Subjective and Objective Performance of Antireflective Lenses During Daily Activities

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Introduction

Antireflective (AR) lenses are designed to reduce reflections and secondary images produced by the spectacle surface. As described by Fresnel's formula (FR=[(n'-n)/(n'+n)])[1] approximately 92% of incident light is transmitted by CR-39 lenses (n=1.498); 8% of the incident light, therefore, will be reflected back from the lens surfaces. Light reflectance is greater for polycarbonate (n=1.586) at approximately 10.3% of incident light. Both the wearer and the observer perceive this reflectance as ghost images and glare. AR coatings applied to transparent surfaces are able to reduce the surface reflections to less than 1% of the incident light. Ghost images are reduced, glare is reduced, and objects appear to be more brightly lit thru AR coated lenses[2-4].

AR coated lenses are often recommended for specific groups of individuals and also in particular daily or work environments. Therefore, we proposed to better quantify the perceived effect of antireflective coatings on various daily activities, concentrating on tasks such as driving, computer use, and usage of handheld devices. We also measured contrast sensitivity thru AR coated and non-AR coated high index lenses to assess any impact at different acuity levels. Lastly, contrast sensitivity was measured under glare conditions while subjects wore both AR coated and non-AR coated lenses.

Methods

Visually normal adults (n=46) between the ages of 18 and 65, with best-corrected distance and near visual acuity of 20/20, were enrolled in this study. All subjects were full time spectacle wearers and computer users. Particular attention was paid to recruiting based on US population statistics for race, gender, and age. Participants were further selected in order to reflect the latest-reported prevalence of refractive error in the US[5] and categorized as myope, hyperope, or astigmat (see table 2). Presbyopia was not a separate category as this was considered a reflectance of age group.

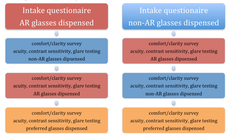
Table1. Demographic breakdown of study participants vs US population

	% US population	% study population
Male 18-34 Caucasian	13.3	12.2
Male 18-34 African American	2.2	2.4
Male 35-49 Caucasian	11.8	9.8
Male 35-49 African American	2.0	2.4
Male 50+ Caucasian	16.6	12.2
Male 50+ African American	2.8	0
Female 18-34 Caucasian	12.8	17.1
Female 18-34 African American	2.3	2.4
Female 35-49 Caucasian	11.7	12.2
Female 35-49 African American	2.1	4.9
Female 50+ Caucasian	18.8	22.0
Female 50+ African American	3.4	4.9

Table 2. Refractive error breakdown of study participants vs US population

	% US population	% study population
Myopes (SphEq* ≤ -1.0D)	33.1	36.6
Hyperopes (SphEq ≥ 3.0D)	22.1	24.3
Astigmats (cylinder ≥ 1.0D)	36.2	39.0

Design Summary



Following consent, each subject was examined and fitted for spectacles of the same type habitually worn (i.e. single vision, bifocal, progressive lenses). Two nearly identical pairs of glasses were made for each subject. One pair had polycarbonate lenses with scratch coating (non-AR), the other pair contained polycarbonate lenses with scratch coating and a premium AR coating (AR). Each pair of glasses was dispensed with identical cleaning instructions and supplies.

The glasses were dispensed for normal use for two weeks, using a randomized, crossover, double-masked design.

The majority of enrolled subjects used their glasses on a full time basis and were tested for acuity and contrast sensitivity using the M&S Technologies Inc. Smart System II 20/20™ Visual Acuity & Fixation System and the Brightness Acuity Tester (BAT, Marco).

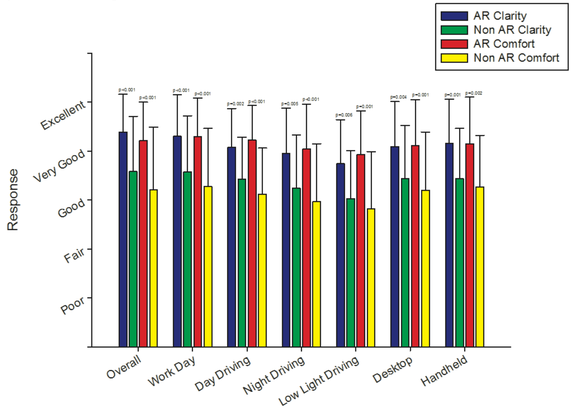
Two participants used their glasses primarily for intermediate and near activities and were tested for contrast sensitivity alone using the Freiburg Visual Acuity & Contrast Test.

Statistical analysis: The average of the repeated results was used for analysis. Non-parametric tests for repeated measures were used to compare AR vs non-AR with a significance level of $p<0.05$. All data are presented as mean ± standard deviation.

Results:

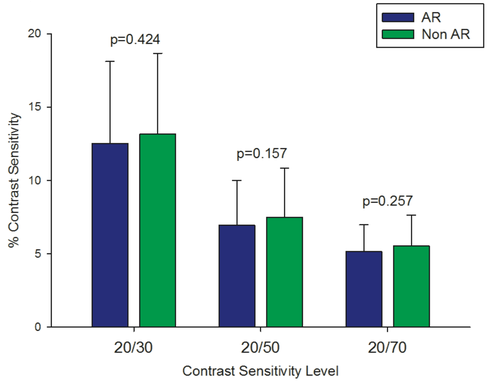
When comparing comfort and clarity under different conditions (daytime work and driving, night driving, low light driving, and when using a desktop computer or a handheld device), the subjects rated the AR lenses as being very good to excellent, while the non-AR lenses were rated good to very good ($p<0.001$).

Subjective Preference Using AR vs non-AR Coated lenses



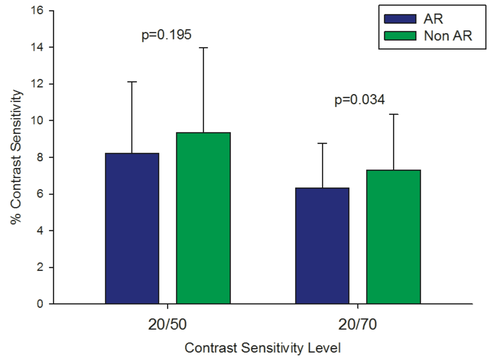
There was not a significant performance difference between the lenses as measured by contrast sensitivity ($p=0.116$).

Contrast Sensitivity Levels in AR vs Non-AR Coated Lenses



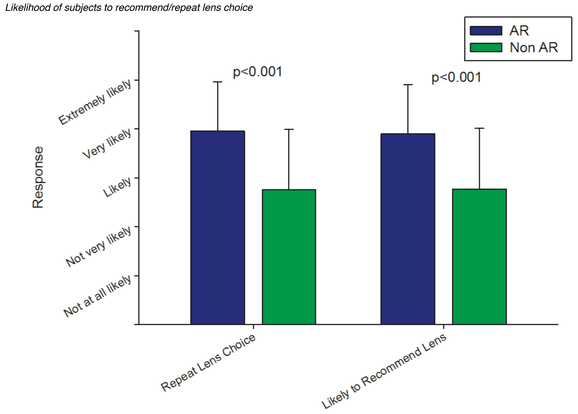
However when testing under glare conditions at 20/70 visual acuity, the driving limit in Illinois , AR lenses significantly improved visual performance as compared to lenses without AR ($p=0.034$), but not at 20/50 visual acuity. Subjects, on average, read one additional line of text under moderate glare conditions when using AR coated lenses.

Glare threshold measured during contrast sensitivity testing



Upon completion, the subjects were more likely to recommend or repeat the AR coated lenses, while 78% of the subjects chose to keep the AR lenses as their preferred pair.

Likelihood of subjects to recommend/repeat lens choice



Conclusions

The majority of subjects displayed a clear preference for AR lenses over non-AR lenses.

Subjectively the AR lenses provided better clarity and comfort when performing normal daily activities and tasks including driving, working at a computer and using a handheld device.

Objectively glare was reduced thru the AR lenses when compared to non-AR lenses, but contrast sensitivity was not significantly improved.

Recommending antireflective lenses may benefit the wearer by reducing glare, as well as enhancing comfort and acuity.

Future Direction

Our subjects had no disposition toward glare difficulty (no presence of cataract etc) yet still performed better using AR coated lenses. A study incorporating subjects known to have increased glare difficulty would provide more information on benefits in other groups.

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References

I. http://www.sciencedaily.com/releases/2007/03/070302082821.htm, last accessed 9-03-13.
II. Coupland SC, Kirkham TH. Improved contrast sensitivity with antireflective coated lenses in the presence of glare. *Can J Ophthalmol* 1981;16(3):136-40.
III. Ross J, Bradley A. Visual performance and patient preference: a comparison of anti-reflective coated and uncoated spectacle lenses. *J Am Optom Assoc* 1997;68(6):361-6.
IV. Bachman WG, Weaver JL. Comparison between anti-reflection-coated and uncoated spectacle lenses for presbyopic highway patrol troopers. *J Am Optom Assoc* 1999;70(2):103-9.
V. http://uscensus.gov, accessed 12-19-2012
VI. Vitale S, Ellwein L, Cotch MF, Ferris FL, Sperduto R. Prevalence of refractive error in the United States, 1999-2004. *Arch Ophthalmol* 2008;126(8):1111-1119.
VII. Kempen JH, Mitchell P, Lee KE, Tielsch Jm, Broman AT, Taylor HR, Ikram MK, Congdon NG, O'Colmain BJ; Eye Diseases Prevalence Research Group. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. *Arch Ophthalmol* 2004;122(4):495-505.
VIII. Vitale S, Sperduto RD, Ferris FL. Increased prevalence of myopia in the US between 1971-1972 and 1999-2004. *Arch Ophthalmol* 2009;127(12):1632-9.
IX. M&S Technologies, Inc. ©2008 Use & Operation Guide, volume 11, June 2008. IMP-0705.
X. http://michaelbach.de/fract/index.html, accessed 3-13-2013.
XI. http://lowvision.preventblindness.org/daily-living-2/state-vision-screening-and-standards-for-license-to-drive, accessed 9-24-2013.

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