Macular Pigment and its Contribution to Spatial Vision

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INTRODUCTION
Macular pigment (MP), which is composed of three dietary carotenoids, lutein (L), zeaxanthin (Z) and meso-zeaxanthin (MZ), is predominantly located at the site of maximum visual acuity in the human retina. MP absorbs short wavelength light prior to photoreceptor stimulation. Filtering such defocused short wavelength (blue) light could enhance visual performance by reducing the effects of chromatic aberration and light scatter. This hypothesis, in relation to MP, remains unproven and poorly investigated to date.

PURPOSE
The Collaborative Optical Macular Pigment ASsessment Study (COMPASS) is a double blind, placebo controlled and randomized clinical trial, designed to investigate whether MP optical density (MPOD) influences spatial vision and visual comfort by means of selective short wavelength light absorption prior to photoreceptor light capture.

SUBJECTS and METHODS
We recruited 142 young healthy subjects (mean ± SD age = 28.85 ± 6.37 years). The spatial profile of MPOD was assessed by customized heterochromatic flicker photometry (cHFP), which has been shown to be a reliable and repeatable method of quantifying MPOD. Visual performance was assessed using visual acuity, mesopic and photopic contrast sensitivity, glare sensitivity and photostress recovery time measures. Each subject also completed a visual performance questionnaire, generating a performance index of the subject’s perception of their functional vision in terms of colour, acuity, glare, light/dark adaptation and daily visual tasks.

RESULTS
These results represent the baseline findings from COMPASS. Mean ± SD MPOD obtained at peak (0.25º eccentricity) was 0.48 ± 0.19. There was a statistically significant positive relationship between BCVA and MPOD at all retinal eccentricities ($r = 0.236$ to $0.354$, $p < 0.01$) [Figures 2 and 3 illustrate the relationship at 0.25º and 0.50º respectively].

There was a statistically significant positive relationship between mesopic and photopic contrast sensitivity and MPOD, but confined to the central 0.50º of retinal eccentricity (mesopic contrast sensitivity @ 7.5 cpd, 11.8 cpd and MPOD at 0.25º, 0.50º: $r = 0.171$ to 0.197, $p < 0.05$; photopic contrast sensitivity @ 1.0 cpd, 7.5 cpd, 11.8 cpd and MPOD at 0.25º, 0.50º: $r = 0.174$ to 0.197, $p < 0.05$). [Figures 4 and 5 illustrate the relationship between MPOD at 0.25º and both mesopic and photopic contrast sensitivities and MPOD, but confined to the central 0.50º: $r = 0.171$ to 0.210, $p < 0.05$; photopic contrast sensitivity at 7.5 cpd and MPOD at 0.25º, 0.50º: $r = 0.174$ to 0.197, $p < 0.05$].

CONCLUSION
Given its short wavelength absorption characteristics and central, prereceptorial location [see Figure 1], MP exhibits ideal properties to optimize visual performance. Visual performance, as assessed by visual acuity and contrast sensitivity measures, does appear to be influenced by MP. Photostress recovery and visual performance under glare conditions however show no significant relationship with MP.

REFERENCES

Best corrected visual acuity (BCVA)
BCVA was assessed using a computer-generated LogMAR, high contrast chart, employing a SLOAN ETDRS letterset. A visual acuity rating (VAR) was computed to quantify precise acuity limits.

Contrast sensitivity function (CSF)
Mesopic (3 cd/m²) and photopic (1000 cd/m²) CSF curves were plotted using spatial frequencies of 1 cycle per degree (cpd), 4.1 cpd, 7.5 cpd, 11.8 cpd and 20.7 cpd. Gabor stimuli were displayed on a CRT monitor and sensitivities were determined using a linear staircase procedure.

Glare sensitivity
Mesopic (3 cd/m²) and photopic (85 cd/m²) contrast sensitivity was also tested under glare conditions using a sine grating functional acuity contrast test, and a radial glare source. CSF curves were plotted using spatial frequencies of 1.5 cpd, 3 cpd, 6 cpd, 12 cpd and 18 cpd. Glare effects on the CSF were determined for medium (35 Lux) and high (128 Lux) glare intensities.

Photostress Recovery Time (PRT)
PRT was evaluated using a previously described macular automated photostress test using a Humphrey 745 visual field analyzer.

MPOD measurement
MPOD measurements were obtained by cHFP (using the Macular Densitometer™) at five loci (0.25º, 0.50º, 1º, 1.75º and 3º of retinal eccentricity), with a reference point at 7º, to generate a complete spatial profile of MP.