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Is an objective refraction optimised using the visual Strehl ratio better than a subjective refraction?

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Abstract

Purpose—To prospectively examine whether using the visual image quality metric, visual Strehl (VSX), to optimise objective refraction from wavefront error measurements can provide equivalent or better visual performance than subjective refraction and which refraction is preferred in free viewing.

Methods—Subjective refractions and wavefront aberrations were measured on 40 visually-normal eyes of 20 subjects, through natural and dilated pupils. For each eye a sphere, cylinder, and axis prescription was also objectively determined that optimised visual image quality (VSX) for the measured wavefront error. High contrast (HC) and low contrast (LC) logMAR visual acuity (VA) and short-term monocular distance vision preference were recorded and compared between the VSX-objective and subjective prescriptions both undilated and dilated.

Results—For 36 myopic eyes, clinically equivalent (and not statistically different) HC VA was provided with both the objective and subjective refractions (undilated mean $\pm$ SD was -0.06 ± 0.04 with both refractions; dilated was -0.05 ± 0.04 with the objective, and -0.05 ± 0.05 with the subjective refraction). LC logMAR VA provided by the objective refraction was also clinically equivalent and not statistically different to that provided by the subjective refraction through both natural and dilated pupils for myopic eyes. In free viewing the objective prescription was preferred over the subjective by 72% of myopic eyes when not dilated. For four habitually undercorrected high hyperopic eyes, the VSX-objective refraction was more positive in spherical power and VA poorer than with the subjective refraction.

Conclusions—A method of simultaneously optimising sphere, cylinder, and axis from wavefront error measurements, using the visual image quality metric VSX, is described. In myopic subjects, visual performance, as measured by HC and LC VA, with this VSX-objective refraction was found equivalent to that provided by subjective refraction, and was typically preferred over subjective refraction. Subjective refraction was preferred by habitually undercorrected hyperopic eyes.

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Disclosure

The University of Houston, along with the Indiana University and the University of Rochester have patented a number of retinal image quality metrics on which RAA is listed as an inventor. The University of Houston and Indiana University have patented the use of retinal image quality metrics for objectively determining refractions on which RAA is listed as an inventor.

Keywords

image quality metrics; wavefront error; objective refraction; visual acuity; visual Strehl (VSX)

Introduction

Here we assert that an ideal objective refraction should result in a prescription that provides an individual observer with equivalent or better visual acuity (VA) than a subjective refraction and, when free viewing the world, the observer evaluates their view of the world as equal or preferable to that provided by the subjective refraction.

To achieve such a goal the objective refraction needs to respect the fact that the visual system has two key components: the optics that form the retinal image and the neural processing that transforms the retinal image into a visual percept.

Subjective refraction has historically been unique among methods of refraction in considering both components by asking the observer to choose between a series of two lens options; the goal being to optimise VA while the eye is refracted to the hyperfocal distance. However, the clinical subjective refraction is a variable process^{1–4} for a variety of reasons including adaptation to a prior prescription as well as examiner prompting and the patient's interpretation of the given choices. These problems are compounded when conducting studies across different subjects and refractionists.

Most objective methods of refraction evaluate the optical component of the visual system to determine a sphere, cylinder, and axis (SCA) prescription. Although wavefront sensors provide the most comprehensive descriptions of the eye's optics and have been found more precise than subjective refraction,⁴ on their own they do not consider the neural processing component. However, by utilising visual image quality metrics, an estimate of the neural processing component can be incorporated with the optical component for the objective determination of ocular prescriptions. (To differentiate these metrics from those that quantify retinal image quality alone, the term *visual image quality* was coined to indicate inclusion of neural processing.)⁵

One visual image quality metric, called the visual Strehl ratio (VSX), has been shown to be predictive of subjective best focus^{5,6} and well correlated with change in visual performance as measured by VA^{7–9} independent of pupil size and underlying wavefront error (WFE).⁹ Based on these prior studies^{7–10} and capitalizing on the precision of wavefront sensing^{4,11} we expect VSX will be useful in identifying a refraction that provides equivalent if not better VA than a subjective refraction and an equal or preferable percept when viewing the world. Furthermore, given the clinical wisdom that patients can and do adapt to new prescriptions (particularly when the changes are relatively small), such objective methods of refraction would not be influenced by factors that can skew subjective refraction, such as adaptation to a habitual prescription.¹²

Numerous studies^{5,6,13–17} have processed wavefront error measurements using image quality metric methodologies (both metrics of visual image quality and retinal image

quality) to identify a SCA prescription. In contrast to methods that use only second-order^{18,19} or other specific Zernike terms such as primary spherical aberration and coma,^{5,20–22} metric-based methods consider the combination²³ of all aberrations in the eye when optimising retinal image quality.^{5,13,16}

Unfortunately, most previous works using WFE data have generally been limited to the difference between the dioptric powers of the wavefront and subjective refractions (generally comparing the spherical equivalents of the refractions, and many were retrospective). As a result, any comparison of the relative visual performance of these prescriptions has hitherto needed to be loosely inferred from the dioptric difference (typically in power vector²⁴ space). This is unfortunate because visual acuity is the outcome measure of subjective refraction. It is also problematic because dioptric spaces are not visually uniform spaces, that is, aberrations can interact differently to increase or decrease retinal image quality.^{23,25,26} To the best of our knowledge, a prospective and double-blind comparison of visual performance of individual normal eyes with wavefront refraction and subjective refraction remains unreported (although Jinabhai *et al.*²² apparently measured VA through both such prescriptions in normal control eyes, they did not report it). Furthermore, subjects' preferences between the two types of refraction remain unreported.

Therefore here, we sought to prospectively and in a double-blind manner examine (1) whether using the visual image quality metric VSX to optimise objective refraction from a wavefront error measurement could provide VA (the outcome measure of subjective refraction) that is equivalent, or better than, traditional gold standard subjective refraction and (2) which refraction the observer preferred for both natural and dilated pupil conditions.

Methods

Prior to data collection, the nature and possible consequences of the study were explained to each subject. University of Houston Institutional Review Board-approved informed consent was signed by each subject, and the research followed the tenets of the Declaration of Helsinki.

Forty visually-normal eyes (of 20 subjects) with well-correctable vision were examined. All subjects were recruited from the University of Houston, College of Optometry; mean age $\pm$ standard deviation (SD) was 26.4 ± 4.8 years, and all had a habitual refractive prescription of greater than 1 D (range was +7.00 to -7.00 D sphere and 0.00 to -1.75 D cylinder).

Uncorrected wavefront error measurements were collected first through each eye's natural pupil in mesopic conditions (COAS HD, <http://abbottmedicaloptics.com>): A minimum of four measurements were recorded (described up to the 10th Zernike radial order and corrected for longitudinal chromatic aberration) of which three were selected that had the maximum number of spots, smallest central reflection, and no clipping of image by lashes. The coefficients of the three measurements were mathematically averaged (for the largest common pupil size) to define the WFE for each eye, which in turn was used to determine the optimised refraction (as described below). Directly thereafter, subjective refraction was performed using a phoropter by one of two experienced clinicians, starting from an

autorefractor output; sphere and cylinder were adjusted in 0.25 D steps and axis was resolved to the nearest degree (astigmatic components were determined with Jackson crossed-cylinders). According to the prescribed clinical convention, the endpoint of subjective refraction was the maximum plus that retained best VA (a hyperfocal refraction). As is the clinical custom (and consistent with conditions under which WFEs were measured) subjective refractions were conducted in a dark room and no attempt was made to fix natural pupil diameters.

High contrast (HC; –100% Weber contrast) and low contrast (LC; –25% Weber contrast) VA were measured monocularly with each of the two prescriptions (VSX-objective and subjective) in trial frames positioned at a 12 mm vertex distance. Twelve different ETDRS (logMAR) charts were generated using Visual Optics Laboratory Professional software (version 7.4, Sarver and Associates Inc.) and presented on a high resolution LCD monitor (M253i2, <https://www.totoku.com>) at a luminance of 380 cd/m². Three charts of each contrast were randomly selected and read monocularly with each prescription and the average of the three acuities was taken as the VA for that eye and condition. Letter-by-letter scoring²⁷ was performed where 0.02 logMAR credit was given for every letter read correctly, and subjects read until they had accrued five missed letters.²⁸ After HC and LC VAs were recorded for each prescription, each subject was asked to monocularly view a distant natural scene (out of a hallway window) and to evaluate whether they could appreciate any difference between the two prescriptions and, if so, to rate how strongly they preferred one over the other on a seven-point Likert scale. During the acuity measurements as well as during the short-term preference evaluation, the investigator and the subject were masked as to which prescription was the objective and which was the subjective. The prescription with which each subject viewed first and second was randomised.

When each subject had completed all of the abovementioned measurements, pupils were dilated with 1 drop of tropicamide 1% and, when the iris had been rendered unresponsive to light (typically after 20 minutes), the entire protocol was repeated.

Optimisation method for objective refraction

The method employed identified the SCA combination (sphere and cylinder to the nearest 0.25 D, and axis in 2° increments) that provided the best image quality (VSX) for the measured WFE by performing a simulated through-focus experiment.^{5,15,16} All calculations were performed using custom Matlab software (<https://www.mathworks.com>). A range of dioptric powers was selected over which visual image quality would be evaluated; this consisted of the 15142 SCA combinations between +3.00 and –2.00 D sphere (in 0.25 D steps) and 0 to –2.00 D cylinder (in 0.25 D steps at 2° axis steps). Previous modelling²⁹ demonstrated this range to be appropriate for visually-normal eyes. Because subjects' refractive errors varied, the range of applied powers was displaced and centred on the dioptric equivalent of the Zernike defocus term for each subject. For instance, for a –5.00 D myopic subject, the range of applied SCA powers ranged from –2.00 D to –7.00 D sphere and 0 to –2.00 cylinder. These SCA combinations were propagated from a 12 mm vertex distance back to the pupil plane^{30,31}, mathematically converted into Zernike terms,^{24,32} and each added individually to the uncorrected second-order Zernike terms of the WFE thereby

generating 15142 “corrected” WFEs. VSX was calculated (using equation A23 from Thibos *et al.*⁵ included below) for each of the “corrected” WFEs and the SCA combination that corresponded to the greatest VSX value was identified as providing best visual image quality and was selected as the objective prescription. Briefly, VSX is calculated⁵ by comparing the point-spread function (PSF) of the eye with the diffraction-limited PSF for the same pupil size, where both PSFs are weighted by the inverse Fourier transform of the neural contrast sensitivity function determined with interference fringes.³³

$$VSX = \frac{\int_{psf} PSF(x, y) N(x, y) dx dy}{\int_{psf} PSF_{DL}(x, y) N(x, y) dx dy}$$

Results

Results are presented and discussed separately for myopic and hyperopic eyes. All standard deviations were calculated using ANOVA and components of variance analyses to account for the dependence of right and left eyes.^{34,35} Similarly, p-values were calculated using split-plot ANOVAs.^{34,35}

Myopic Eyes

Visual Acuity—Figures 1 and 2 show scatter plots and limits of agreement plots that compare the HC logMAR VA recorded with the VSX-objective prescription to that recorded with the subjective refraction.

Figure 1 (A) and (B) correspond to typical clinical conditions (that is, HC measures of VA through natural (undilated) pupils) and show that for almost all myopic eyes the VSX objective refraction provided VA that was clinically and statistically equivalent to that provided by subjective refraction. The actual HC undilated VAs of myopic subjects with the objective prescription were all around 20/20 (0.00 logMAR) or better (mean -0.06 ± 0.04), as can be seen in Figure 1(A). There was no significant difference in HC VA ($p=0.67$) with the two refractions (mean difference 0.00 ± 0.04). The strong agreement between the VAs recorded with the two prescriptions can also be seen in (B) where mean difference is plotted as the middle blue line and is less than one letter.

When dilated (therefore all measurements were through identical fixed pupils for each subject), myopic subjects also achieved good HC VA with the objective prescription (mean -0.05 ± 0.05) and there was no significant difference ($p=0.99$) between the HC VA with the subjective and objective refractions (mean difference 0.00 ± 0.04), as can be seen in Figure 2.

The LC logMAR VA data are presented in Table 1. Through both natural and dilated pupils, the LC VA with the two prescriptions were not significantly different (mean difference undilated -0.02 ± 0.07 and dilated -0.01 ± 0.06).

Short-Term Preference—Figure 3 illustrates the short-term distance vision preference between the two prescriptions for myopic eyes. When viewing through natural pupils (A) 72% of myopic eyes preferred the objective prescription. When dilated (B), 47% of eyes

preferred the objective prescription, 16% judged them to be equivalent, and 36% preferred the subjective.

Hyperopic Eyes

Visual Acuity and Short-Term Preference—We report the hyperopic eyes because the result was fundamentally different than for myopic eyes, even though the number of eyes studied is too small for meaningful statistical analysis. Four habitually undercorrected high hyperopic eyes were examined – one subject's habitual spectacle prescription was R: +7.25 D, L: +5.75 D, while the other subject's was approximately +3.00D in both eyes. The objective refraction generally did not provide equivalent VA to the subjective refraction. All four high hyperopic eyes preferred the subjective refraction over the objective when undilated and dilated.

Discussion

We sought to examine whether using the visual image quality metric VSX to optimise objective refraction from a wavefront error measurement could provide visual performance equivalent, or better than, traditional subjective refraction. Visual acuity was selected as the primary measure for this comparison because it is the most common outcome measure of refraction and is what subjective refraction is intended to optimise. Numerous studies have evaluated the test-retest variability of HC logMAR VA; the average SD of six studies summarised by Raasch *et al.*³⁶ was ± 2.56 letters (± 0.05 logMAR); while that of another five adult studies compared by Manny *et al.*³⁷ was ± 3.97 letters (± 0.08 logMAR). Typical statistical practice defines a 95% confidence interval as ± 2 SD (approximately one line of logMAR VA). Here we elected a stricter criterion and defined *clinically* equivalent HC logMAR VA as differences less than ± 2.5 letters (± 0.05 logMAR).

Hyperopic Eyes

The VSX-objective prescription did not provide equivalent or better VA than subjective refraction for the two habitually undercorrected high hyperopic subjects examined. For both hyperopic subjects, the wavefront sensor measured higher levels of hyperopia than the subjective refraction (and the habitual prescription); however, the astigmatism components were very similar across the two refractions. When not dilated, the VSX-objective prescription was over 1.00 D more positive in spherical power than the subjective, for three of the four eyes. Despite accommodation being largely relaxed when dilated, the difference for three of the four hyperopic eyes was still over 0.75 D, with the objective being more positive than the subjective. Although four high hyperopic eyes is a limited sample size from which to form conclusions we believe, that being young and habituated to a constant level of accommodation (one subject had even functioned unaided until high school), these subjects did not relax their tonic level of accommodation during the ~20 minutes of VA and preference testing and, consequently, performed poorly with the much the more positive objective prescription.

Tonic accommodation as a result of habitually undercorrected hyperopia remains a challenge for objective and subjective methods of refraction, and care needs to be taken when

examining hyperopic subjects particularly in rare cases of hyperopia as high as those examined here. Most other studies of metric-based refraction have either examined only myopic subjects^{13,14} or mild hyperopic subjects with spherical equivalent^{15,17} or spherical power¹⁶ of +1.75 D or less. The rarity of such high hyperopic subjects means that they form a small proportion of clinical cases and also limits the extent to which this finding can be explored at this time.

Myopic Eyes

The VSX-objectively determined prescription met the ± 2.5 letters visual performance hypothesis of being equivalent to the subjective refraction in nearly all myopic eyes, both through natural pupils and when dilated. Figure 5 shows the number of myopic eyes that were within the ± 2.5 letters SD reported by Raasch *et al.*,³⁶ as well as the number of eyes that performed better with either of the refractions. These findings demonstrate that equivalent visual performance can be objectively provided for myopic eyes from either dilated or undilated WFE measurements by using VSX as a refraction optimization metric even though pupil diameter might vary when undilated as it would in clinical practice.

While VA was clinically and statistically equivalent for myopic eyes, both through natural pupils and when dilated, in both conditions the majority of these eyes preferred the objective prescription over the subjective in a short-term comparison. This finding is consistent with the observation³⁸ that a just noticeable difference in blur can be perceived well before a change in VA occurs. These preference data suggest that subjects were able to discern a noticeable difference in image quality with the objective refraction and expressed it in their preference. The difference in image quality ($\log VSX$) between the objective and subjective refractions was greater than the JND in perceived blur determined by Ravikumar *et al.*³⁸ for all 36 myopic eyes when not dilated, and for 32 of the 36 eyes when dilated.

The best VAs of the subjects examined here are on average a few letters worse than what has been reported for the same age group.³⁹ This is possibly due to our predominantly myopic sample and particularly the number of significantly myopic eyes;^{40–42} 10 eyes had ≥ 5 D of myopia.

Dioptric differences between the two refractions are included here for comparison with other studies, despite the many different metric^{5,13–17}, wavefront refraction^{18–22}, and subjective refraction¹⁷ methodologies used in the past. However, when stating dioptric values, bear in mind that while a particular VSX value quantifies visual image quality essentially independent of pupil size, a particular dioptric value does not, for instance, -1 D affects vision very differently when viewing through small and large pupils.^{43,44}

The objective and subjective refractions were converted from sphere, cylinder, and axis into power vectors²⁴ and the subjective refractions components were subtracted from the objective.

Astigmatism components have generally been found very similar between wavefront and subjective refractions^{5,14,16,20–22}, and that was also true here; the mean differences in the

astigmatic components (J_0 and J_{45}) were all less than one-tenth of a dioptre (as can be seen in Table 2).

Very few studies have performed undilated comparisons of the spherical equivalent (M) component of wavefront refractions. Using metrics Iskander¹⁶ found differences in M that ranged between -0.31 and -0.62 D, while, calculating refraction from coefficient terms, Zhu *et al.*²¹ found -0.39 D. The mean difference in M for undilated myopic eyes found here was -0.65 D (and for all eyes was -0.48 D). When dilated, that difference was more than halved, -0.26 D for myopic eyes (and -0.16 D for all eyes), which is consistent with other metric-based studies, such as Teel *et al.*¹⁷ who found -0.24 D, and Kilintari *et al.*¹⁴ where most differences ranged between -0.17 and -0.36 D; as well as other methods of wavefront refraction, such as Jinabhai *et al.*,²² where differences were around -0.19 D.

Because chromatic aberration was accounted for, and Kilintari *et al.*¹⁴ found very little improvement in the accuracy of wavefront refractions using polychromatic metrics rather than monochromatic or by accounting for the Stiles-Crawford effect, remaining explanations for the dioptric difference between wavefront and subjective refractions include: That the infrared (IR) light used in wavefront sensors reflects from structures deeper than the apertures of the photoreceptors⁴⁵ – this can only perhaps be mitigated by custom modification of an instrument.¹⁵ Accommodation during measurement (instrument myopia) could play a role when not dilated, however, the hyperopic subjects examined here evidently managed to relax their accommodation much more while being measured than when viewing a letter chart.

We believe the mantra of ending subjective refraction on the most positive prescription that does not reduce VA also contributes to this finding because, as pointed out by Thibos *et al.*,⁵ image quality metrics identify the centre of the depth of focus (maximum image quality) while subjective refraction finds the most positive end of the depth of focus.

Although maximising the usable range of depth of focus might be sound practice as patients approach presbyopia, the method used here provided equivalent VA to the subjective refraction in myopic eyes, and our short-term preference data (as described above) suggests that maximising visual image quality is preferred by younger eyes.

While this study supports the possibility of prescribing refraction directly from an objective measurement for myopic eyes, and may be particularly useful for patients that provide poor subjective refraction responses, there are some limitations to the study: A relatively small sample of 40 young eyes (20 individuals) was used; although the reduced accommodative ability associated with presbyopia would likely improve the accuracy and precision of objective refraction, this remains to be demonstrated. The technique was not evaluated on low hyperopic eyes. Currently, the objective refraction does not incorporate binocular balancing that might be necessitated by anisometropia. Despite not being given any opportunity to adapt to the objective prescription, the majority of eyes preferred that prescription through natural pupils. Allowing subjects time to adapt could inform any broader advocacy of this method and also speak to the typically challenging cases of

adaptation such as the high undercorrected hyperopic eyes examined here, as well as first-time cylinder wearers.

Conclusions

A method of simultaneously optimising sphere, cylinder, and axis from a wavefront error measurement, using the visual image quality metric VSX, was described. In myopic subjects, visual performance, as measured by VA, with this VSX-objective refraction was prospectively found to be equivalent to that provided by subjective refraction, and was preferred over subjective refraction by the majority of myopic eyes. The four habitually undercorrected hyperopic eyes examined here, preferred and benefitted from subjective refraction.

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Figure 1.

(A) Scatter plot and (B) limits of agreement plots comparing the high contrast (HC) logMAR VA recorded with the VSX-optimised-objective refraction to that recorded with the subjective refraction through natural pupils for myopic eyes (n=36). The values of the mean differences illustrated here, as well as their standard deviations, can be found in Table 1.

Figure 2.

(A) Scatter plot and (B) limits of agreement plots comparing the high contrast (HC) logMAR VA recorded with the VSX-optimised-objective refraction to that recorded with the subjective refraction through dilated pupils for myopic eyes ($n=36$). The values of the mean differences illustrated here, as well as their standard deviations, can be found in Table 1.

Figure 3.

Frequency histograms of short-term monocular preference comparison between the VSX-optimised-objective prescription and the subjective prescription for myopic eyes. The objective prescription was preferred by 72% of myopic eyes when viewing through natural pupils (**A**). When dilated (**B**), 47% of myopic eyes preferred the objective refraction while 16% judged them to be equivalent to the subjective refraction.

Figure 4.

For four habitually undercorrected hyperopic eyes, comparison of the high contrast (HC) logMAR VA recorded with the VSX-optimised-objective refraction to that recorded with the subjective refraction through natural pupils (black crosses) and dilated pupils (red plusses).

Figure 5.

Frequency histograms for myopic eyes of the difference in HC logMAR VA between the VSX-objective and the subjective prescriptions when (A) not dilated and (B) dilated. Clinically equivalent VAs were defined as differences less than 2.5 letters.

Summary of the mean logMAR VA with each prescription as well as the difference in VA (objective – subjective). Split-plot ANOVAs found none of the differences to be statistically significant for myopic eyes.

Table 1

Pupil	Visual Acuity		Objective VA Mean $\pm$ SD	Subjective VA Mean $\pm$ SD	Difference Mean $\pm$ SD
Undilated	High Contrast	n=40	-0.03 $\pm$ 0.13	-0.07 $\pm$ 0.05	0.03 $\pm$ 0.14
		Myopic n=36	-0.06 $\pm$ 0.04	-0.06 $\pm$ 0.04	0.00 $\pm$ 0.04
		Hyperopic n=4	0.19 $\pm$ 0.41	-0.17 $\pm$ 0.07	0.37 $\pm$ 0.34
	Low Contrast	n=40	0.07 $\pm$ 0.16	0.04 $\pm$ 0.07	0.03 $\pm$ 0.18
Dilated		Myopic n=36	0.04 $\pm$ 0.05	0.05 $\pm$ 0.06	-0.02 $\pm$ 0.07
		Hyperopic n=4	0.36 $\pm$ 0.48	-0.09 $\pm$ 0.07	0.44 $\pm$ 0.41
	High Contrast	n=40	-0.04 $\pm$ 0.08	-0.06 $\pm$ 0.06	0.02 $\pm$ 0.10
		Myopic n=36	-0.05 $\pm$ 0.04	-0.05 $\pm$ 0.05	0.00 $\pm$ 0.04
		Hyperopic n=4	0.04 $\pm$ 0.26	-0.17 $\pm$ 0.02	0.22 $\pm$ 0.24
	Low Contrast	n=40	0.11 $\pm$ 0.10	0.09 $\pm$ 0.08	0.02 $\pm$ 0.13
		Myopic n=36	0.09 $\pm$ 0.06	0.10 $\pm$ 0.07	-0.01 $\pm$ 0.06
		Hyperopic n=4	0.30 $\pm$ 0.22	-0.02 $\pm$ 0.02	0.32 $\pm$ 0.21

Table 2

Summary of dioptric component differences (VSX-objective – subjective).

Pupil	M	J ₀	J ₄₅	Euclidean Separation
Undilated				
n=40	-0.48 ± 0.68	0.07 ± 0.16	-0.03 ± 0.10	0.74 ± 0.42
Myopic n=36	-0.65 ± 0.35	0.07 ± 0.17	-0.03 ± 0.10	0.69 ± 0.34
Hyperopic n=4	1.09 ± 1.08	0.03 ± 0.12	-0.02 ± 0.08	1.17 ± 0.94
Dilated				
n=40	-0.16 ± 0.40	-0.03 ± 0.14	-0.02 ± 0.10	0.40 ± 0.23
Myopic n=36	-0.26 ± 0.25	-0.02 ± 0.15	-0.02 ± 0.10	0.36 ± 0.19
Hyperopic n=4	0.75 ± 0.32	0.00 ± 0.08	-0.02 ± 0.12	0.76 ± 0.31