On the Relation Between Intraocular Straylight and Visual Function Parameters

To the Editor:

Whitaker, Elliott, and Steen reported on the influence of a glare source on a visual function parameter. There has been a dispute about the basis of glare (review4) for different test configurations. Is glare caused by lateral neuronal interaction or the optical effect of light scattering (or a combination of these two)?

The paper by Whitaker et al might suggest that glare is only optically based. They defend a method for assessment of light scattering based on glare effects. But, in fact, matters are more complicated. The defended method makes use of the change in contrast threshold for sinusoidal gratings as result of a glare source. In general, assuming Weber's law holds, from a change in contrast threshold the amount of straylight must be proportional to the intensity of the glare source. The original method was replicated by Yager et al and found to fail the proportionality test. Also, the original authors found difficulty with the proportionality demand. Whitaker et al abandoned the use of gratings and used flicker instead. They stressed that the other parameters of the method are critical to avoid (proportionality) failure. Using flicker, they succeeded in Weber's law to hold to sufficient approximation over their range of the proportionality test. But this does not disprove Yager's finding, and it is no confirmation of the defended method. In fact, the method as defined by the original authors and copied by Yager was not studied.

The failures mentioned above are but a few examples that the relation between light scattering and visual function parameters is more complicated. It is especially remarkable that a glare source can improve sensitivity. A practical example for this was found in the case of the Vistech glare tester. In the Vistech, the test object is also a grating. The BAT glare tester (medium setting) was recently reported to improve contrast sensitivity. Both reports concern relatively low straylight levels. Indeed, contrast improves using the glare source of these instruments, an experience shared by many colleagues.

There are many nonglare studies that point to the same. Studies on the effects of surround illumination have shown improvements of sensitivity up to a factor of 5 for flashes, a factor of 3 for flicker (review3), and a factor of 10 for sinusoidal gratings. In all cases, improvements are largest when the surrounds are large, equiluminous, and contiguous with the test field. Straylight surrounds are by nature large and contiguous. When a straylight surround is equiluminous, the straylight in the center is less than equiluminous because straylight monotonically decreases with distance from the glare source. So, contrast reduction in the test field because of straylight is less than a factor of 2, and the examples from the literature all correspond to situations in which straylight can have larger improvement than deterioration effects. More recently, it has been shown that large sensitivity improvement effects can also result from rod-cone interaction (review10).

These examples show that the relation between straylight and sensitivity is not so straightforward. They are not given to suggest that improvement rather than deterioration is the rule. With other test conditions, deterioration effects may prevail and the optical effect may dominate. As proof, it would be needed to show that inferred straylight values equal true straylight values. The proportionality test is not enough. Whitaker et al found that the inferred straylight values for their subjects fell within the range of published straylight values for the normal population. Some older studies contain examples of conditions in which proportionality was found (review). Only one study directly compared sensitivity effects to measured straylight intensity. The result deviated from what was expected on the basis of the optical hypothesis.

To study the relation between intraocular straylight and visual function parameters, independent assessment of intraocular straylight would be needed. The method used should be free of lateral interaction effects and independent of model assumptions (such as Weber's law). To fulfill these demands, the "direct compensation method" was designed (review1). To avoid neuronal (de)sensitizing interaction effects, no sensitivity (difference) was measured. Instead, in 8 Hz alternation, a (distant) glare source and a foveal test light were presented so that straylight was (quasi) instantaneously compensated with test light. Extinction of the induced foveal flicker was used as a criterion for identity between straylight and test light so that no model assumptions were needed. Because lateral retinal signal transport introduces phase shifts, as a test for potential lateral signal transport the phase shift for optimal compensation was used (unpublished data). This phase shift could not be discriminated from 180°, indicating absence of lateral signal transport.

In summary, there is abundant evidence that a glare source can influence (contrast) sensitivity because of (optical) contrast loss as well as lateral neuronal interactions. The layout of the glare experiment may be critical for the effect obtained. The (optical) contrast loss can be estimated using straylight measure-
ment. Lateral neuronal interactions need to be researched for current glare testing procedures.

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References


The authors reply:

Intraocular straylight arising from a peripheral glare source usually causes a reduction in visual performance, which may be termed disability glare. The issue in question is whether straylight and disability glare are interchangeable. In other words, can the level of straylight be predicted from disability glare measurements or, equivalently, can the reduction in visual performance caused by a glare source be predicted from direct measurements of straylight.

In a recent paper, we demonstrated that intraocular straylight estimated on the basis of disability glare measurements varied in direct proportion to the intensity of our glare source. If this were not the case, the only conclusion could have been that factors other than straylight played a part in determining disability glare. We went on to specify several situations in which this type of proportionality may break down and highlighted factors other than straylight that, under certain conditions, could influence the observed level of disability glare. Included in this list were the factors van den Berg identifies, namely, lateral neuronal interaction between the glare source and the stimulus and facilitatory effects of increasing stimulus surround illumination in the presence of glare. The latter effect is simple to combat in practice simply by ensuring that an equiluminant border surrounds the stimulus used to measure disability glare, and it therefore merits no further consideration. The suggestion that lateral neuronal interaction effects have a significant role in disability glare measurements is, however, more important and is potentially fatal to any attempt at predicting straylight from measurements of visual function with and without glare. Historically, distinguishing between straylight effects and neural inhibitory effects has been a matter of some concern. The situation is reviewed by Vos, who made the conclusion (which has been generally accepted for some time) that, at the sort of glare angles used in disability glare studies, it is quite justifiable to attribute the glare effect entirely to intraocular straylight and that long-range neural interactions play no part.

van den Berg points to a phenomenon he thinks indicates that lateral neuronal interaction effects play a part in disability glare testing. This is the observation that some subjects actually show an improvement in contrast sensitivity in the presence of a glare source. There are several potential factors that may counteract the reduction in image contrast caused by straylight. First, straylight from the glare source increases the retinal illumination level, which, in turn, may be associated with an improvement in contrast sensitivity. This effect was discussed in our report. In addition, one should consider the effect of practice because the subject becomes acquainted with the technique in the no-glare condition. With and without glare measurements should, therefore, be randomized. The improvement in the optical transfer function of the eye due to a glare-related reduction in pupil size may also improve visual performance at retinal illumination levels in the Weber region. Chance variation in performance level could lead to an apparent improvement in performance, especially because this phenomenon only occurs at low glare levels where disability glare is expected to be close to zero. The latter factor will be