The Australian Orthoptic Journal published an article by Piraino and Goodacre in the last edition on the thresholds for red perimetry. This drew the following letter from Jean Pollock.

Dear Editor,

I noted with interest the welcome normative data for "...threshold values for red targets in the central 10 degree visual field" (Piraino J. & Goodacre H. Aus Orth Jnl 1996; 32:19-25[1]). The authors raised the old clinical conundrum of how and why a chromatic stimulus demonstrates greater apparent sensitivity in revealing pathology compared with an achromatic stimulus.

If we assume that a chromatic stimulus is only behaving as a diminished luminance stimulus, then we should expect that simply decreasing the luminance of an achromatic stimulus will reveal the same distribution of visual field loss as that demonstrated by the red stimulus. Is this the case using the Humphrey Visual Field Analyser (HVFA)?

Amongst their normal population Piraino & Goodacre[1] found that the mean threshold decibel (dB) measurements for white and red stimuli were significantly different. They also identified 3 "abnormal" fields where no defect was seen with a white stimulus, despite the presence of a definite abnormality with a red stimulus. In one of these subjects a borderline contrast sensitivity function was noted. How should we view the potential dB differences between white and red stimuli in the presence of pathology?

I suggest that comparison of the relative defect depths could be more informative of whether actual differences exist between results using these stimuli.

A comparison of this type would accept that the magnitude of the measurements were different, instead comparing the log scale of relative difference. The comparison instead is therefore between *relative* defects in dB.

The following data compare the threshold dB defects between a 30-2 white and a 30-2 red HVFA measurement from the same patient. A diagnosis of left sphenoidal ridge meningioma was confirmed radiologically and surgically. In the interests of brevity only the dB deficits in the central 10° are presented for the left, affected eye. (See Figure 1.)

In 11/16 (69%) of the measurements, the defect depths for the white stimuli were more severe or equal to those of the red stimuli.

11 **10**	12 **11**	12 **8**	12 **7**
12 **15**	14 **14**	14 **10**	5 **11**
12 **14**	14 **16**	14 **31**	13 **36**
12 **16**	14 **19**	13 **29**	13 **36**

Figure 1

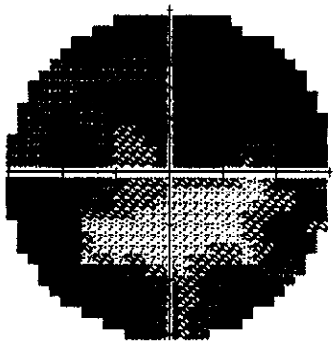
Decibel defect depth with HVFA 30-2 red and ***30-2 white***

However, when viewing the distribution of threshold (graytone) visual field loss (Figures 2. & 3.), we note the evident enlargement and profundity demonstrated by the red compared with the white stimulus. We do not see a similar pattern of field distribution loss with the white stimulus even at high dB defect depths.

There appears to be no controversy regarding chromatic stimuli eliciting responses in their own right and not simply as diminished luminance stimuli, when their luminance is matched to that of the achromatic stimulus (isoluminant). This is acknowledged by Piraino and Goodacre[1]; citing Flanagan & Hovis[2]. What luminance levels does the HVFA actually offer then for each of these test paradigms? According to the 1994 User's Guide the maximum stimulus intensity for the achromatic test is 10,000 apostilbs (apostilbs

Figure 2

Threshold graytone 30-2 white

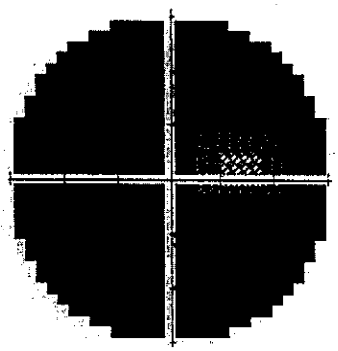


[asb] are measurement units of luminance) which is equivalent to 0 dB or a 4e Goldmann stimulus (i.e. no neutral density filter attenuation). "In color testing, zero decibels still represents the maximum instrument brightness although that maximum brightness is less than 10,000 asb"[3]. The light transmittance of The Hoya R62 red filter is 91.5%.The background luminance of 31.5 asb[3] provides an intensity in the photopic range.

In order to begin to understand the possible mechanisms underlying chromatic and luminance sensitivity we need to consider the neural substrates of the sensory visual system. The primate retino-geniculo striate pathways have been clearly documented[5,6,7]. Two parallel pathways are described according to the differences between their cell structures and functional capacities. The parvocellular (small cell) pathway conveys signals from colour

Figure 3

Threshold graytone 30-2 red. The central reference was 16dB compared with 27dB in the unaffected eye.



opponent retinal ganglion cells (80%). It responds to high contrast stimuli with small receptive field size and weakly to movement. Cell discharges are slow (tonic). The magnocellular (large cell) pathway conveys signals from broadband wavelengths (i.e. not spectrally isolated or "coloured"), representing 10% of the ganglion cells. The remaining ganglion cells project to subcortical areas[7]. The magnocellular pathway demonstrates greater contrast sensitivity compared with the parvocellular pathway and responds to low contrast stimuli with large receptive field size and strongly to movement. Cell discharges are fast (phasic).[1,5,6,7,8]

The parvocellular system (P) projects to layers 3,4,5, and 6 of the lateral geniculate nucleus (LGN) while the magnocellular system (M) projects to layers 1 and 2. The systems appeared to remain relatively separate in their projections and this was supported histologically by their structural differences[7].

This lent credence to an "unashamedly reductionist" theory of functional specialization[8]. In order to describe the terminations of these projections in the cortex it is helpful perhaps to review some nomenclature.

The cortex is a laminated structure that has its projections from the LGN terminating in the striate layers named 2, 3, 4A, 4B, 4Cα, 4Cβ, 5 and 6. These layers occur with the designated smallest number, caudally, through to the highest number rostrally. The visual cortex is further divided by its spread from the primary occipital lobe V1 (Brodmann's area 17), to V2, (Brodmann's area 18), to V3, to V4 and V5, distally, along the convolutions from V1. [7, 8, 10,12]

The P system projects to layer 4Cβ of V1 separating into "blob" and "interblob" layers. The blob or thin stripe pathway conveys information about colour (50% demonstrate double opponency)[7,9,10] and is thought to be only wavelength sensitive rather than colour perceptive[11]. Cells found here are sensitive to luminance at low spatial frequencies but are not orientation selective. The interblob or pale stripe pathway conveys information in response to contours produced by differences in wavelength or luminance and fine detail and form. Cells found here are sensitive to luminance at high spatial frequencies and are orientation selective[7]. In V2 the blobs pass via dark, thin stripes and the interblobs via pale interstripes to V4. Colour perception occurs in V4[11].

There are also connections to V3, an area specialized for orientation and to the Middle Temporal (MT) area, which is the major reservoir for M pathway input. Connections from V4 (P system), then predominantly synapse in the temporal lobe at the rostral superior temporal sulcus and the inferotemporal gyrus (ventral stream)[7,10], where object recognition occurs[12].

The M system projects to layer 4Cα of V1, terminating in layer 4B. All cells here are orientation and motion selective. In V2 passage via thick dark stripes terminates in V3 (orientation centre), V5 (motion and binocular disparity centre) and also to the MT area, before synapsing in the posterior parietal lobe (dorsal stream).

Functionally then, the ventral stream has been associated with object, but not spatial vision and the dorsal stream with spatial, but not object vision[10,12].

The above descriptions understate enormously the abundant inter-connectivity between the P, M systems and the cortical areas V1, V2, V3, V4, V5 and their underlying cell layers of 4Cβ 4Cα and 4B. This necessarily weakens the purely reductionist view of one area or process being responsible for one type of sensitivity/sensation or behaviour[12].

The visual acuity of the patient described above was essentially normal at VR 6/4 VL 6/5. However, contrast sensitivity measurements using the Pelli-Robson Chart demonstrated a low frequency loss: VR 1.65 VL 1.05. Not surprisingly a L RAPD was also noted.

My temptation is to theorize that the parvocellular system with its specialty for chromatic sensitivity and static stimuli at high contrasts, could be seen to be selectively responsible for the difference in dB sensitivity demonstrated with a chromatic rather than an achromatic stimulus. The photopic adaptation created by the HVFA background luminance further supports the notion of a P system response. Piraino & Goodacre's[1] 3 "abnormal" red fields despite normal white fields, especially in a subject who demonstrated borderline contrast sensitivity function, must surely support the contention that a red stimulus is enabling measurement of a different sensitivity in the presence of pathology.

Jean Pollock

Acknowledgments

The patient: for permission to use their visual data. Dr Larry Abel: for scanning the field images.

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Response to a Letter to the Editor: Morabito (Piraino) and Wozniak (Goodacre) have taken the opportunity to comment on the Letter to the Editor by Jean Pollock, concerning their original article on thresholds in red perimetry.

As implied by Pollock in the Letter to the Editor the use of coloured targets in automated perimetry is far from understood. Essentially Pollock is providing a case example to suggest that the use of the chromatic (red) target in automated perimetry may reveal greater defects than those found using conventional white or achromatic targets; and that a possible mechanism for such a finding be related to the parvocellular pathway. While not wishing to comment on the proposed mechanism for any differences, we feel that there are several issues regarding the information provided in the case that warrant further discussion.

Figure 1, the dB readings, outlines the "relative defect depths" for both white and red stimuli in the central 10°. To be able to comment on such "figures", further information is required stating how these "relative defect depths" were calculated. For example when calculating defect depths for white targets the Humphrey Field Analyser uses the subject's actual dB values recorded and compares these to normative data to calculate any differences. For red targets no such normative data is used for the calculation of degree of defect depth. Pollock does not state whether the normative data previously published[1] was used to calculate the values in Figure 1. It is likely that the magnitude of these values for the red targets would be different depending on which method was used. (Infact when the 3 cases mentioned in the published article[1] showing field loss with red targets not apparent with white targets are reviewed; the defect depth calculated by the Humphrey Field Analyser is greater than the defect depth calculated from the normative data. Thus the Humphrey Field Analyser appears to be over-estimating any loss noted with a red target.)

Apart from the above the letter states after Figure 1 that 11/16 (69%) of points show a similar or greater defect depth with white targets. Are white targets therefore considered more sensitive than red? When comparing this data one needs to be mindful of the overall variability or scatter of any automated perimetry threshold measurements. The threshold value obtained on any given measurement location may fall anywhere along the frequency of seeing curve [2,3] and gives rise to a certain amount of variability. This variability occurs during a test as the short term fluctuation, and also occurs between tests known as long term fluctuation. It is believed that this fluctuation is greatest in areas of the field with defects (magnitude in the literature varying from 4dB[4] up to 10dB[5]). As Liebermann and Drake state: "one must not assign too much importance to a 2-4dB change in an isolated value from one test to another."[4] When this variability in the measurement is taken into account, and the data in Figure 1 reviewed, it can be seen that only 7/16 points show a greater than 4 dB difference - where the white target has a greater "relative defect depth". The remaining points show a difference that could be accounted for by variability in the measurement technique alone.

Gray scale printouts are then provided to suggest the opposite; that a greater defect is noted with a red target than a white target. As shown in our article[1] the dB level for red targets will always be lower than that for white, thus explaining the darker "picture" shown in Figure 2. The dB values recorded for red targets and used to create the gray scale printout are those that the white stimulus would have had if the red filter were not in place[6].

What remains to be addressed in the colour perimetry debate is whether or not a chromatic target is able to detect defects that could not be detected with achromatic stimuli. This would be best researched by examining fields that are normal with achromatic targets yet showing apparent defects with chromatic targets. Personal communications that HW has had with clinicians across the globe[7] indicate that chromatic targets

are currently being used to monitor the toxic effects of certain drugs to the visual field, but little has been published to date. Easterbrook who has published widely on the toxic effects of hydroxychloroquine does state that "in some patients with established retinopathy, testing with a red test object and the 10/2 Humphrey perimeter may show larger and deeper scotoma than that determined using a white test object, even when the reduced illumination of the red test object is taken into consideration. However red-field testing has not been standardized with age matched controls and currently is considered a research tool."[8]

Despite what may occur in the future, it is imperative that researchers addressing this issue consider normative data when making comparisons between targets, and also the inherent variability of the threshold measurement; before any conclusions about the effectiveness of chromatic targets and automated visual field testing be made.

In the words of others:(Henson, p.19): "Its (colour perimetry) role in the detection and monitoring of ocular pathologies has not yet reached the level it deserves. This is due to inertia in the perimetric community, lack of commercially available equipment, and lack of standardization."[2]

Helen Wozniak (nee Goodacre)
Josephine Morabito (nee Piraino)

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Response to a letter by R. Duyshart in the AOJ Volume 32.

In response to the letter by R. Duyshart published in the Australian Orthoptic Journal 1996 volume 32. pg 7-8, reference in her letter was made to the article "Comparison of crowded single optotypes with linear acuities in amblyopes" by Williams et al. Although the authors recognise her points regarding the choice of visual acuity tests for screening programs, we feel that the discussion in her letter unfairly reflected the nature of the original research undertaken. We feel that it is necessary to clarify the ideas behind our research.

The aim of the research was to simply assess the validity of the LM test (one we had seen in limited use in the clinical setting) to detect amblyopia, by comparing it to some well known tests which had been more thoroughly investigated as to their validity to detect amblyopia (the SG Linear and SG Singles test). We felt that if the LM test showed an ability to be able to detect amblyopia, then further research would be able to determine if the test was suitable for detecting amblyopia in the younger population undergoing vision screening.

Duyshart states that our results would have had greater clinical significance if the research was performed on children aged 3-5 years, if it included reliability analyses and examined different types of amblyopia separately. Although all these ideas are logical it is often necessary when undertaking clinical research to investigate different issues separately and hence break a research question down into its component parts.

Although the area that this test would clinically be most helpful is in the age bracket of 3-5 years, we were faced with two dilemmas in testing within this age group.

a) Children of this age were not available to use in the numbers that we would need for the study.

b) Children of the age, known to have short attention spans, would most likely find it hard to concentrate for VA testing for 3 tests of each eye in one sitting. We wanted to minimise this confounding factor in our research. Thus the research question investigated the ability of the test to detect amblyopia, not the ability of this age group to perform the test. Further research using the LM test on this population would need to examine the test's reliability.

As far as the amblyopic population tested is concerned, the small sample size made it impossible to consider each type of amblyopia separately, and be able to make valid conclusions from such an analysis.

The shortcomings of the research were clearly outlined in the original paper.

We believe that it is important to design research studies that answer adequately the research question being asked. Often it is necessary to look at a research area and break it up into a series of questions, such that not all outcomes of research have direct clinical significance. This was infact clearly stated in our conclusion: "What remains to be established is whether the LM test is as simple as the Sheridan Gardiner test to comprehend in the population where it is most needed: screening large numbers of perverbal children who can not perform linear tests." p 27

The suitability of this test for vision screening is yet another question. The test does appear to be easy to understand, quick to perform and sensitive to amblyopia. It may be of benefit in the detection of amblyopia or when loss of concentration or lack of co-operation with other tests makes it difficult to perform screening. Although there are many other alternatives for testing vision in the orthoptic setting, these tests may be costly and more difficult to perform by vision screeners who have more limited training and knowledge of amblyopia.

We were not stating that because our research showed the LM test to have a favourable result in the detection of the crowding phenomena that it should be implemented, rather that its availability should be noted, its effectiveness as a test should be considered, and of course after further research its use considered.

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Tiffany Wong,
Helen Wozniak (Goodacre)