# Age of onset of myopia in a population-based twin cohort

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## Introduction

Myopia in the form of 'simple' myopia that is not associated with syndromic or dominantly-inherited high myopia has been termed 'school' myopia as its age of onset is usually in children and adolescents of school age[1].

Thus most research on causes and determinants of myopia has relied on cohorts of subjects in childhood/adolescence years[2-4].

A study in a nationally representative sample of 45 year olds of the 1958 British Birth Cohort suggested that the majority of myopes had good uncorrected acuity at age 16, and even 30% of high myopes did not have reduced vision at that age[5].

This raises the question not only of what factors may be involved in adult-onset myopia but of possible misclassification into non-myopes if ascertained at too young an age for genetic and other studies.

## Aim

The aim of this study was to examine the age of onset of myopia in a large cohort of adult twins who have had refractive error ascertained and who answered questions about age of first spectacle wear.

## Methods

Subject volunteered through media campaigns to be on the TwinUK Adult Twin Registry at St Thomas' Hospital London[6].

Subjects were invited to attend a hospital visit where collection of phenotypes including refractive error using non-cycloplegic autorefraction was undertaken[7-8].

Questionnaires on ocular history including lens use for close work, distance or both were sent via post. Age of first spectacle wear was asked.

Subjects were excluded if there was history of cataract surgery, laser, retinal detachment or ocular problems that may have influenced refractive correction.

The mean spherical equivalent for both eyes calculated for each individual. The variance for spherical equivalence was calculated as the between sib-pair variance by partitioning total sums of squares between and within sib-pairs using one-way analysis of variance.

## Results

*Characteristics of subjects with refractive error (spherical equivalent SE in dioptres) measured by autorefractor, those with questionnaire data relating to age of spectacles wear, and myopes with data about spectacle wear. Myopia defined as SE <= -1 dioptres. All SDs calculated as between sib-pair SD.*

| | | |
|---|---|---|
| Subjects | Number | 3712 |
| | Age (SD) | 54.4 (13.0) |
| | Mean SE (SD) | -0.31 (2.47) |
| | % myopic | 27.3 |
| | | |
| Questionnaire | Number | 2435 |
| | Age (SD) | 57.1 (11.4) |
| | Mean SE (SD) | -0.28 (2.71) |
| | % myopic | 29.6 |
| | Age (SD) any distance Rx | 28.5 (17.6) |
| | | |
| Myopes | Myopes with full data | 689 |
| | Age (SD) | 53.8 (11.9) |
| | Age (SD) distance Rx | 18.3 (12.2) |
| | Mean (SD) SE | -3.72 (2.33) |
| | % myopic <=age 16 yrs | 57.8 |
| | | |

## Results

Refraction data was available for 3769 subjects. 57 were excluded.

689 subjects (27%) were myopic .

Mean age of subjects was 54.4 (SD 13.0) and for myopes 53.8 (SD 11.9).

The age range was 16-82 years.

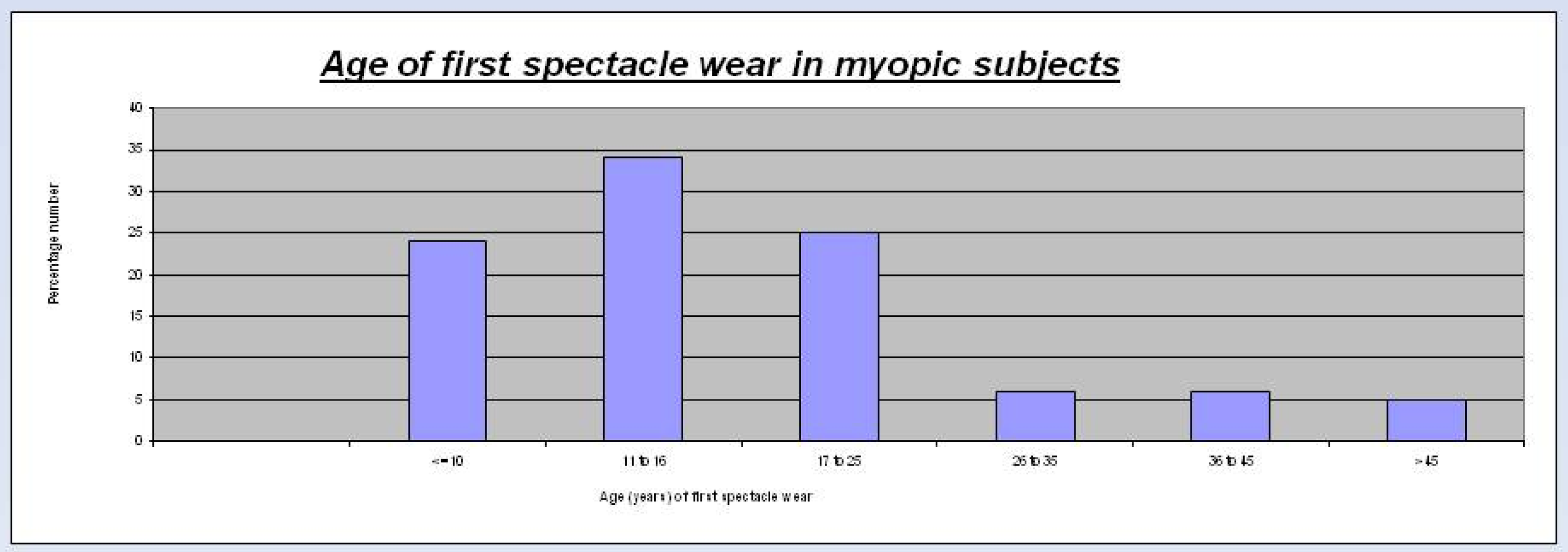
Overall 14% subjects had low myopia (-3>SE>=-1), 9% moderate myopia (-6>SE>=-3) and 4% were highly myopic (SE <=-6).

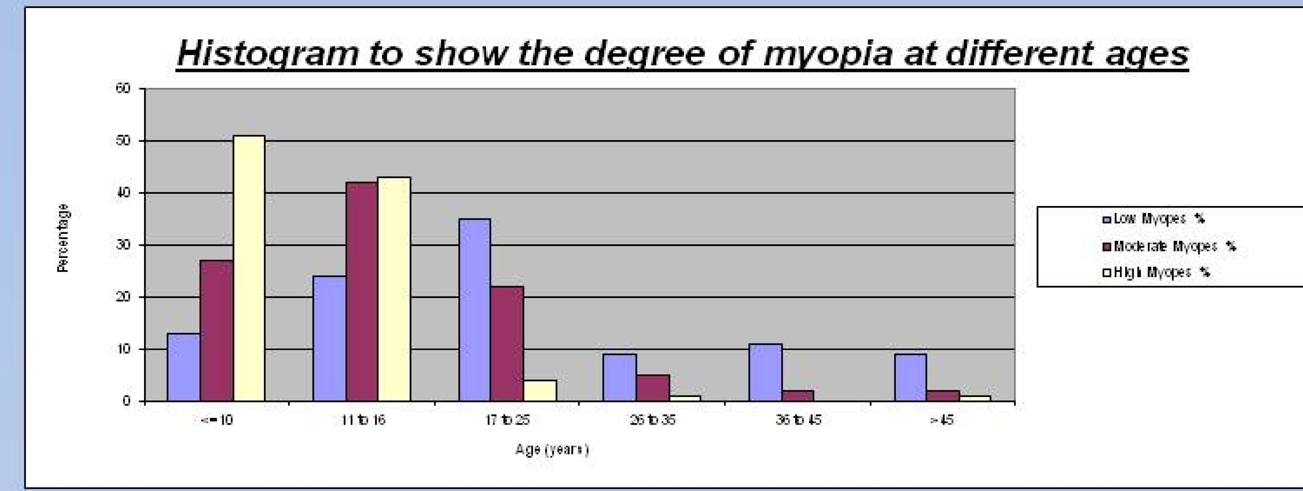
Information from questionnaire data including questions on age of first spectacle was available for 66% all subjects (2435/3712).

Full data on age of spectacle wear available was for 68% (689/1014) myopes in the sample.

*Age of first spectacle wear for myopes, measured by autorefractor (mean spherical equivalent SE in dioptres) and age of spectacle wear for low (-3>SE<=-1D), moderate (-6>SE <= -3D) and high (SE<=-6D) myopes with autorefraction data.*

| Age (years) of first spectacle wear | N (%) | Mean SE (SD) | Low myopes N (%) | Moderate myopes N (%) | High myopes N (%) |
|---|---|---|---|---|---|
| <=10 | 167 (24) | -5.4 (3.26) | 44 (13) | 66 (27) | 57 (51) |
| 11 to 16 | 231 (34) | -4.1 (2.15) | 81 (24) | 102 (42) | 48 (43) |
| 17 to 25 | 173 (25) | -2.7 (1.53) | 117 (35) | 52 (22) | 4 (4) |
| 26 to 35 | 42 (6) | -2.4 (1.21) | 30 (9) | 11 (5) | 1 (1) |
| 36 to 45 | 41 (6) | -1.9 (0.71) | 37 (11) | 4 (2) | 0 |
| >45 | 35 (5) | -2.1 (1.42) | 29 (9) | 5 (2) | 1 (1) |
| Total | 689 (100) | -3.7 (2.53) | 338 (100) | 240 (100) | 111 (100) |




58% of myopic subjects needed correction by the age of 16.

83% were wearing spectacles by 25.

There is a higher prevalence of early onset myopia among high myopes with 51% needing correction before 10 years age, compared to 27% and 13% for moderate and low myopia respectively.

Subjects wearing spectacles by age 10 years ended on average -5.4D while those wearing spectacles for the first time between 17-25 years ended on average -2.7D myopic.

The vast majority of high myopes were diagnosed by age 16 (95%) but only 70% and 37% of moderate and low myopes were wearing correction by 16.

## Discussion

A significant proportion (at least 40%) of those who are myopic (SE<=-1) were not wearing spectacle correction by 16 years. This reinforces the idea the suggestion there is a significant amount of adult-onset myopia [5]. This means that future myopia genetic studies may wrongly classify subjects if they are selected while still in teenage years. In our series of unselected subjects with autorefraction, almost 20% wore spectacle correction for the first time after the age of 25.

The majority of blinding complications occur in more highy affected myopes:[9] 95% of high myopes in this series were myopic by age 16, and 99% by 25.

This provides encouragement that if effective strategies to reduce progression become available targeting younger-onset myopes will have an impact on the serious complications of myopia. However, 30% of moderate myopes were not wearing spectacle correction by the age 16, with 93% wearing spectacle correction by age of 25 years.

Although a smaller proportion of myopes were not wearing spectacles by age 16 in this study compared to the 1958 cohort[5], our results still reinforce the suggestion there is a significant amount of adult-onset myopia.

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# Influence of target spatial content on accommodation response dynamics

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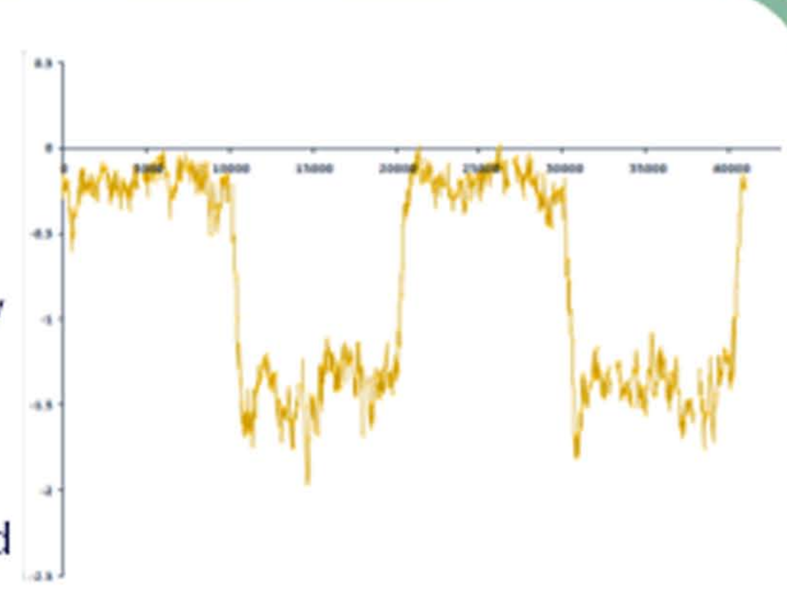
***Purpose:*** Accommodation responses are thought to be driven by mid-range spatial frequencies. Dynamic accommodation responses have previously been shown to be slower in myopes, particularly inward accommodative responses to blurred stimuli (Rae 2007). This may indicate poorer blur driven accommodative sensitivity in myopes. The influence of target spatial content on dynamic accommodative responses, response accuracy and accommodation micro-fluctuations in myopes and emmetropes was investigated in a free-space environment.

***Methods*:** **Five** emmetropes, five low myopes and four moderate myopes (mean SERx +0.13D; -2.53D; -7.69) made 2D step responses viewing monocularly in free space. Near targets consisted of a block of N10 size text and the same text band pass filtered for low, medium, high and very high spatial frequencies (see Poster 90).

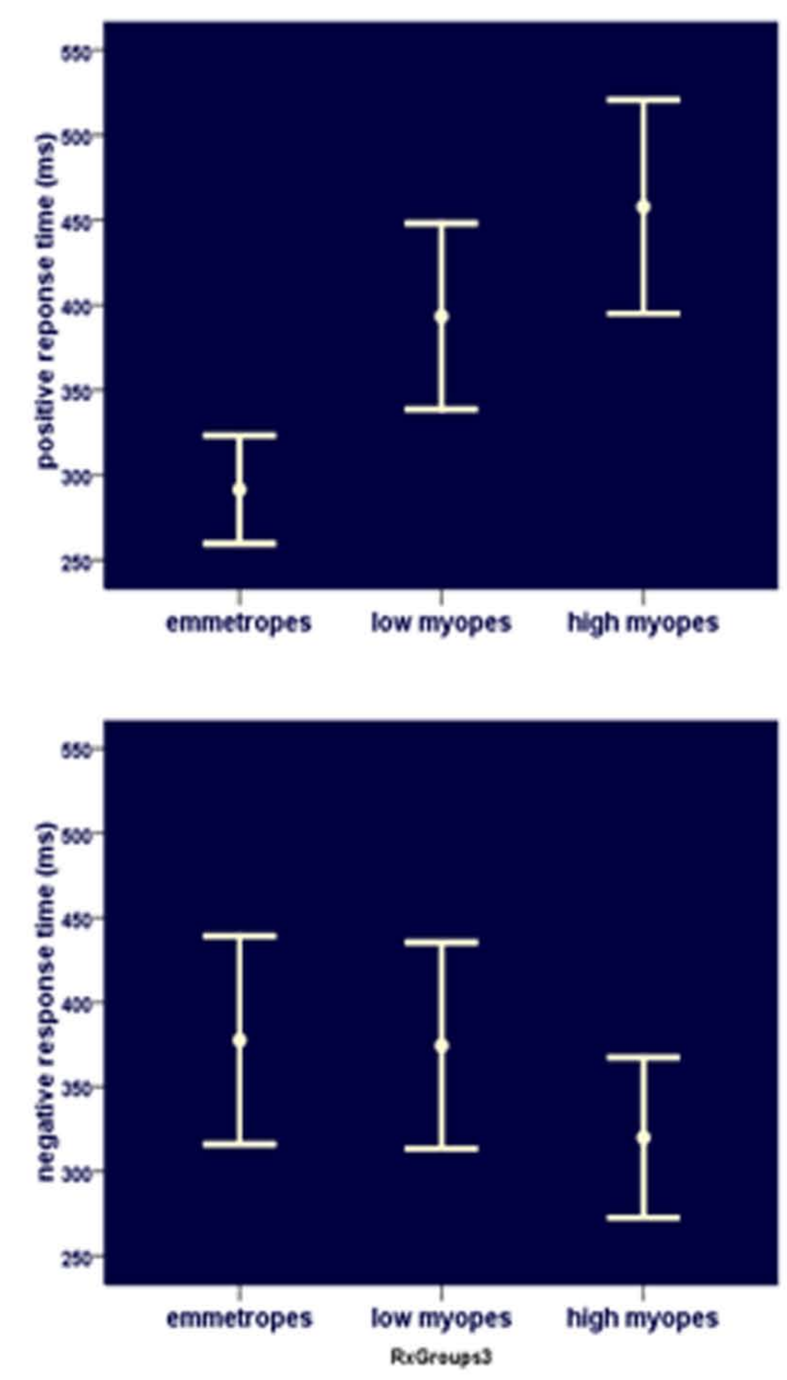
Accommodation response times (start to end of change in accommodation response), magnitude of the accommodation response change and fluctuations in the accommodation response were assessed for inward (increasing accommodation) and outward (decreasing accommodation) steps.

**Figure 1**. Sample accommodation response trace. The start and end of the change in response was identified using an algorithm by Kasthurirangan *et al.* (2003). Magnitude of accommodation change was the difference in mean response between far and near targets.



***Results***: Accommodation micro-fluctuations were higher for near than distance and more variable for near viewing for all groups. Fluctuations were significantly higher in the myopic groups than emmetropes ($p$<0.05) for distance and near viewing.

**Figure 2**. Response times in myopes and emmetropes




Positive accommodation response times (inward) were significantly longer in both myopic groups than emmetropes (ANOVA: p<0.0001) but negative response times (outward) were not (p=0.334).

There was no significant effect of target spatial content on the duration of the accommodation response when tested in free-space. Positive response times were significantly longer in myopes for each band passed filtered target.

Accommodation response magnitude was also not influenced by target in this free-space environment.

***Conclusions:***

- Slow accommodative dynamics in myopes to blur only has been thought to relate to poorer blur sensitivity in myopes.
- In this experimental set-up where proximal cues were also available, accommodation response dynamics and response magnitude were not influenced by the spatial content of the destination target, although responses were slower in myopes than emmetropes.
- This suggests that proximal cues rather than blur cues are used in free space to drive the initial accommodation response where large step accommodation changes are made.
- Accommodation micro-fluctuations are thought to be involved in the feedback mechanisms of accommodation to respond to changes in blur but these may be influenced by the target spatial content more so where smaller changes in accommodation are required.

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# Peripheral Refraction along Horizontal, Vertical and Oblique Meridians in Emmetropes and Myopes

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## PURPOSE

To investigate the changes in peripheral refractive error across four major meridians in myopes and emmetropes.

## INTRODUCTION

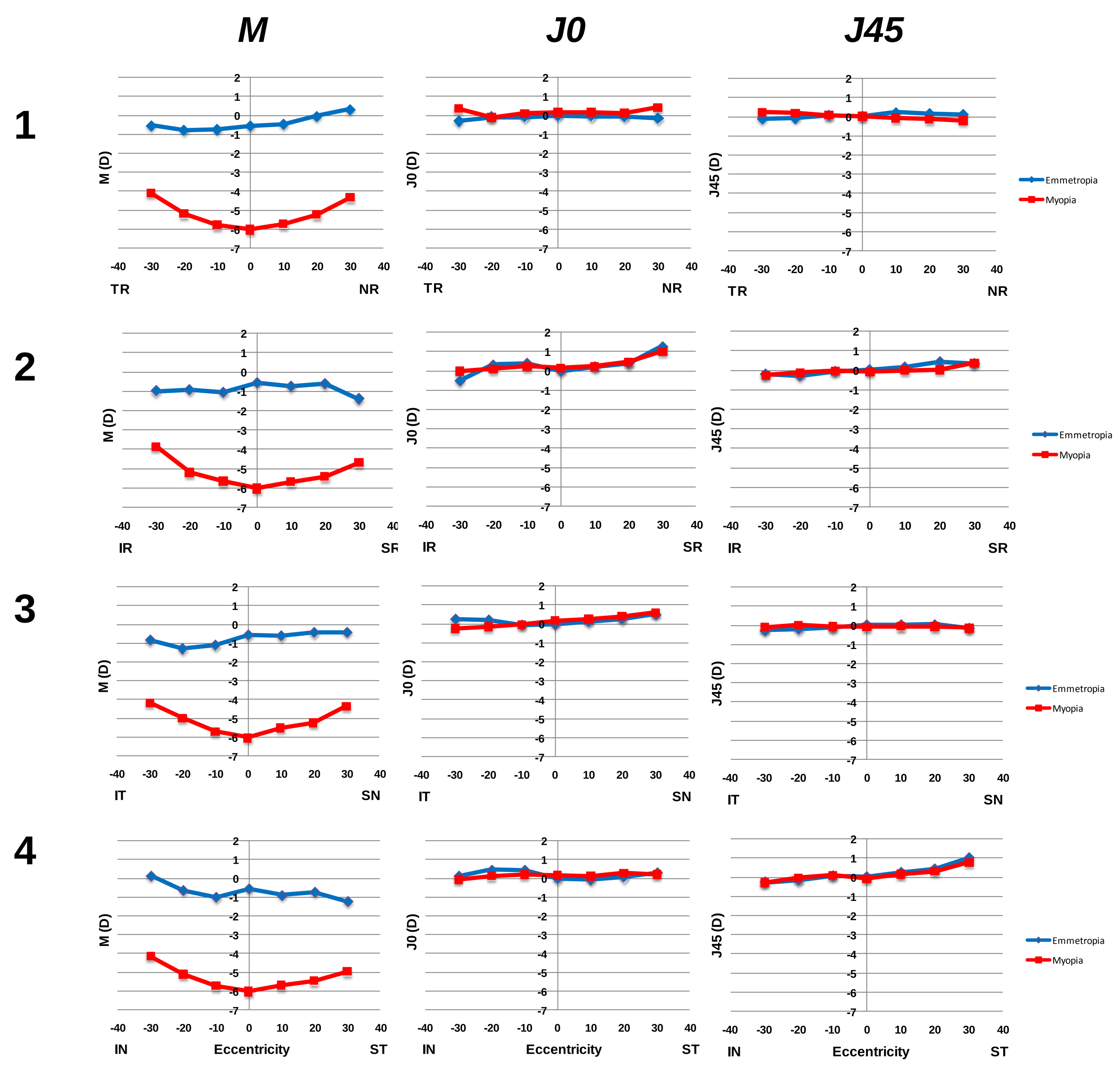
- It has been hypothesized that hyperopic blur in the retinal periphery in myopic eye degrades the quality of retinal images and might promote central myopia as shown in animal studies[1].
- Several studies have reported differences in the peripheral refraction patterns of emmetropes and myopes. Emmetropes usually have relative myopic shifts into the periphery, while myopes usually have relative hypermetropic shifts[2].
- Most of the studies investigated refraction changes only along the horizontal meridian, with some reporting on the vertical meridian also[2].

## METHODS

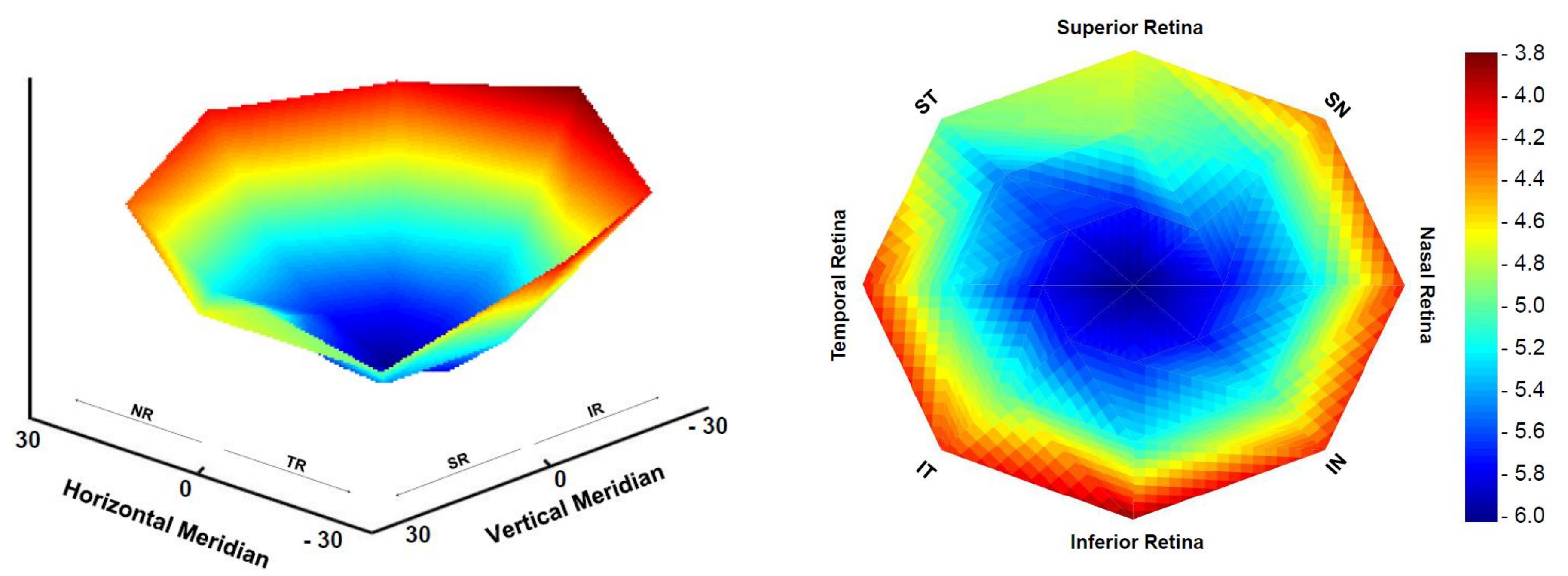
- 20 myopic (-3.00 to -9.00 D) and 20 emmetropic (+0.75 to -0.25 D) visually normal subjects were recruited.
- Participants with >0.50 D of astigmatism, measured by subjective refraction, or with a corrected visual acuity poorer than 6/6 in the test eye were excluded.
- Peripheral refraction was measured in the right eye at ±30˚, ±20°, ±10°, 0˚ along the horizontal, vertical and two oblique meridians (IT-SN, IN-ST) using a Shin-Nippon NVision-K 5001 autorefractor.
- A device was designed to mount and rotate a beam splitter and badal optometer, in front of the eye, so that subjects could view a cross target at optical infinity in the desired locations.
- Using vector analysis[3], we investigated the peripheral refraction profile differences in 4 meridians in 2 major refractive groups. (Figures 1-4)
  - $M = S + C/2$ $J180 = -C\cos(2\theta)/2$ $J45 = -C\sin(2\theta)/2$

## RESULTS

- Consistent with previous studies, our results showed that subjects with central myopia exhibited less myopic peripheral spherical values in all meridians.
- The area between ST and SN was identified as the most myopic region, and the Inferior retina was the least myopic region across all myopic participants. (Figures 5a-5b)
- Subjects who were emmetropic centrally often showed little difference between the central and peripheral refractive error with considerable inter-individual variation.
- Our results showed a steady increase in astigmatism with increasing eccentricity in all meridians. The average amount of astigmatism was the same between refractive groups (P = 0.64) and increased from 0 DC at the centre to about 5 DC at 30° eccentricities in all meridians.




Figures 1-4: Mean spherical equivalent refraction *M*, *J0* (90°_ 180° astigmatism) and *J45* (45°_135° astigmatism) as a function of eccentricity for emmetropes and myopes in horizontal (1), vertical (2), along IT-SN (3) and along IN-ST (4) meridians.




5a 5b

- Figure 5: 3D graphs of mean spherical equivalent up to 30 degree eccentricity with 10 degree steps along 4 major meridians for all myopic participants.

### Asymmetry in peripheral refraction:

- For mean spherical equivalent, there were asymmetrical differences in horizontal (nasal more myopic), vertical (superior more myopic) and oblique meridians ( SN and ST as more myopic regions).
- As for *M*, there was inferior-superior asymmetry for 90°–180° astigmatism ($J_0$) in which changes in refraction into the peripheral location were generally greater for the superior than the inferior for both groups.

## CONCLUSION

Peripheral refraction data from oblique meridians were found to be consistent with the well-established prolate elliptical and spherical globe shapes found in myopic and emmetropic eyes respectively.

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# Peripheral aberrations in myopia

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## Background & Aim

Peripheral image quality may influence ocular growth and thus affect development and progression of myopia. Most previous studies have been restricted to the horizontal visual field or to a few positions in the peripheral visual field. We measured higher-order aberrations across the central 42° x 32° of visual field in emmetropes and myopes.

## Methods

- Participants – 10 emmetropic (MSE: 0.1 ± 0.5 D) and 9 myopic (MSE: -3.7 ± 1.9 D) young adults.
- Corneal topography measured using Medmont corneal topographer.
- Peripheral aberrations measured using modified Hartmann-Shack aberrometer (Figure 1) for 5 mm pupil at 555 nm for each target point, taking into account the elliptical shape of the off-axis pupil.

## Results

- Along the horizontal field meridian, spherical equivalent refraction relative to the centre of the field (*RPRE*) showed hypermetropic shifts in at least along one semi-meridian in 5 of the 9 myopes.
- Across the field, *RPRE* showed negative shifts in the periphery for both groups (Figure 2). Both the groups exhibited similar patterns of astigmatic components $J_{45}$ and $J_{180}$ (Figure 2).
- Mean spherical aberration (Figure 3) across the field was significantly lower for myopes (-0.007 ± 0.045 µm) than for emmetropes (+0.023 ± 0.043 µm).
- Coma (Figures 3, 4) – increased at a higher rate across the field for myopes (-0.014 ± 0.007 µm/deg) than for emmetropes (-0.006 ± 0.002 µm/deg).
- Myopes (Figure 5) had smaller corneal radii of curvature (R: 7.65 ± 0.21 mm) and more negative asphericities (Q: -0.16 ± 0.09) than the emmetropes (R: 7.73 ± 0.26 mm, Q: -0.08 ± 0.04).
- Theoretical out-of-eye ray tracing using the Liou and Brennan model eye with 0.0 D and -4.0 D spherical refractive error was performed (Figure 6). The majority of the differences in coma between the 2 groups can be explained by differences in anterior corneal shape and axial length between the 2 groups. However, modeling could not explain differences in spherical aberration, presumably because of some lenticular factors which may play a role. (Figure 6).

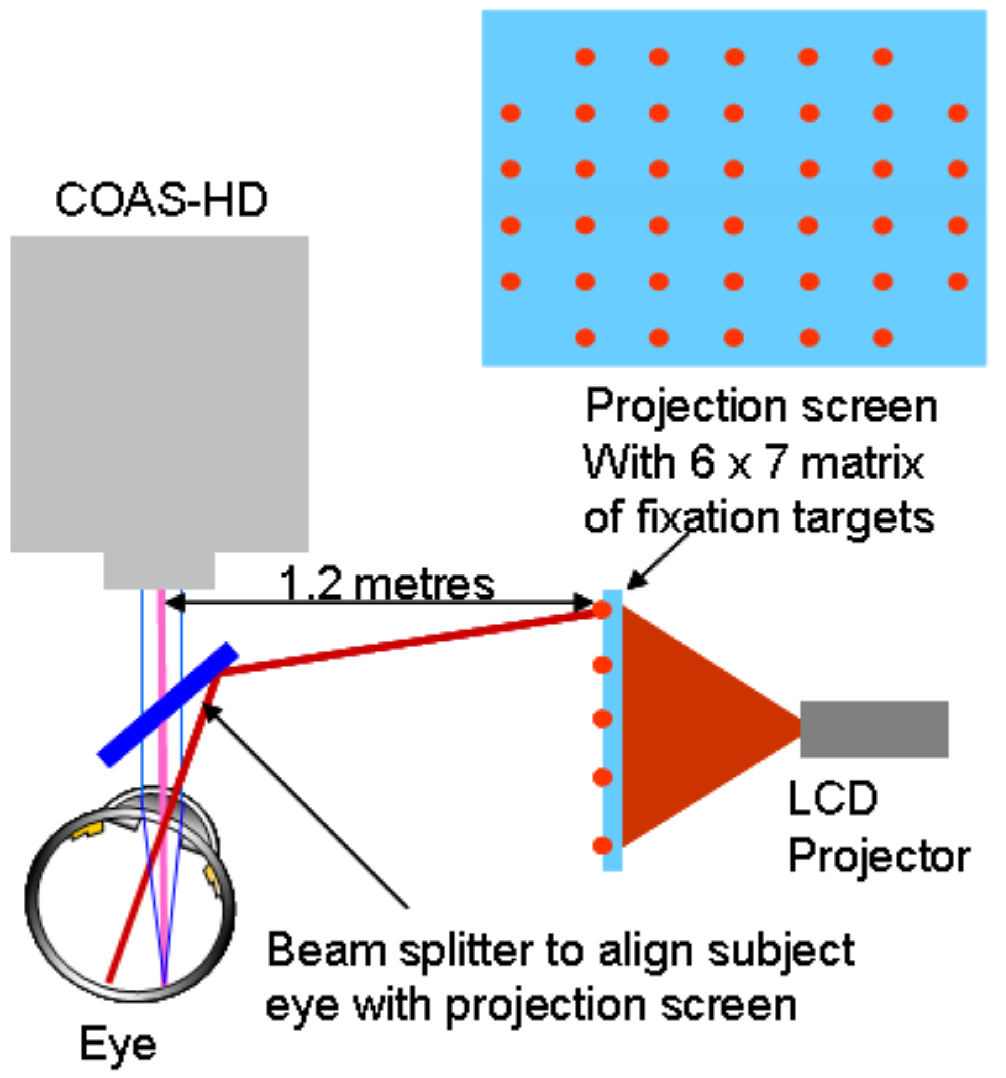


Figure 1. Setup for measuring peripheral aberrations. The eye looked through a beam splitter at a target eccentric to the instrument axis. Targets were arranged in a 6 x 7 matrix covering 42°x 32° of visual field.

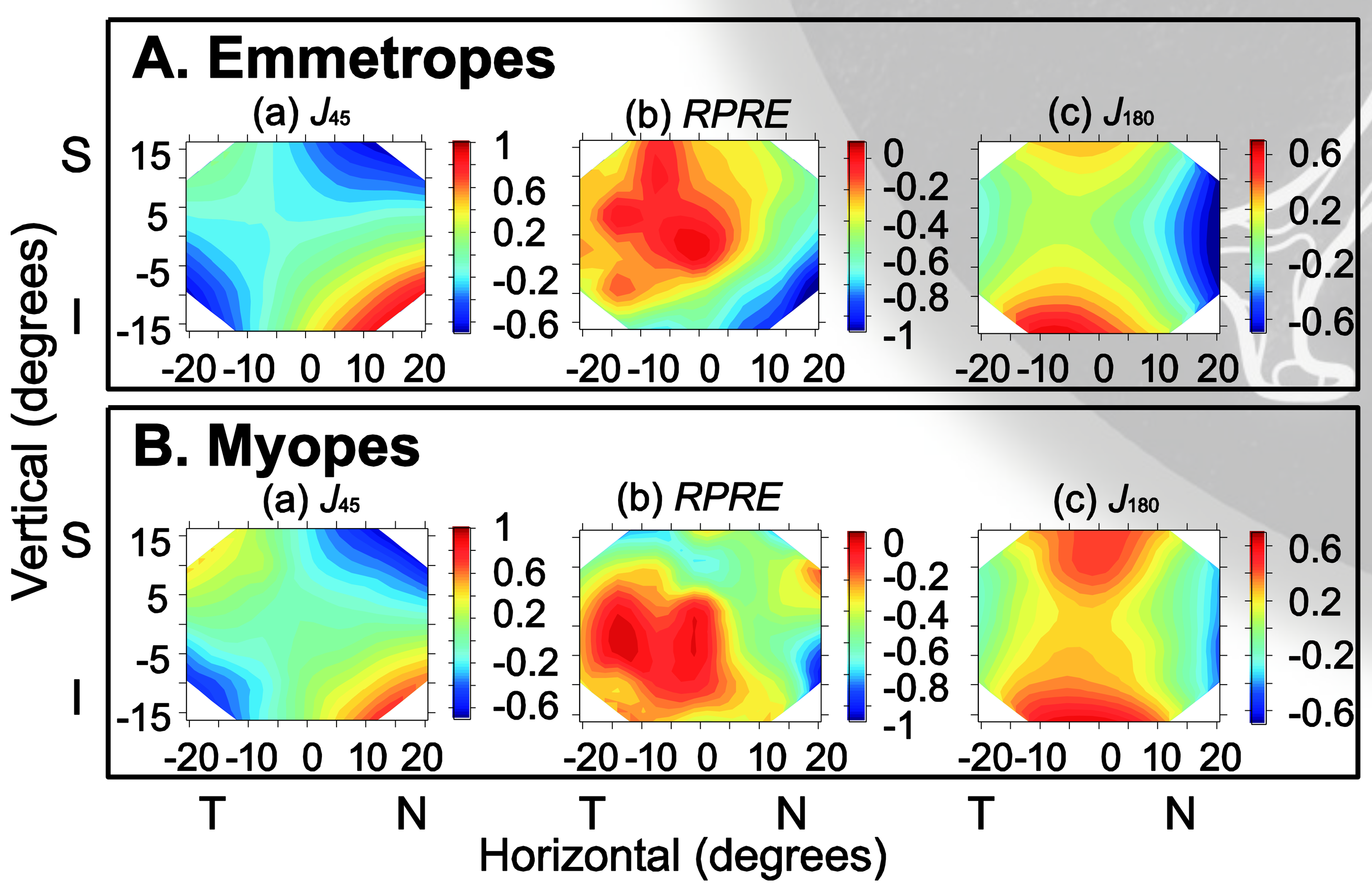


Figure 2. Mean refractive components (a) oblique astigmatism $J_{45}$, (b) spherical equivalent *M* and (c) with/against the rule astigmatism $J_{180}$ in A) young emmetropes and B) young myopes. The spherical equivalent *M* across the field for any group is relative to the mean axial spherical equivalent for that group (i.e. the *RPRE* is plotted). The color scales represent the magnitude of each refractive component in dioptres and are same for a given refractive component in panels A and B. S, I, N and T represent superior, inferior, nasal and temporal visual fields, respectively.

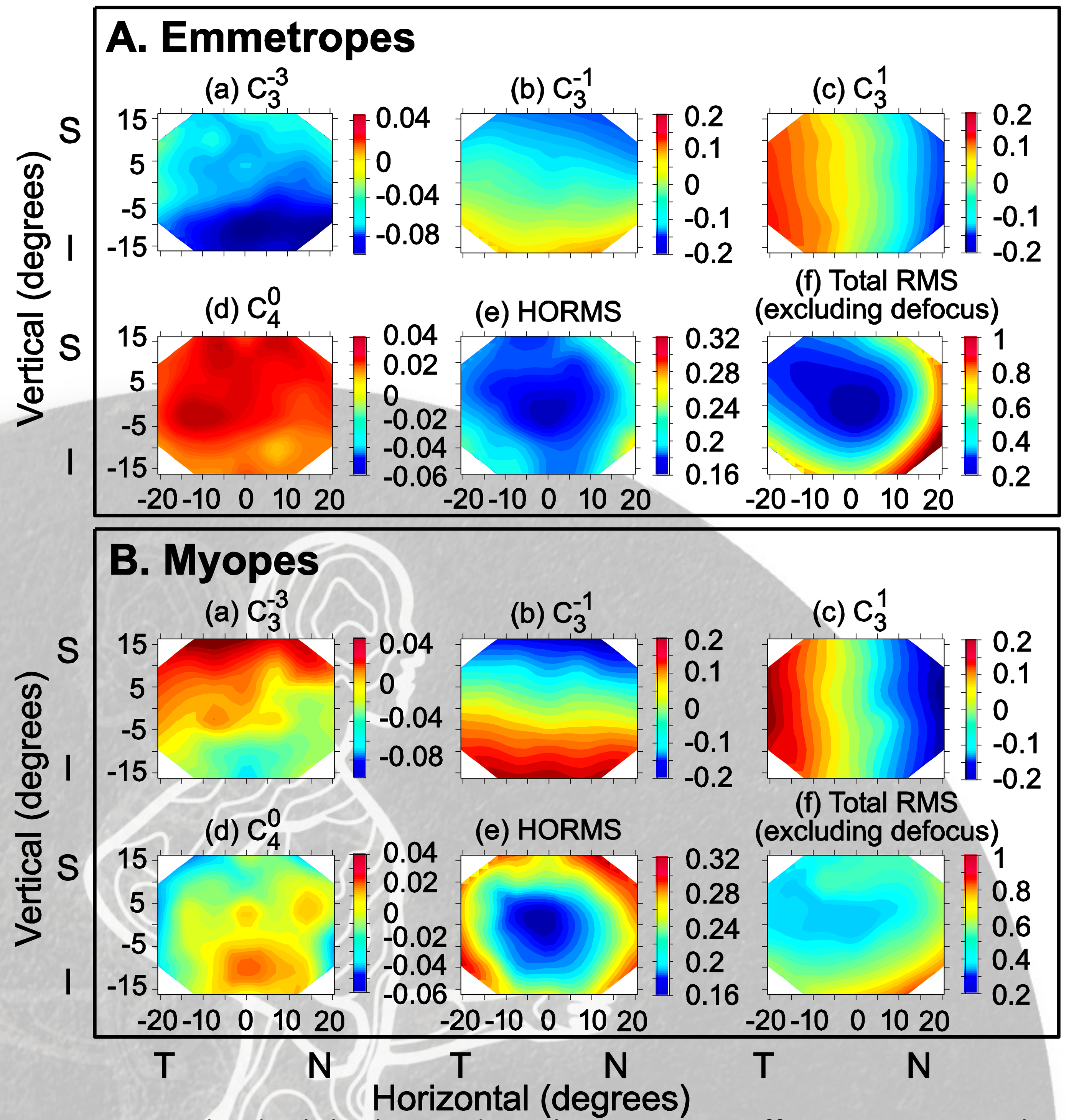


Figure 3. Individual higher-order aberration coefficients across the visual field for A) young emmetropes and B) young myopes. (a) trefoil coefficient C(3, -3), (b) vertical coma coefficient C(3, -1), (c) horizontal coma coefficient C(3, 1), (d) spherical aberration coefficient C(4, 0), (e) higher-order root-mean-squared aberration (*HORMS*) and (f) total root-mean-squared aberration (*Total RMS*). The scale for any co-efficient is the same for both emmetropes and myopes. N, T, S and I represent nasal, temporal, superior and inferior visual fields, respectively.

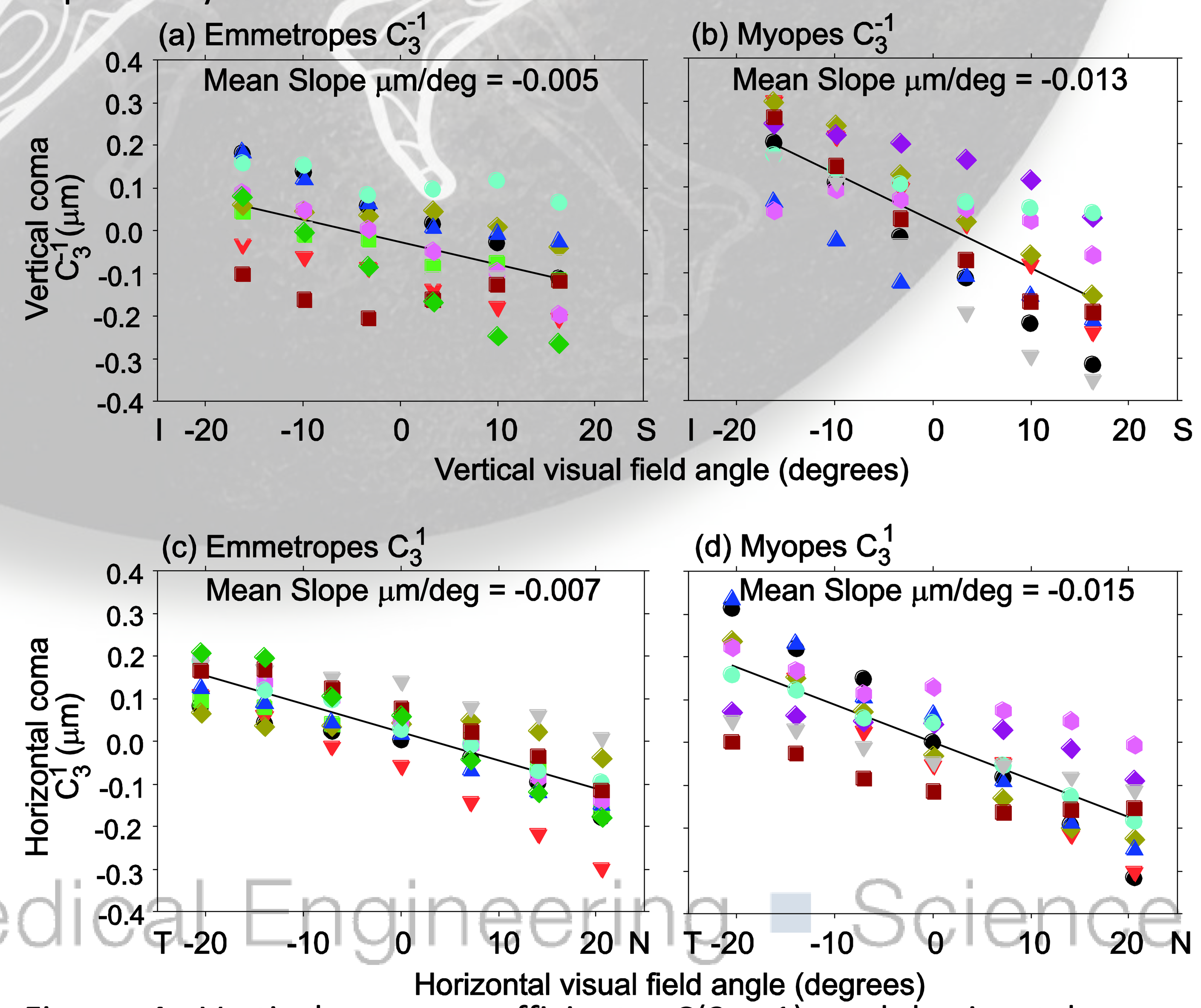


Figure 4. Vertical coma coefficient C(3, -1) and horizontal coma coefficients C(3, 1) along vertical (a, b) and horizontal (c, d) visual field meridians, respectively, for emmetropes and myopes. Different symbols represent different subjects.

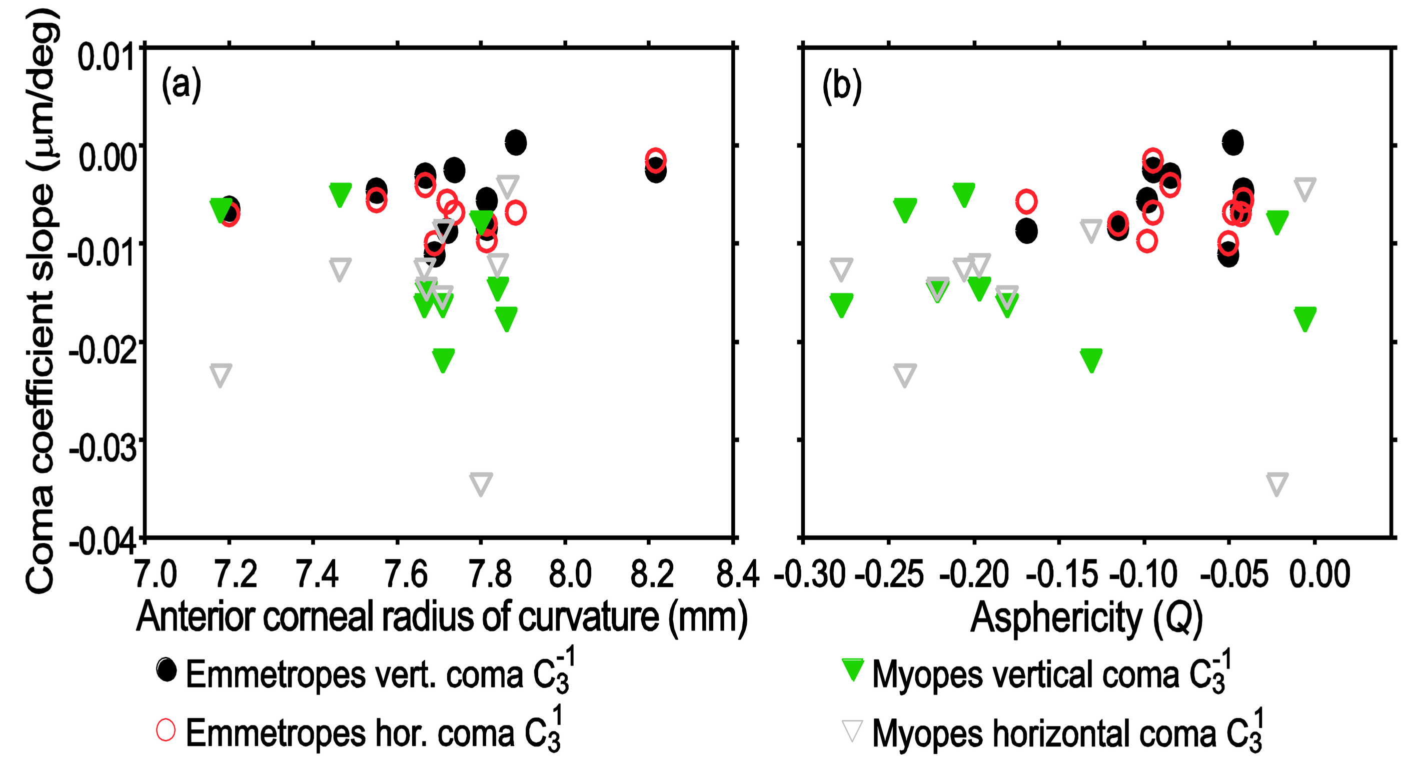


Figure 5. Vertical coma coefficient and horizontal coma coefficient slopes (µm/deg for a 5 mm pupil) as a function of (a) anterior corneal radius of curvature and (b) corneal asphericity for emmetropes and myopes.

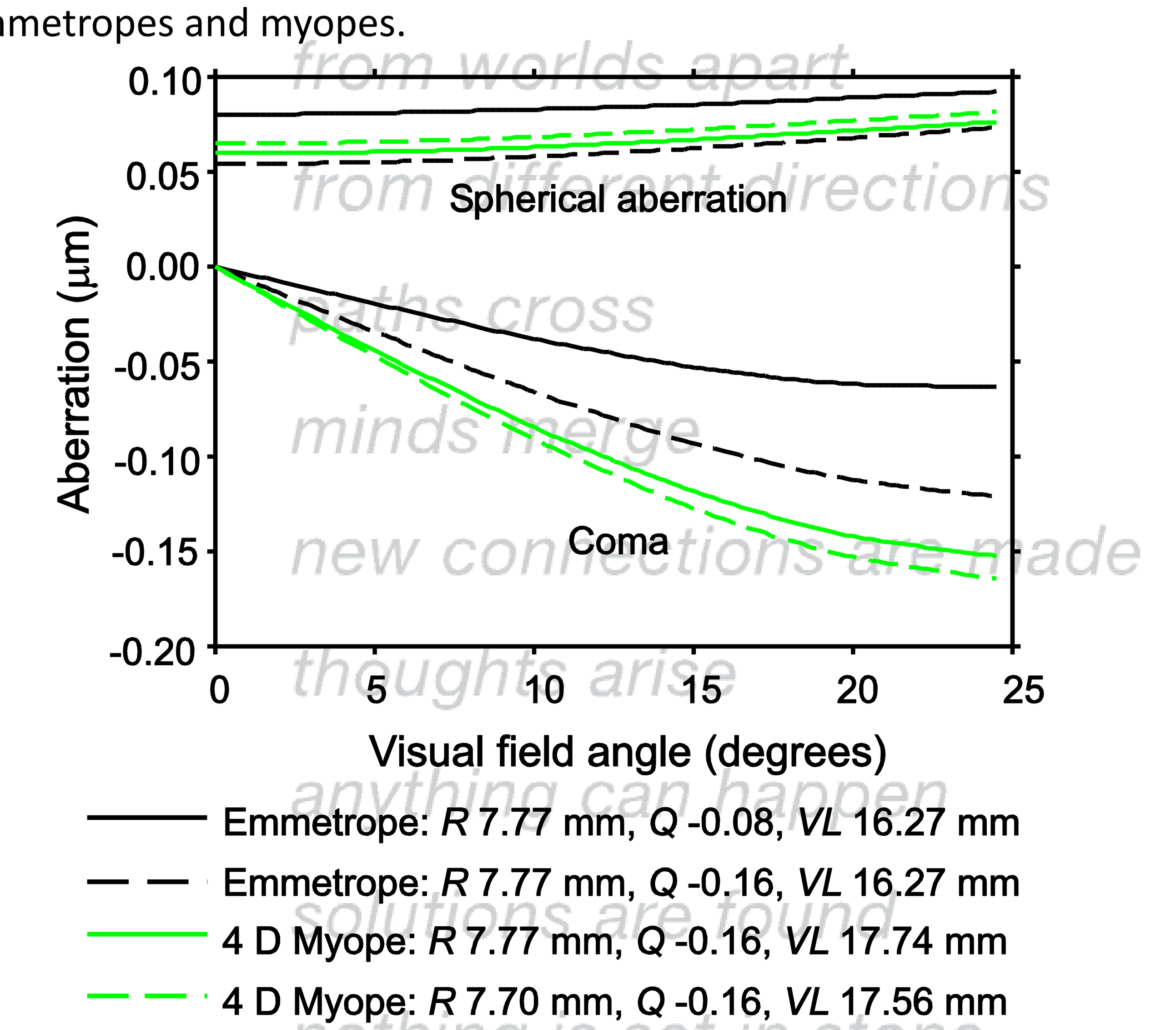


Figure 6. Theoretical effects of changes in anterior corneal asphericity, vitreous length, and anterior corneal radius of curvature on coma and spherical aberration (SA). *R, Q* and VL represent anterior corneal radius of curvature, corneal asphericity and vitreous length, respectively.

## Conclusion

*RPRE* was similar for both the groups across the field, with mean *RPRE* being myopic, although there was substantial variation in different semi-meridians and between subjects. Peripheral higher-order ocular aberrations, especially coma and spherical aberration, differed considerably between the two groups. The linear rate of increase in coma with field angle was higher in myopes than in emmetropes. Spherical aberration varied little across the field and exhibited negative shift across the field with myopia. In general, however, the magnitude of the higher-order aberrations was always small compared with that of second-order aberrations.