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Quantifying the effect of straylight on photopic contrast sensitivity

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The visual performance of a reference group (RG) using diffuser filters was compared to a cataract-diagnosed group (CatG). Measurements of straylight (SL) parameter, photopic contrast sensitivity (CS), and visual acuity (VA) were carried out in both groups. Before the analysis, the performance of the instruments used for this purpose was tested. The RG was comprised of three healthy, young eyes (25–30 years old) while 59 subjects (aged 50–80 years old) with lens opacities were recruited for the CatG. Six diffuser conditions were tested in the RG. To discriminate between light scattering levels, SL measurements proved to be most sensitive, VA did not discriminate at all, while CS showed intermediate sensitivity. VA was not correlated with SL, while the correlation between CS and SL was significant ($p < 0.05$) in both groups. Since the correlation in the RG was particularly strong, parameters of a linear regression model are presented. The behavior of CS as a function of SL was comparable to some extent between RG and CatG.

OCIS codes: (330.1800) Vision - contrast sensitivity; (290.2558) Forward scattering; (290.2648) Stray light; (330.1070) Vision - acuity; (330.5510) Psychophysics; (330.7328) Visual optics, ophthalmic appliances.

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1. INTRODUCTION

The various eye components change with aging [1]. In the case of the lens, opacities progressively appear, causing loss of its natural transparency, which is known as a cataract. The interaction of light with these opacities causes the phenomenon of intraocular scattering, which spreads light heading to the retina leading to visual impairment. Although it is possible to replace the lens, the appropriateness of cataract surgery is questionable in some cases [2–6]. This remains so, likely because there is not a precise description of how certain visual functions are affected by the stage of cataract development.

Studies have been performed in the past decades testing some visual functions in the presence of intraocular scattering due to cataracts [7–10] and other conditions linked to increased scattering [11–13]. Grading scales shown to be inadequate or imprecise were utilized to quantify either intraocular scattering [8,14,15] or visual functions [16–18], and that is possibly the reason that the relationship between scattering and contrast sensitivity (CS) was not accurately modeled. Another difficulty is the necessity of isolating the scattering effect from other effects also present in conditions such as cataracts.

There are currently some devices available for the measurement of forward intraocular scattering [14,19,20], i.e., scattering reaching the retina that impairs vision. Regarding visual function measures, visual acuity (VA) has been traditionally the parameter used to quantify visual loss, though there are studies that show its low sensitivity and suggest the complementary use of CS [7,9,21,22].

The hypothesis of this work is that it is possible to quantify the effects of forward intraocular scattering on photopic CS by controlling scattering levels in young subjects with normal visual and eye conditions. We also hypothesize that the visual performance under controlled scattering levels might be compared to eye conditions where scattering is elevated, such as cataracts.

2. METHODS

First, we conducted an experiment in order to test the equipments used for measurements of scattering and CS. Once we checked the reliability of those instruments, we studied the effect of forward scattering on VA and contrast vision. Finally we evaluated the validity of these results in individuals with crystalline lens opacification.

Therefore, we divided this work into two parts. The first part regards the capabilities of the instruments for measuring scattering and CS. The second part considers the relationship between them in a scattering controlled group and a cataract group.

A. Subjects

Two ophthalmologists (WA and EF) performed eye examination and selection of observers in three ophthalmologic institutions: Cátedra de Oftalmología (Universidad Nacional de Tucumán), Instituto de Microcirugía Oftalmológica, and Clínica de la Visión Dr. Jure. They recruited observers for two groups: one group of healthy young subjects and the other one consisting of people diagnosed with cataracts. After recruitment, optical and visual measurements were performed.

Every subject who participated in either group was informed of the aims of this study, and provided consent following the tenets of the Declaration of Helsinki. The bioethics commission of the Universidad Nacional de Tucumán also approved this study.

1. Reference Group

Criteria for inclusion in the reference group (RG) considered three participants between 25 and 30 years old and with a logMAR VA of at least 0.0 (20/20 Snellen) on their right eyes. The clarity of the optical path was assessed through slit lamp examination. An intraocular scattering study was included to ensure they were within the normal limits matched by age, since it was required that scattering was primarily caused by filters (see B.1. Diffuser Filters).

2. Cataract-Diagnosed Group

Inclusion criteria in the cataract-diagnosed group (CatG) were restricted to eyes where the presence of cataract was the only apparent source of scattering. Opacities could be present in one or more zones (nuclear, cortical, posterior subcapsular) of the crystalline lens. There were no limitations with the severity of opacities as long as the eyes were measurable. Eyes with ocular alterations other than cataract were excluded.

Fifty-nine cataract eyes were recruited with pure and mixed cataracts. They spanned a large range of opacities development according to the Lens Opacities Classification System III (LOCS III) [23]: nuclear cataracts ($n = 14$, NO3 to NO6), posterior subcapsular cataracts ($n = 9$, P1 to P5), cortical cataracts ($n = 3$, C2 to C3), and mixed cataracts ($n = 33$, N02 to NO6, P1 to P5, and C2 to C5). We considered a group of VAs higher than or equal to 0.7 ($n = 30$), expecting that the visual performance of this subset of data was closer to the RG data, as they resemble their characteristics in a better manner.

B. Apparatus

1. Diffuser Filters

Four diffuser filters were used to induce scattering in the RG: BPM1, BPM2, Lee258, and filter f3020. Also, a naked eye condition ("no-filter") and a combination of Lee258 and f3020 ("f3020 + Lee258") were included, so that six conditions were achieved. Although filter Lee258 was reported as inadequate in representing the scattering properties of a cataract condition [24,25], here we study the effect of scattering over CS in an ample way and without restricting it to just one eye condition. We hypothesize that the straylight (SL) values (see Section 2.B.2. Straylight Measurements) are correlated with CS, irrespective of the scattering properties of the medium through which the light passes.

Table 1. Straylight Parameter at 10° and Percentage of Transmittance of the Diffuser Filters Used in this Work[b]

Diffuser Filter	SL_{10}[a]	Transmittance (%)[a]	Pupil Diameter (mm)
No-filter	N/A	1.00	3.9 ± 0.3
BPM1	7.9 ± 0.2	70.6 ± 0.3	4.3 ± 0.3
BPM2	11.5 ± 0.3	64.8 ± 1.2	4.2 ± 0.3
Lee258	19.0 ± 0.4	93.4 ± 0.8	3.9 ± 0.3
f3020	61 ± 2	87.9 ± 0.6	3.9 ± 0.2
f3020 + Lee258	—	82.1	4.6 ± 0.3

[a]Extracted from Ref. [25].

[b]SL_{10} parameter for "f3020 + Lee258" was not available, and its transmittance was calculated from f3020 and Lee258 filter transmittances. Pupil diameters measured in one of the observers while wearing the filters and looking at a screen of 70 cd/m^2 are also provided.

Table 1 shows the SL values and transmittances [25] of these filters. Since uneven transmittances may change the state of retinal adaptation and hence CS results, we also included a control measurement of pupil diameter for one of the observers of the RG. Measurements were carried out with an eye-tracker (250 Hz) while the subject wore the filters and looked at a uniform gray screen with luminance equal to the one used for CS measurements. Table 1 also shows the averaged and standard deviation pupil sizes measured during 60 s. We calculated the retinal illuminance to be between 630 Td and 990 Td, corresponding to conditions BPM2 and "f3020 + Lee258," respectively.

The filters were located in a test lens mount. When corrective lenses were needed, diffuser filters were placed in front.

2. Straylight Measurements (C-Quant)

The straylightmeter C-QUANT (OCULUS Optikgeräte GmbH, Germany) employs a psychophysical method called compensation comparison [20] to calculate the SL parameter defined by the scattered angle (θ) and the point spread function (PSF) ($SL(\theta) = \theta^2 \times PSF(\theta)$) and related to the veiling luminance caused by the illuminance produced by a glaring source [26,27]. This instrument gives the logarithm of the SL parameter (log (SL)) measured with a glaring source located at 10 deg.

The straylightmeter was used to quantify the scattering effect of all filter conditions and opacities. As already mentioned, a control measurement was first carried out in subjects of the first group to verify that SL values were normal according to their ages. Every filter condition was measured three times in each observer and averages of all nine values were used in data analysis. In CatG, five measurements of each eye were performed and also averaged.

Even though there is no global standard measurement system for intraocular scattering, Elliott and Bullimore [28] provided some reasons for using the straylightmeter. Also Piñero *et al.* [14] recommended this instrument instead of other optical methods that are less dependent on the subjective response of the observer. The authors made this suggestion based on the existence of reports considering very large samples, as well as the variety of ocular conditions in which it was tried [29]. Moreover, this instrument incorporates age-matched normal ranges for the log(SL) parameter.

Table 2. Average and Standard Deviations of Straylight Parameter (log(SL)), Best Corrected Visual Acuity (BCVA), and Contrast Sensitivity (log(CS)) for Each Diffuser Condition of the RG and for the CatG and for Subsets of CatG

				log(CS)				
Group	**Condition**	**BCVA**	**log(SL)**	**1 c.p.d.**	**2 c.p.d.**	**4 c.p.d.**	**8 c.p.d.**	**12 c.p.d.**
RG $n = 3$	No-filter	1.19 ± 0.33	0.88 ± 0.06	2.05 ± 0.14	2.40 ± 0.07	2.54 ± 0.09	2.24 ± 0.18	2.18 ± 0.25
	BPM1	1.19 ± 0.33	1.29 ± 0.04	2.04 ± 0.09	2.32 ± 0.10	2.41 ± 0.14	2.07 ± 0.22	1.99 ± 0.19
	BPM2	1.09 ± 0.14	1.36 ± 0.02	2.00 ± 0.06	2.30 ± 0.05	2.39 ± 0.09	2.02 ± 0.24	1.91 ± 0.18
	Lee258	0.93 ± 0.11	1.79 ± 0.09	1.72 ± 0.10	1.92 ± 0.01	1.81 ± 0.15	1.47 ± 0.22	1.36 ± 0.20
	f3020	0.95 ± 0.26	2.16 ± 0.05	1.40 ± 0.04	1.58 ± 0.07	1.70 ± 0.14	1.34 ± 0.21	1.20 ± 0.36
	f3020 + Lee258	0.48 ± 0.15	2.40 ± 0.06	1.05 ± 0.04	1.07 ± 0.04	1.03 ± 0.15	0.54 ± 0.22	0.51 ± 0.20
CatG	All, $n = 59$	0.64 ± 0.26	1.58 ± 0.31	1.63 ± 0.27	1.80 ± 0.36	1.72 ± 0.44	1.07 ± 0.50	0.92 ± 0.42
	VA ≥ 0.7, $n = 30$	0.86 ± 0.13	1.42 ± 0.26	1.71 ± 0.20	1.92 ± 0.27	1.90 ± 0.39	1.36 ± 0.46	1.16 ± 0.39
	VA < 0.7, $n = 29$	0.42 ± 0.15	1.74 ± 0.27	1.55 ± 0.32	1.67 ± 0.40	1.52 ± 0.41	0.79 ± 0.37	0.66 ± 0.27

3. Visual Acuity and Contrast Sensitivity

VA was measured with a standard logMAR Bailey–Lovie chart in the RG and Snellen chart in the CatG. CS was measured with a computerized system (FVC-100, Tecnovinc, UNT-CONICET, Argentina) capable of reproducing low contrast sinusoidal gratings (duration of 500 ms) in a cathode ray tube monitor at five spatial frequencies (1, 2, 4, 8, and 12 cycles per degree, or c.p.d.) [30]. Based on the observer responses to the inclination of the gratings (left or right), the system computes the next contrast to be displayed using an adaptive method [31]. The complete range of spatial frequencies was measured and the CS function (CSF) was obtained. Every subject of the RG completed three measurements of the whole CSF for each diffuser condition, while only one CSF measure was obtained for each eye of the CatG. CS measurements were photopic (mean luminance of the screen: 70 cd/m^2). No lights other than those from the instruments were present during the experiment.

3. RESULTS

A. Instruments and Test Discriminability

Table 2 summarizes mean and standard deviation of averaged SL, decimal VA, and CS for all diffuser conditions. Data are sorted from the lowest to the highest scattering condition considering values found by straylightmeter. The same variables are shown for the CatG and for subsets of CatG.

Prior to analyses, we tested the performance of the straylightmeter, the CS instrument, and the VA test to differentiate between levels of scattering induced by the filters in the RG. In this regard, we carried out an analysis of the variance and found that the effect of filters was statistically significant in all tested variables ($p < 0.05$), and the effect of observers was not significant in any of them ($p > 0.05$), so the three will be considered as one in further analysis. We then performed comparisons between pairs of scattering conditions (Table 4 in Appendix A). We found that the straylightmeter C-Quant through its SL parameter was able to establish statistically significant differences between all scattering conditions. CS measured with FVC-100 reaches a good specificity at 2 cycles per degree, as all comparisons were statistically significant except for BPM1 versus BPM2. At the lowest spatial frequency of 1 c.p.d., CS could not discriminate among low scattering levels. CS showed a similar response at intermediate and high spatial frequencies, as the same three pairs of diffuser filters could not be discriminated for frequencies 4, 8, and 12 c.p.d. On the contrary, the VA test could discriminate only the most strongly scattering condition ("f3020 + Lee258") from the other diffuser filters.

B. Relationship among Straylight, Contrast Sensitivity, and Visual Acuity in the Reference and the Cataract-Diagnosed Groups

Table 2 shows that the average VA is higher than 1.00 (Snellen acuity better than 20/20) for no-filter, BPM1, and BPM2 conditions, slightly lower than 1.00 for filters Lee258 and f3020 and equal to 0.48 (approximately 20/40) for filters "f3020 + Lee258." Regarding the SL parameter, it is observed that BPM1 and BPM2 induce intermediate straylight values. Unlike those filters, SL takes higher values when Lee258 and f3020 are used, which is comparable to values that might be present in eyes with advanced cataract [29].

Photopic CSFs for all six conditions are plotted in Fig. 1. It is noted that scattering conditions are located from top to bottom in increasing order regarding intraocular scattering

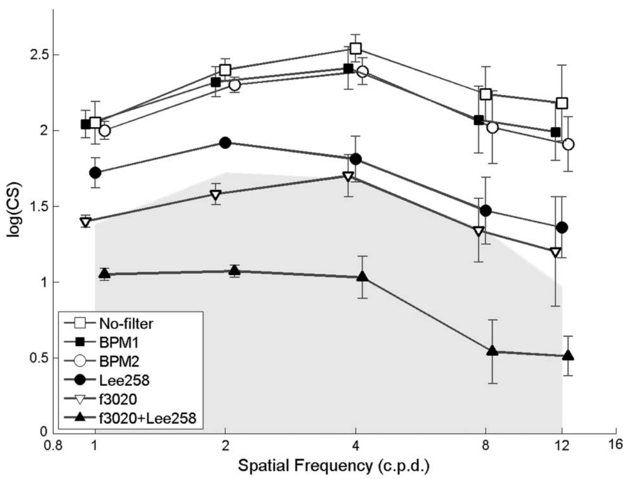

Fig. 1. CSF for six diffuser conditions: "no-filter," BPM1, BPM2, Lee258, f3020, and "f3020 + Lee258" measured at five spatial frequencies. Every CSF is the average of three individual CSFs corresponding to three observers, and error bars correspond to one standard deviation. The area shaded in gray corresponds to CS below normality according to CSF curves provided by the instrument FVC-100.

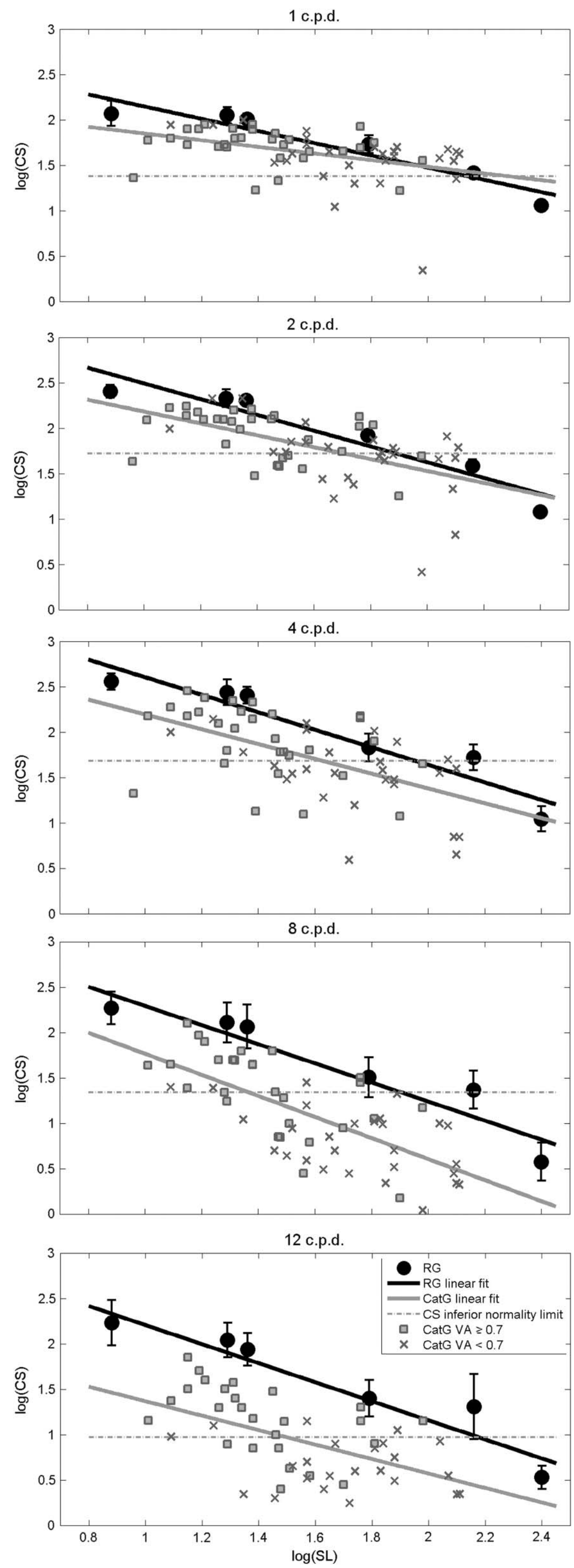

Fig. 2. Contrast sensitivity (log(CS)) versus straylight parameter (log(SL)) at five spatial frequencies (top to bottom: 1, 2, 4, 8, and 12 c.p.d.). Black filled circles correspond to RG data, and gray filled squares and crosses correspond to CatG data with Snellen VA ≥ 0.7 and <0.7, respectively. Linear models fitted to RG and CatG data are represented by black lines and gray lines, respectively. Horizontal dashed lines represent the inferior normality limit for CS according to values provided by the instrument FVC-100.

Table 3. Correlations between Contrast Sensitivity (log (CS)) and Straylight Parameter (log(SL)) at All Five Spatial Frequencies are Shown for RG, CatG, and the Subgroup of CatG with VA ≥ 0.7[a]

		log(CS) versus log(SL)				
		1 c.p.d.	2 c.p.d.	4 c.p.d.	8 c.p.d.	12 c.p.d.
RG	r	−0.94	−0.95	−0.95	−0.94	−0.96
	(p value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	a	−0.67	−0.87	−0.97	−1.05	−1.05
	b	2.82	3.36	3.57	3.34	3.25
CatG, All	r	−0.41	−0.56	−0.56	−0.69	−0.55
	(p value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
CatG, VA ≥ 0.7	r	−0.24	−0.42	−0.36	−0.62	−0.47
	(p value)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

[a]Pearson coefficient (r) and statistical significance value (p) are presented. Coefficients a and b of the linear model $\log(\mathrm{CS}) = a * \log(\mathrm{SL}) + b$, fitted to RG data are also presented.

$p < 0.05$ are statistically significant.

(according to the SL parameter). There are just a few crossings between curves corresponding to low scattering conditions.

Figure 2 shows the results of photopic CS as a function of SL for the RG (black filled circles) and CatG (gray filled squares and crosses) at the five spatial frequencies. Both groups behave similarly as CS decreases with SL increments. Cataract data are similar to RG data, but when spatial frequency increases, cataract data decrease to lower CS. Another similarity is that both fit well to linear regression models ($\log(\mathrm{CS}) = a * \log(\mathrm{SL}) + b$) as represented by black solid lines and gray solid lines for the RG and CatG groups, respectively. It can be seen that CatG lines run virtually parallel to RGs at almost all spatial frequencies (except for 1 c.p.d.) though shifted downwards, and the separation between both lines is greater at higher spatial frequencies. Table 3 shows high correlations (Pearson higher than 0.9) for the model fitted to RG at all spatial frequencies (model parameters for averaged data of the three subjects are reported in Table 3 and for each individual in Appendix A, Table 5), indicating that photopic CS is highly dominated by scattering. In order to compare CatG with RG, we tested the correlation between CS and SL in the cataract data group as well as in the subgroup of decimal VA ≥ 0.7 ($n = 30$). Note in Table 2 that averaged values of SL and CS are better in the cataract subgroup of VA ≥ 0.7 than in the subgroup of VA < 0.7. Pearson coefficients in the whole CatG were lower than those in RG, and coefficients for the subgrouping of VAs were even lower. Nevertheless, the effect of SL was a significant factor on the visual performance of CatG (also shown in Table 3).

4. CONCLUSIONS AND DISCUSSION

In this work, we studied the relationship between the SL parameter and both VA and photopic CS by using clinical instruments to test a group of young eyes with induced intraocular scattering. We also compared those results with clinical cataract data under natural conditions of intraocular scattering.

First we have seen the wide range in which C-Quant and FVC-100 can perform measurements of intraocular scattering. The most strongly scattering condition ("f3020 + Lee258") reached an average value of $\log(SL) = 2.40$, which is higher than almost any other value that can be found in the literature, and corresponds to advanced cataracts [29,32]. Second, the straylightmeter has shown good sensitivity to respond to different scattering conditions as well as good specificity to statistically differentiate between levels of diffusion, as previous reports have shown [25,33]. In the case of FVC-100, spatial frequency of 2 c.p.d. showed the best discrimination, suggesting that it is the most appropriate to account for the diffusion effect produced by a clinical condition such as cataracts, especially when trying to reduce measurement times of CSF, including solely the most informative spatial frequencies.

VA measurements showed poor sensitivity to discriminate the scattering changes caused by the filters, showing that good VA may coexist with high intraocular scattering. This is also seen in some points of CatG with $VA \geq 0.7$ (gray filled squares in Fig. 2). The impact of scattering on VA is an issue already addressed in many works [8,9,10,34] and known in qualitative terms, but many of them do not use a measure of the forward scattering but subjective grading scales for conditions such as cataract. In a recent publication, van den Berg [17] has presented the independence of VA and straylight considering three different perspectives: a methodological one, another one that is optics based, and the last one considering a large sample size. All these results are very important, as VA is one of the main parameters used to decide a cataract surgery. Our results confirm that VA may overestimate the visual performance of eyes with significant degrees of intraocular scattering.

Conversely, photopic CS dropped under increasing intraocular scattering, and was a good representation of visual impairment. Correlations presented in Table 3 for RG were strong, and the parameters of the linear regression models fitted to the data could be sufficient to model the CS dependence on the SL parameter under photopic conditions of adaptation. The estimated retinal illuminance variation due to different filter transmittances was not meaningful for photopic levels of adaptation; however, we believe that the compensation of luminance loss could enhance these models. The reason to include young healthy eyes in the RG was to reduce the effect of retinal sensitivity variability caused by aged eyes; however, Patterson *et al.* found [35] that CS dependence on glare illuminances, eccentricities, and background luminances were best predicted when including retinal sensitivity corrections to a model based on forward scattering corrections. We have found no evidence testing the relationship between the CS function and measures of forward intraocular scattering under controlled levels of scattering on healthy young eyes. It is possible to find studies testing CS under high ranges of intraocular scattering [8,34], but they are mostly based on cataract eye samples, so most of the subjects tested were aged over 50 years old where high inter-subject variability would be expected due to changes in eye structures with aging [2,36–40]. Other studies considering the use of filters to induce scattering are also found, but they are limited to showing the loss of visual functions (VA and CS) in few scattering conditions [7,41,42]. The models presented in the current study have some limitations, since contrast measurements were done for only one photopic level, and it is well known that CS depends on the level of retinal adaptation [43], so they cannot be extended to other levels. Another limitation is related to the forward scattering quantification. Although the straylightmeter is a reliable instrument, it uses a light source located at 10 deg to the target, and since the veiling luminance depends on the angle subtended by the glaring source, these models should also be restricted to equivalent measures of forward intraocular scattering.

The use of diffuser filters worked well to approximate the CS of the CatG and we believe these models could be also extended to other eye conditions where intraocular scattering is increased. The weaker correlations between contrast vision and straylight in the CatG suggest that factors other than scattering, which are present in cataractous eyes, may have a greater effect on CS and may explain the differences between reference and cataract groups. Increments of higher order aberrations (HOA) have been found in cataract eyes and correlated to the loss in CS at high spatial frequencies [44], so this may be a reason for the greater separation between RG and CatG lines encountered at those frequencies. Moreover, non-optical factors such as the findings of Patterson that are mentioned in the previous paragraph are particularly relevant, since neural sensitivity was found to be decreased in aged eyes and may play a role in the decreased CS found for the cataract data [36,37]. Retinal sensitivity might also explain why the cataract subgroup considering $VA \geq 0.7$ did not improve the correlations between CS and straylight, meaning that good visual acuity would not be sufficient to significantly reduce inter-observer retinal sensitivity variations. On the other hand, CS was able to differentiate between levels of scattering induced by filters; however, it can be seen in Fig. 1 that the variability of the CS measurement system is elevated in some cases. CS reached accurate values for the RG, since every point was an average of nine measurements, but there could have been inaccurate measurements in the CatG, as every eye was measured once, and many subjects performed this test for the first time.

We have not separated the analysis into different cataract types, as larger samples would be needed. It is known that posterior subcapsular cataract can cause a dramatic reduction in vision; however, our models are expressed in terms of forward scattering, so it would be interesting to study whether the measure of forward scattering is sufficient to account for contrast vision performance or if it is important to also consider the type of cataract.

The evidence presented here shows that it is possible to model the effect that forward intraocular scattering has on photopic CS. The use of diffuser filters was a good way to induce scattering and reduce the inter-subject variability of aged eyes. There are notable differences between contrast vision performances of eyes with cataract and young eyes with induced levels of scattering when only forward intraocular scattering is considered, although in qualitative terms they behave similarly. Last, the ophthalmologic practice would benefit from models such as these, as the sole measure of straylight might give an idea of contrast vision and help to decide the necessity of a certain treatment, as in the case of cataract surgery.

APPENDIX A

Table 4. LSD Fisher Comparisons between Different Scattering Conditions for Variables: Best Corrected Visual Acuity, log(SL), and log(CS) in the Complete Spatial Frequency Range[a]

			log(CS) According to Spatial Frequencies (c.p.d.)				
Pairs	**BCVA**	**log(SL)**	**1**	**2**	**4**	**8**	**12**
No-F versus BPM1		*		*			
No-F versus BPM2		*		*	*	*	*
No-F versus Lee		*	*	*	*	*	*
No-F versus F3020		*	*	*	*	*	*
No-F versus Lee+3020	*	*	*	*	*	*	*
BPM1 versus BPM2		*					
BPM1 versus Lee		*	*	*	*	*	*
BPM1 versus 3020		*	*	*	*	*	*
BPM1 versus Lee+ 3020	*	*	*	*	*	*	*
BPM2 versus Lee		*	*	*	*	*	*
BPM2 versus 3020		*	*	*	*	*	*
BPM2 versus Lee+ 3020	*	*	*	*	*	*	*
Lee versus F3020		*	*	*			
Lee versus Lee+ 3020		*	*	*	*	*	*
3020 versus Lee+ 3020		*	*	*	*	*	*

[a]Cells with an asterisk correspond to p-values lower than 0.05. Blank cells correspond to p-values higher than 0.05.

Table 5. Correlations between Contrast Sensitivity (log (CS)) and Straylight Parameter (log(SL)) at All Five Spatial Frequencies are Shown for Every Observer[a]

		log(CS) versus log(SL)				
Subject		**1 c.p.d.**	**2 c.p.d.**	**4 c.p.d.**	**8 c.p.d.**	**12 c.p.d.**
S1	r	0.83	0.84	0.87	0.84	0.89
	a	−0.62	−0.85	−0.94	−1.07	−1.02
	b	2.67	3.35	3.60	3.48	3.26
S2	r	0.94	0.93	0.91	0.90	0.90
	a	−0.72	−0.88	−0.94	−1.02	−1.05
	b	2.95	3.38	3.57	3.40	3.42
S3	r	0.90	0.93	0.93	0.92	0.97
	a	−0.66	−0.86	−1.00	−1.04	−1.06
	b	2.82	3.32	3.51	3.11	3.06

[a]Pearson coefficient (r) and statistical significance value (p) are presented. Coefficients a and b of the linear model $\log(CS) = a * \log(SL) + b$ fitted to RG data are also presented.

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