madeleine McNess	Case History: right convergent strabismus
1965	Margaret Doyle	Diagnostic pleoptic methods and problems encountered
1966	Gwen Wood	Miotics in practice
1967	Sandra Hudson Shaw	Orthoptics in Genoa
1968	Leslie Stock	Divergent squints with abnormal retinal correspondence
1969	Sandra Kelly	The prognosis in the treatment of eccentric fixation
1970	Barbara Dennison	A summary of pleoptic treatment and results
1971	Elaine Cornell	Paradoxical innervation
1972	Neryla Jolly	Reading difficulties
1973	Shayne Brown	Uses of Fresnel prisms
1974	Francis Merrick	The use of concave lenses in the management of intermittent divergent squint
1975	Vicki Elliot	Orthoptics and cerebral palsy
1976	Shayne Brown	The challenge of the present
1977	Melinda Binovec	Orthoptic management of the cerebral palsied child
1978	Anne Pettigrew	
1979	Susan Cort	Nystagmus blocking syndrome
1980	Sandra Tait	Foveal abnormalities in ametropic amblyopia
1981	Anne Fitzgerald	Assessment of visual field anomalies using the visually evoked response
1982	Anne Fitzgerald	Evidence of abnormal optic nerve fibre projection in patients with Dissociated Vertical Deviation: A preliminary report
1983	Cathie Searle	Acquired Brown's syndrome:A case report
1983	Susan Horne	Acquired Brown's syndrome; A case report
1984	Helen Goodacre	Minus overcorrection: Conservative treatment of intermittent exotropia in the young child
1985	Cathie Searle	The newborn follow up clinic: A preliminary report of ocular anomalies
1988	Katrina Bourne	Current concepts in restrictive eye movements. Duane's retraction syndrome and Brown's syndrome
1989	Lee Adams	An update in genetics for the orthoptist, a brief review of gene mapping
1990	Michelle Gallaher	Dynamic Visual Acuity versus Static Visual Acuity. Compensatory effects of the VOR
1991	Robert Sparkes	Retinal Photographic Grading: The orthoptic picture

1992	Rosa Cingiloglu	Visual Agnosia: An update on disorders of visual recognition
1993	Zoran Georgievski	The effects of central and peripheral binocular visual field masking onfusional-disparity vergence
1994	Rebecca Duyshart	Visual acuity: Area of retinal stimulation

The Mary Wesson Award

1983 Diana Craig (Inaugural)
1986 Neryla Jolly
1989 Not awarded
1992 Kerry Fitzmaurice
1995 Margaret Doyle

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1960-61	Helen Hawkeswood
1961-62	Jess Kirby
1962-63	Patricia Lance
1963-64	Leonie Collins
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1965-66	Beverley Balfour
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