Glare testing in cataract patients: Instrument evaluation and identification of sources of methodological error

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ABSTRACT

This study sought to determine the relative sensitivity of two commercially available glare testers in predicting outdoor acuity in a population of patients with minimal cataracts. Two target optotypes were evaluated: high contrast letters and varying contrast sinusoidal gratings. Although both instruments demonstrated a significant correlation between indoor and outdoor acuity, they showed a significant difference between predicted outdoor acuity and obtained visual acuity. The brightness acuity tester on high intensity was inaccurate in predicting outdoor vision regardless of test optotype, overpredicting glare disability in 76% (average) of the study population. Glare disability overpredictions fell to 8% on the medium setting with ± 2 lines of vision classified as "no change." Using the same criterion, the Miller-Nadler glare tester overpredicted glare disability in 2% of the cataract population but underpredicted glare disability in 62%. In this study, letter optotypes resulted in less variability than sinusoidal grating stimuli. In addition, we identify several methodological factors to consider before designing a glare experiment. These potential sources of error can influence the outcome of any glare study that compares indoor and outdoor acuity and include the study population, visual stimuli (optotypes), and elements of the outdoor testing situation.

Key Words: cataract, contrast, glare, methodology, optotype

High contrast Snellen letters, which traditionally have been used to assess visual acuity, are usually presented in a darkened refracting lane, a testing situation that provides incomplete information about the patient's ability to function in the multicontrast world outside the examining room. Determining visual acuity in the presence of a glare field[1,2] is a quantitative method of objectively documenting the debilitating effect of light scatter from media opacity. The patient, however, is the ultimate authority in assessing whether changing vision from opacities, such as a cataract, impairs lifestyle. While commercial glare testers have only been available since 1983, these standardized instruments have already become a valuable part of the visual assessment of many cataract patients. Although there is no question about removing a cataract in a patient whose visual acuity is 20/400, the decision to operate on a patient whose acuity is 20/50 is not so clear. The numerical results from glare tests help substantiate the patient's need for a cataract extraction.

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curate documentation of functional visual loss is sential, but existing studies that have tried to weigh e relative sensitivity of various instruments may not ve been conclusive. This study compares the relative nsitivity of two commercial glare testers with two totypes (sinusoidal grating at various contrasts rsus high contrast letters).

In addition we identify several methodological fac- rs to consider before designing a glare experiment or nen interpreting other studies in the literature. ese potential sources of error can influence the tcome of any glare study that compares indoor to tdoor acuity and include the study population, visual muli (optotypes), and elements of the outdoor test- g situation. Statistical methods to determine the are disability over- and underprediction rates accu- ely are also discussed.

MATERIALS AND METHODS

tient Population

The subjects were recruited from two populations: patients who were found to have cataracts upon utine screening and (2) control patients without taracts. All subjects had normal retinas, visual path- ys, and visual cortical function. None demonstrated rneal opacities or had previous corneal surgery. The treous was examined for clarity by direct and indirect hthalmoscopy and individuals demonstrating vitreal anges were not included in the study. After optically rrecting for myopia, presbyopia, and hyperopia, the ly ocular and functional difference between control d study patients was the presence of an early taract. We specifically used patients with minimal taracts (average indoor visual acuity 20/46 ± 24 SD). nce the purpose of this investigation was to evaluate e relative sensitivity of the various instruments to edict outdoor functional vision, we excluded patients th significant cataracts whose data would tend to scure the study's conclusions. Patients with dense taracts would have impaired acuity indoors and tdoors, regardless of instrument, thus producing an tificially high correlation coefficient.

The average age for controls (N=51) was 34.4 years, th ages ranging from 17 to 75 years; 37 were females d 14 were males. Cataract patients (N=47) were gnificantly older, with a mean age of 72.7 years nging from 48 to 85 years; 27 were female and 20 ere male. Each patient contributed data from one eye ly and the same eye was used in all testing condi- ons. Prior to enrolling in the study, all patients ceived a detailed description of the study and their pected participatory role.

struments

Glare disability was assessed with two instruments: iller-Nadler glare tester (Titmus Corporation, Pe- rsburg, VA) and the brightness acuity tester (BAT—Mentor, Norwell, MA). These were used in conjunction with two optotypes: a high contrast letter chart and the Vision Contrast Test System 6500 chart (VCTS—Vistech, Dayton, OH) which is composed of varying contrast sinusoidal gratings. Performance on both optotypes was evaluated with the same glare source (BAT). All light measurements were determined with a United Detector Technology model 40× light meter, cosine correlated.

Miller-Nadler Glare Tester. This is a contrast test[3,4] surrounded by a uniformly bright light source.[5-9] The instrument uses a 20/400 black Landolt C, with a background annulus that becomes progressively darker. The orientation of the "C" changes in one of four directions. A bright projector screen (420 foot-lamberts) serves as a constant glare source, surrounding the target "C" and the annulus. The final glare disability score, expressed as a percentage, is converted to a Snellen equivalent from a table provided by the manufacturer.

Brightness Acuity Tester. The BAT provides a uniform glare source by projecting light onto a 60 mm white diffusing hemisphere with a 12 mm viewing port.[10] The instrument resembles an ice cream scoop with a hole in the center. Testing was conducted at two luminance settings, high and medium. The BAT provided an average luminance of 400 foot-lamberts at the highest luminance setting and an average luminance of 100 foot-lamberts at the medium setting. These settings are roughly equivalent to brightness reflected from a white sand beach (high) or from the surrounding foliage (medium) on a clear day when the overhead illuminance is 10,000 foot-candles.

Testing Procedure: Optotype

Indoor and outdoor testing were randomized as was the order of instrument presentation.

Early Treatment Diabetic Retinopathy Study (ETDRS) Acuity Chart. In this study we elected to use the ETDRS eye chart, a modified Bailey-Lovie chart, that corrects for several deficiencies associated with the conventional Snellen acuity chart.[11,12] The ETDRS chart contains the same number of letters per line. Therefore one mistake per line has the same meaning at different levels of acuity. There is a regular progression in letter size and each line has letters of equal difficulty. Two ETDRS acuity charts with different letters were used indoors and outdoors at a standard viewing distance of 13 feet.

The subject's acuity was determined by totaling the number of letters correctly identified (X in the following equation) and converting this score into a direct Snellen equivalent (Table 1):

$$\text{Equivalent Snellen acuity} = 20 * \left[10^{(55-X)/50}\right]$$

An outdoor vision score that was worse than predicted was considered to be a glare disability under

Table 1. Conversion table for ETDRS chart to Snellen equivalent.

Total Number Correct ETDRS	Snellen Equivalent 20/	Total Number Correct ETDRS	Snellen Equivalent 20/
0	251.79	36	47.98
1	240.45	37	45.82
2	229.63	38	43.76
3	219.30	39	41.79
4	209.43	40	39.91
5	200.00	41	38.11
6	191.00	42	36.39
7	182.40	43	34.76
8	174.19	44	33.19
9	166.35	45	31.70
10	158.87	46	30.27
11	151.72	47	28.91
12	144.89	48	27.61
13	138.37	49	26.37
14	132.14	50	25.18
15	126.19	51	24.05
16	120.51	52	22.96
17	115.09	53	21.93
18	109.91	54	20.94
19	104.96	55	20.00
20	100.24	56	19.10
21	95.73	57	18.24
22	91.43	58	17.42
23	87.30	59	16.64
24	83.37	60	15.89
25	79.62	61	15.17
26	76.04	62	14.49
27	72.62	63	13.84
28	69.35	64	13.21
29	66.23	65	12.62
30	63.25	66	12.05
31	60.40	67	11.51
32	57.68	68	10.99
33	55.08	69	10.50
34	52.61	70	10.02
35	50.24		

prediction. Conversely, outdoor acuity improvement was recorded as a glare disability overprediction. Instrument over- and underprediction rates, or line differences, were established for each individual by determining the total difference in the number of letters identified indoors and outdoors. This difference score was then divided by five, the number of letters per line on the ETDRS chart.

Indoors, the ETDRS chart was affixed to an open black box and obliquely illuminated (52 foot-candles) by two vertically placed 30 inch fluorescent lights that could not be directly seen by the subject. The overhead room lights were turned off. The illuminance from the chart and box at the subject's eye level position 13 feet away was negligible, 0.4 foot-candle (i.e., no glare effect). The ETDRS chart was viewed with the BAT. at the high and medium luminance settings.

When measuring outdoor acuity, the ETDRS eye chart was mounted on an easel with the 20/160 line (center of the chart) approximately at eye level. The chart was positioned so the subject would face the sunlight directly. Illuminance measurements were taken directly overhead and at eye level in the direction of the chart. The latter procedure measured light impinging on the cornea. Data were not collected if the direct eye level illuminance was less than 4,000 foot-candles.

VCTS 6500 Eye Chart. This eye chart combines visual acuity and contrast sensitivity tests.[13] The chart is composed of vertical and oblique sinusoidal bar gratings that subtend approximately one degree of retinal area at ten feet. Each of the five gratings is similar in visual angle to letters found in the standard Snellen acuity chart. Along each acuity line the bar gratings become lower in contrast by an average of 0.2 log units while maintaining the same spatial frequency. The chart was used both indoors and outdoors, at the recommended viewing distance of ten feet.

Indoor testing was conducted with the overhead fluorescent room lights turned on (620 foot-candles) which illuminated the VCTS chart with 64 foot-candles. After the examiner demonstrated the three possible orientations of bar gratings (examples provided at the bottom of the VCTS chart), each subject began on line "C" (6 cycles/degree-medium spatial frequency). Subjects continued to identify the orientation of the decreasing contrast patches on line "C" (6c/d) until they were unable to resolve the stimulus. The last perceivable grating determined the acuity score which was converted to Snellen acuity based on the manufacturer's equivalent acuity score. If two acuity scores could be assigned to a particular grating, the two scores were averaged. This procedure was then repeated for the two higher spatial frequency lines (narrower bars) "D" (12c/d) and "E" (18c/d). Only the best acuity from these three acuity scores constituted the Snellen acuity score recorded as datum. If the patient was unable to see any grating, he or she was assigned an acuity of 20/251, equivalent of zero letters correct on the ETDRS chart. Testing was conducted at two BAT luminance settings: high and medium. Guessing was eliminated by repeating segments of the test. Outdoors, the VCTS chart was placed on an easel against a bright sun backdrop.

Instrument Procedure

Miller-Nadler Glare Tester. The examining room lights were turned off and the subject's pupil was aligned with the eye level marker on the side post of the headrest. The subjects were then instructed to fixate on the Landolt "C" and to note each of its four possible orientations. Beginning with the highest contrast slide, the subject informed the examiner of the letter orientation. The examiner then proceeded to slides of lower contrast until the patient could not correctly determine the orientation of the Landolt "C". The subject's glare disability score was determined by the last correctly perceived slide. On the second trial the descending staircase method of limits was used to ensure data reliability and validity: the examiner randomly advanced three to six slides above threshold and again proceeded to present slides of reduced contrast. An acceptable data point was within one slide of the previous threshold point. To eliminate guessing, certain slides were repeated at the examiner's discretion. The glare disability score was then converted to an equivalent Snellen acuity using a table furnished by the manufacturer. The predicted acuity was compared to the outdoor ETDRS letter-chart acuity.

Brightness Acuity Test. For the ETDRS (letters) and VCTS (sinusoidal gratings) charts the subject held the BAT vertically, positioned to allow a direct view of the chart optotype, unobstructed by the edge of the 12 mm aperture, thereby avoiding acuity loss secondary to the penumbra phenomenon. The light source was then set to the brightest intensity and the subject was given 20 seconds to adapt to the glare field before beginning acuity testing. After acuity testing was performed at the high setting, the intensity was lowered to the medium setting and the subject was given 90 seconds for retinal recovery before determining acuity at the reduced luminance setting. For all conditions the subjects were asked to identify the largest letters first, reading lines right to left or left to right in a random fashion to minimize memorization.

Outdoor Testing Conditions

Testing was conducted at the edge of a lightly pigmented concrete parking lot surrounded by a grass field extending 200 yards which abutted several two-story white apartments and four 30-foot trees. The background environment occupied an average of 15 degrees of visual field as determined by sextant measurement. We tested between 8:00 AM and 1:30 PM from August to October. The subjects all faced the eastern sun which subtended an angle of 30 to 80 degrees above the horizon, producing overhead light readings averaging 9,277 foot-candles and 6,376 foot-candles at eye level. The light levels at the eye (along the patient's line of sight) ranged from 4,200 foot-candles to 8,100 foot-candles and did not differ significantly between cataract and normal populations with almost identical mean and standard deviations for the two groups: normals 6,296 foot-candles (1,039 SD); cataract patients 6,316 foot-candles (993 SD). To assess further the effect of variation in outdoor light levels among cataract patients, a stepwise regression was run with illuminance as the first stepwise predictor. The results of this analysis showed outdoor illuminance to be a poor predictor of outdoor acuity ($r = -.09$, not significant $P = .73$), suggesting that the influence of outdoor light variability among cataract patients was minimal.

RESULTS

Controls

Controls had an average acuity of 20/20 (2.11 SD) indoors with both letter and sinusoidal grating regardless of BAT glare intensity. Outdoor acuity was also 20/20 (1.18 SD). The Miller-Nadler glare tester tended to overpredict glare disability slightly in controls (i.e., predict worse visual acuity than obtained outdoors) with an average predicted acuity of 20/24 (0.66 SD).

Cataract Patients

ETDRS Letter Chart with BAT Glare Source. The average visual acuity indoors taken in a dark refracting lane was 20/43.41 (18 SD) for cataract patients and decreased with increasing BAT glare intensity. With the BAT at high intensity, mean acuity was 20/93 (63 SD); it dropped to 20/59 (41 SD) when the glare source was reduced to the medium setting. This indoor acuity difference between the two light settings was significant, $P = .0002$. Outdoor visual acuity among the minimal cataract patient population was 20/45.13 (17 SD) but predicted visual acuity at both BAT settings, high and medium, was significantly different than readings obtained in the outdoor glare situation (paired t-test BAT high, $t = 5.93$, $P < .001$; BAT medium, $t = 2.83$, $P = .007$).

Figures 1 and 2 show individual data points and the regression line for outdoor acuity versus indoor vision with the BAT at high ($r = +.48$) and medium ($r =$

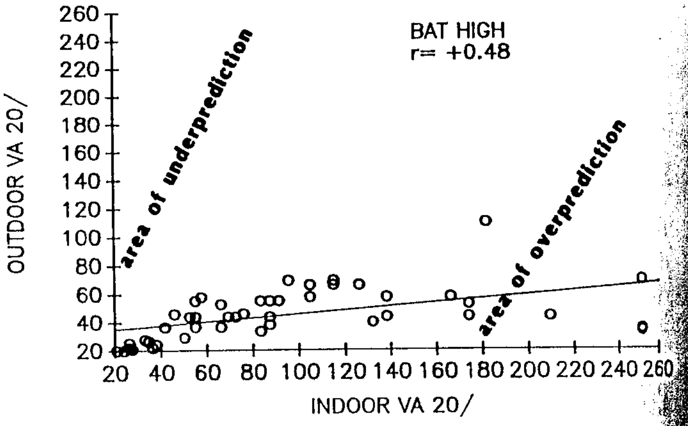

Fig. 1. (Prager) Scattergram of indoor visual acuity with BAT at the high luminance setting versus actual outdoor acuity for 47 subjects with minimal cataracts. A line of best fit is drawn through the data. The BAT was used in conjunction with high contrast letter optotypes. Areas of glare disability under- and overprediction are indicated.

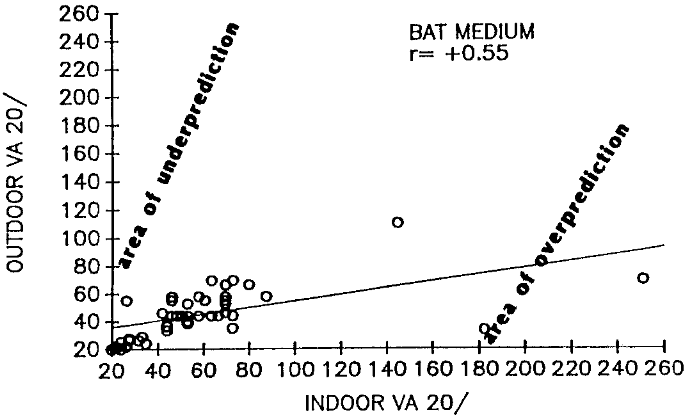

Fig. 2. (Prager) Scattergram of indoor visual acuity with BAT at the medium luminance setting versus actual outdoor acuity for 47 subjects with minimal cataracts. A line of best fit is drawn through the data. The BAT was used in conjunction with high contrast letter optotypes. Areas of glare disability under- and overprediction are indicated.

+ .55), respectively. Even though the BAT at the medium setting significantly correlated to outdoor acuity, only 30% of the total variability can be accounted for (R^2) with the 70% majority of variability unexplained. Note that datapoints in the lower right aspect of the graphs represent the area of glare disability overprediction (outside acuity found to be better than expected), whereas the area of glare disability underprediction (outside vision worse than instrument prediction) lies on the upper left portion of the plot.

A histogram of the percentage of the cataract population demonstrating lines of vision lost, gained, or remaining the same from indoor vision at high (upper aspect) and medium (lower aspect) BAT settings to outdoor conditions is depicted in Figure 3. For purposes of this analysis a change of plus or minus one line was considered no change (same). It is evident that the BAT at the high setting overpredicted glare disability in the minimal cataract population, with 70% of the patients demonstrating better vision outdoors than predicted. No patient demonstrated a glare disability underprediction, whereas 30% had no change in vision. The reduced glare condition, medium setting, showed a marked change in the number of overpredictions from the brightest BAT condition with the false-positive rate falling to 31%. If the criterion of "no change" were extended to include plus or minus two lines of vision, the number of glare disability overpredictions would fall to 8%; glare disability underpredictions would remain at 2%. The majority of the population demonstrated no change in vision (67% one line criterion, 90% two line criterion). These findings compare favorably with the results from other investigators.[16]

VCTS (Sinusoidal Grating Chart) with BAT Glare Source. Similar to letter stimuli, the grating optotype evoked only a slight change between indoor acuity without a glare field and outdoor acuity: indoors 20/44.84 (21 SD) and outdoors 20/55.77 (38 SD). The relative amount of variability in the outdoor condition was almost twice that found with the ETDRS letter chart (SD divided by the mean, 38% letters versus 68% gratings). The mean acuity values with the BAT and sinusoidal gratings were higher than the scores from the BAT and letter stimuli. In other words, the varying contrast grating stimuli in conjunction with the BAT predicted more glare disability than the same amount of glare and high contrast letters (sinusoidal grating — BAT high 20/146.04 (94 SD), BAT medium 20/73 (55 SD). Although a separate one-way analysis of variance showed no significant difference between letter and sinusoidal grating acuity when the BAT was at medium brightness, a significant difference was noted between indoor visual acuity with the BAT at high and with it at medium with sinusoidal gratings ($t = 5.51$, $P < .0001$).

Outdoor visual acuity was significantly better than predicted by the BAT at both brightness levels. This glare disability overprediction was more evident at the

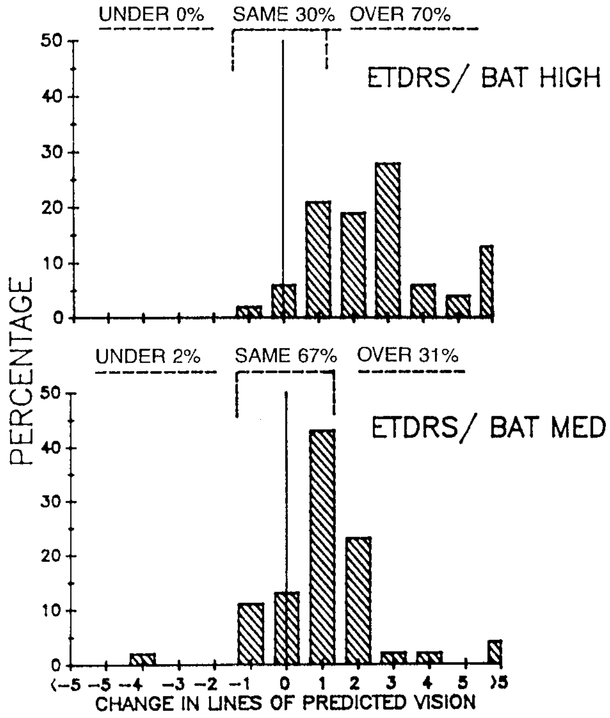

Fig. 3. (Prager) The percentage of the cataract population that saw better outdoors than predicted (glare disability overprediction), same as predicted, or worse than predicted (glare disability underprediction). Percentage change is in lines of vision. A change in outdoor vision that is plus or minus one line of predicted vision is no change (same). The upper aspect of the figure depicts data from letter optotypes and the BAT at the highest luminance setting; the lower aspect graphs data from letters and the BAT at medium intensity.

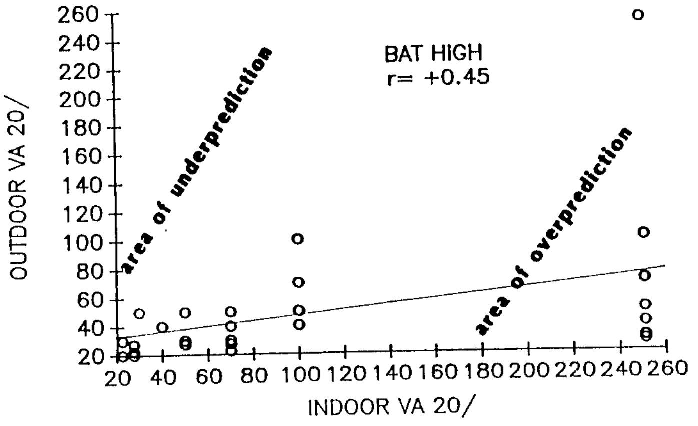

Fig. 4. (Prager) Scattergram of indoor visual acuity with BAT at the high luminance setting versus actual outdoor acuity for 47 subjects with minimal cataracts. A line of best fit is drawn through the data. The BAT was used in conjunction with varying contrast sinusoidal gratings. Areas of glare disability under- and overprediction are indicated.

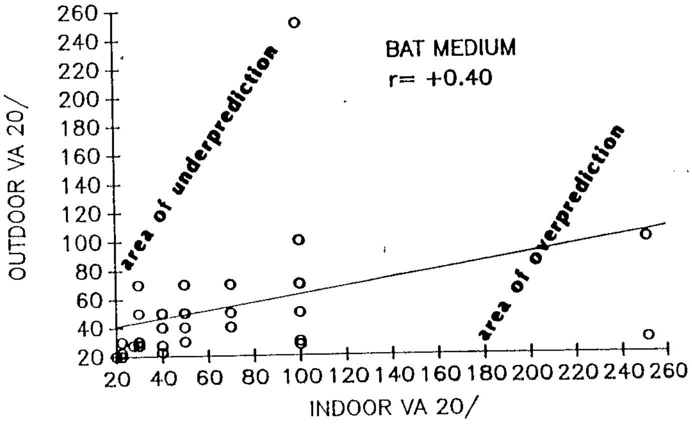

Fig. 5. (Prager) Scattergram of indoor visual acuity with BAT at the medium luminance setting versus actual outdoor acuity for 47 subjects with minimal cataracts. A line of best fit is drawn through the data. The BAT was used in conjunction with varying contrast sinusoidal gratings. Areas of glare disability under- and overprediction are indicated.

high glare setting than at the medium glare setting (BAT high $t = 7.37$, $P < .001$; BAT medium $t = 2.23$, $P = .03$). The individual data points for indoor (predicted acuity) versus outdoor vision (obtained acuity) and the linear regression line are plotted for sinusoidal grating stimuli with the BAT at high illuminance, Figure 4, and at medium illuminance, Figure 5. The correlation between predicted and obtained acuity was +.45, BAT high, and +.40, BAT medium.

The change in lines of vision from the indoor testing condition at the two BAT luminance settings to outdoor acuity reveals the same trend toward glare disability overprediction with increasing glare light as found with letter stimuli, but with an apparent reduction in predictive precision. At the high BAT setting (upper aspect of Figure 6), 81% of the minimal cataract population demonstrated glare disability overpredictions, 17% had the same vision, and 2% showed glare disability underpredictions. More than 11% of the cataract patients were overpredicted at high luminance with the sinusoidal gratings than with letters. At the medium BAT setting, 42% of the population were overpredicted; 48% demonstrated no change in vision, and 10% were underpredicted. Taking the more liberal criterion of plus or minus two lines of vision as "no change" still shows 27% of patients with glare disability overpredictions at the medium setting, a false-positive rate 19% more than found with letter stimuli, and the same amount of glare.

Miller-Nadler Glare Tester. The average predicted acuity for cataract patients was 20/29.17 (3.0 SD) versus 20/45.14 (18.0 SD) for outdoor acuity. In other words, most subjects had glare disability underpredictions; their outdoor acuity was worse than predicted. Figure 7 shows the individual data points and linear

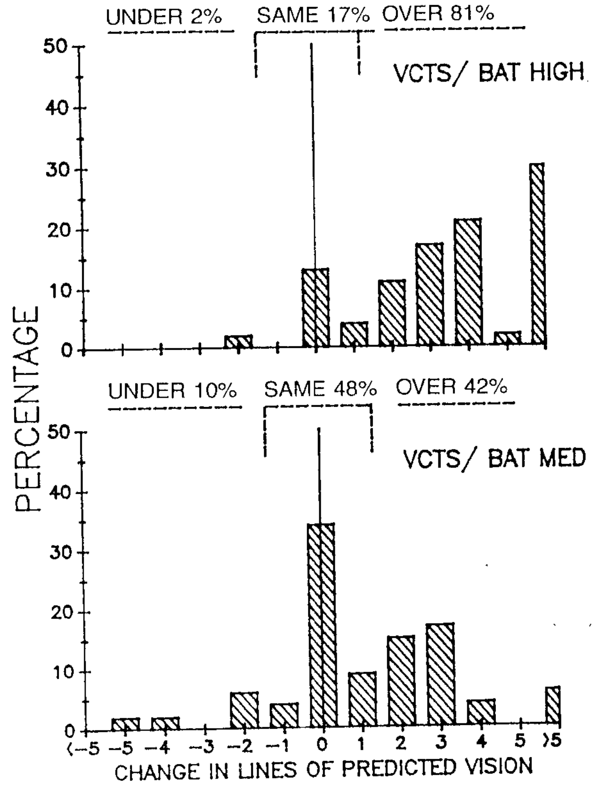

Fig. 6. (Prager) The percentage of the cataract population that saw better outdoors than predicted (glare disability overprediction), same as predicted, or worse than predicted (glare disability underprediction). Percentage change is in lines of vision. A change in outdoor vision that is plus or minus one line of predicted vision is no change (same). The upper aspect of the figure depicts data from sinusoidal grating optotypes and the BAT at the highest luminance setting; the lower aspect graphs data from sinusoids and the BAT at medium intensity.

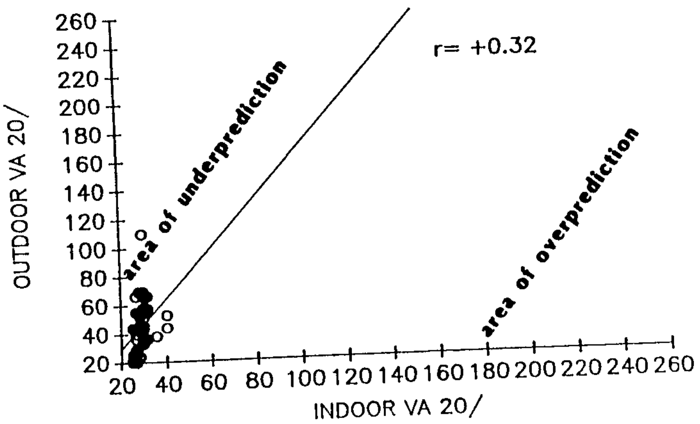

Fig. 7. (Prager) Scattergram of indoor visual acuity as determined by the Miller-Nadler glare tester versus obtained outdoor acuity for 47 subjects with minimal cataracts. A line of best fit is drawn through the data. Areas of glare disability under- and overprediction are indicated.

regression line between indoor predicted vision with the Miller-Nadler glare tester and acuity obtained outdoors using the ETDRS chart. There was a weak but significant correlation of +.32 ($t = 6.48$, $P < .001$). Only 10% of the variability can be accounted for, with over 90% unexplained. A line difference analysis between predicted and obtained values (Figure 8) shows only 2% of the population had glare disability overpredictions, 36% were the same, and the majority, 62%, demonstrated glare disability underpredictions. By extending "no change" to include plus or minus two lines of vision, no one was overpredicted by this instrument.

DISCUSSION

This study sought to determine the relative sensitivity of several commercially available glare testers in predicting glare disability/outdoor acuity in a population of patients with minimal cataracts. Although both instruments demonstrated a significant correlation between indoor and outdoor acuity, they also showed a significant difference between predicted outdoor acuity and obtained visual acuity.

The BAT at the high setting was inaccurate in predicting outdoor vision regardless of test optotype, overpredicting glare disability by an average of 76% in the study population using a criterion of plus or minus one line as no change in vision. This was expected since our testing conditions were not equivalent to a snow-covered field or a white-sand beach. Even with a reduction in glare luminance (BAT medium), over 37% of the cataract patients had better acuity in the bright sunlight than predicted. By reducing the criterion of "no change" in outdoor vision to plus or minus two lines of vision, the false positive rate fell to a more acceptable 8% with letter stimuli. The Miller-Nadler glare tester consistently underpredicted glare disability (false negative rate 62% ± 1 line criterion). Although these results suggest instrument sensitivity to be less than that of other testers, at least the data from an instrument that rarely overpredicts glare disability (2%) will not provide information that could lead to an unnecessary surgery.

A recent article by Legge et al.[14] concludes that change in acuity or resolution is inversely proportional to the square root of contrast; thus, glare should affect contrast more than letter perception. In this experiment we found that in the absence of a glare field, high contrast letter stimuli demonstrated essentially the same visual acuity as found with multicontrast sinusoidal gratings (20/43 versus 20/45). In the presence of the same medium intensity glare source, the varying contrast sinusoidal stimuli did predict greater glare disability than the high contrast letters (20/73 gratings, 20/59 letters). This same trend was noted outdoors, with patients demonstrating somewhat greater disability with the reduced contrast bar gratings (20/56 gratings, 20/45 letters). However, patient data from both optotypes led to glare disability overpredictions with the BAT at medium intensity.

Theoretical and clinical studies have proven the need for contrast sensitivity testing; however, the choice of target is subject to debate. It is not clear that sinusoidal gratings are superior to letters. From a theoretical perspective, sinusoidal gratings are simpler than letters because sinusoidal grating stimuli only

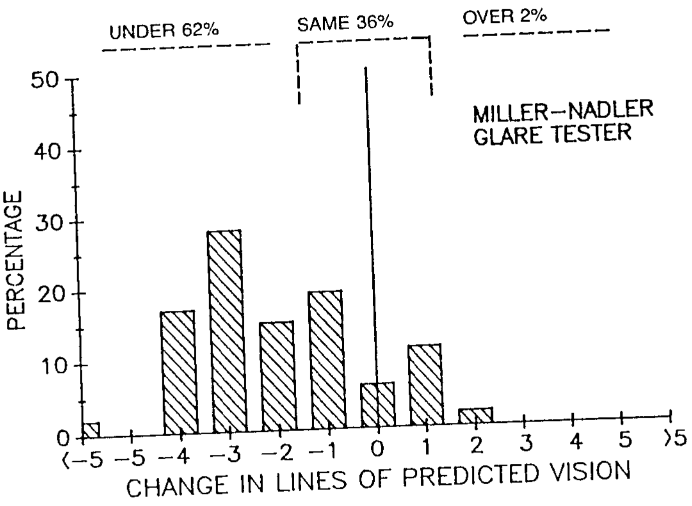

Fig. 8. (Prager) The percentage of the cataract population that saw better outdoors than predicted (glare disability overprediction), same as predicted, or worse than predicted (glare disability underprediction). Percentage change is in lines of vision. A change in outdoor vision that is plus or minus one line of predicted vision is no change (same). Data was collected using the Miller-Nadler glare tester.

contain a fundamental frequency as opposed to letters composed of higher frequency harmonics. Because of this difference in spatial frequencies between sinusoids and letters, there is only an approximate conversion, in terms of acuity, between the two optotypes. Many cognitive skills used in educational and industrial situations center around the ability to read letters. In opthalmology Snellen letters have been used for over 125 years to measure visual acuity. The perception of letters with their many spatial frequencies is less susceptible to the degradating effects of astigmatism on visual acuity than sinusoidal gratings presented at just three orientations, when the odds of guessing correctly are very high—33%. The VCTS sinusoidal grating chart had forced choice alternatives within 45 degrees of one another, which could induce a bias against patients whose astigmatism is in the meridian being tested. We feel that the best chart for determining the effects of glare disability would use ETDRS letters, equated for equal line interval and letter difficulty at varying contrasts.[15] Optimally these charts would be mounted on a projector slide with a calibrated light source for ease of presentation.

Although the results of this controlled, prospective study indicate that instrument technology needs to be improved, several important methodological considerations must be taken into account when designing glare studies or when interpreting them. Special consideration should be given to the study population, optotype, and the outdoor testing situation. While our reported correlations are lower than others reported in the literature,[7,9,10] this may be due to our study population which included only patients with minimal cataracts and moderately reduced visual acuities. Including patients with dense cataracts, who will not see well indoors or outdoors regardless of instrument, will result in an artificially high correlation coefficient and loss of instrument sensitivity. An appropriate study population is required to validate functional complaints in patients with minimal pathological changes and abnormal glare results. Second, in an evaluation of glare testers using letter stimuli, it is important to use a chart that corrects for the previously identified drawbacks of the traditional Snellen chart.[11] Accurate computation of line differences and visual acuity can only result from a chart that contains an equal number of letters per line and equal increments between the lines. The same type chart should be used in both indoor and outdoor testing conditions. Conclusions are confounded, for instance, if sinusoids are used indoors and Snellen letters outdoors.[16] Finally, light readings at the eye should be measured and equated among the study patients; just reporting the angle of the sun is not sufficient since perceptual brightness changes with the angle of the sun, cloud conditions, and time of year. The influence of varying ambient light may be readily identified and minimized by stepwise regression or analysis of covariance. Without a detailed description of the outdoor testing conditions, it is impossible to equate glare test results collected in dissimilar environments such as the parking lot of the Houston Astrodome, a blacktop parking lot bordered by pine trees, and a testing situation using a solid white concrete wall that diffuses light uniformly. Research that clarifies and standardizes glare testing is important to allow accurate determination and documentation of a patient's visual complaint. However, to assess the validity/sensitivity of the various instruments, additional methodological considerations must be addressed and experiments designed and replicated to demonstrate that the theoretical issues found in the laboratory are clinically significant when evaluating cataract patients. The fact that these methodological considerations, by and large, have not been taken into account during the development of glare testing apparatuses should make us cautious about their use as valid documentation of functional disability.

The entire field of glare testing in cataract patients is evolving. One hopes that first generation instruments will lead to more sophisticated glare testers and/or calibration procedures that better correlate to real-world conditions. The results of this experiment only underscore the fact that there are no standards for glare type, illuminance, or target configuration. The most important conclusion for the clinician is that impairment of an individual patient's lifestyle should be the overriding consideration when discussing cataract surgery. This is more important than a score from an instrument.

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