Glare Sensitivity in Relation to Age

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● THE visual sensation called glare is produced by light entering the eye in such a fashion that distinct vision is inhibited. If the glare-producing light is superimposed on a visual image so that contrasts are reduced, it is called veiling glare. When the luminances involved become exceedingly high, producing a dazzling effect, it is called dazzling glare; and when intense directed light interferes with normal retinal function, blinding or scotomatic glare is experienced. All types of glare reduce vision and make the performance of visual tasks harder, if not impossible (1).

In night driving, for instance, blinding or scotomatic glare produced by oncoming headlights seriously interferes with the visibility of objects on the road and thus jeopardizes the safety of drivers and pedestrians. Headlight glare has therefore been regarded as one of the most serious obstacles in the safety of night driving, and many efforts have been made to cope with it.

Means such as night driving goggles and tinted windshields are only illusionary remedies because they reduce road visibility to the same extent that they reduce glare, and have, therefore, no advantages but rather serious disadvantages (2, 3). Many attempts have also been made to reduce glare by avoiding specular reflections from the trim of vehicles, road surfaces, and objects on the side of the highway. Furthermore, illuminating engineering has shown that glare depends to a major extent on the brightness of an object in relation to its surround. The headlights which appear obnoxiously bright as seen against a dark background have no ill effects when seen against a bright background or the sun-lit sky. Scotomatic glare from headlights, therefore, does not seem too objectionable when experienced on a well-lighted city street, even when the four lights of a negligent driver are directed against the oncoming driver. The ill effects could therefore very well be eliminated by raising the over-all illumination prevailing on highways to such levels that the contrast between oncoming headlights and the brightness of the surround would be sufficiently reduced. However, this would require exorbitant expenses, and therefore the problem of glare cannot be easily solved in this fashion.

In the past, glare has often been regarded as a problem hard to deal with because one did not know how much of it had to be attributed to the physical nature of the light source, or sources, producing it, or the eyes of the individuals experiencing it. Only recently the properties of absorption and transmission of the various media of the eye have been studied sufficiently to understand the importance of absorption and scatter of light in the media as a factor eliciting the sensation of glare (4, 5, 6).

In studies on retinal sensitivity, and particularly through contact with photophobic patients it seemed desirable to obtain a quantitative measure of glare sensitivity. This appears useful in advising patients in the use of tinted lenses or sunglasses. In studies on tinted windshields (3), first quantitative measurements were made on glare sensitivity (2). Continuation of this work yielded a clear-cut relationship between glare sensitivity and the physiological state (age) of the individuals tested (7, 8). Thus, glare seemed to be an entoptic phenomenon, and in attempting to deal with it, the physiological conditions of the human eye at various age levels must be taken into consideration (9).

To study the effect of scotomatic glare an instrument was developed (3, 8) providing a glare source of 2-deg angular subtense at the center of a circular test field. On this test field are exhibited for identification visual targets at various distances and in different radial directions from the glare source (Fig. 1(a)). The glare source consists of a concentrated filament lamp, S_1, the light of which is collumated by a lens system, L_1, and sent through a plastic rod of 1-in. diameter. The rod is curved in a quarter circle and its end fits into a 1-in. center hole of a translucent plastic plate serving as target screen. The full luminance of the glare source is in excess of 15,000 millilamberts; by inserting filters in front of the source, F_1, the luminance can be reduced to $^1/_{10}$, $^1/_{100}$, $^1/_{1,000}$ and $^1/_{10,000}$.

The target screen is evenly illuminated by a second light source, S_2, variable in luminance in 10 percent steps between 0.00025 and 27.5 millilamberts. The luminance is varied by inserting neutral filters, F_2 and F_3, in the light path. On the target screen are exhibited Landolt rings (split rings) with an outer diameter of 0.3 in., and a gap width of 0.06 in. They are arranged in three concentric circles so that when the eyes of the observer are positioned 28 in. from the center of the target screen, the symbols of the outer circle are approximately 10 deg removed from the center of the glare source, those of the middle circle 7 deg, and those of the inner circle 4 deg (Fig. 1(b)).

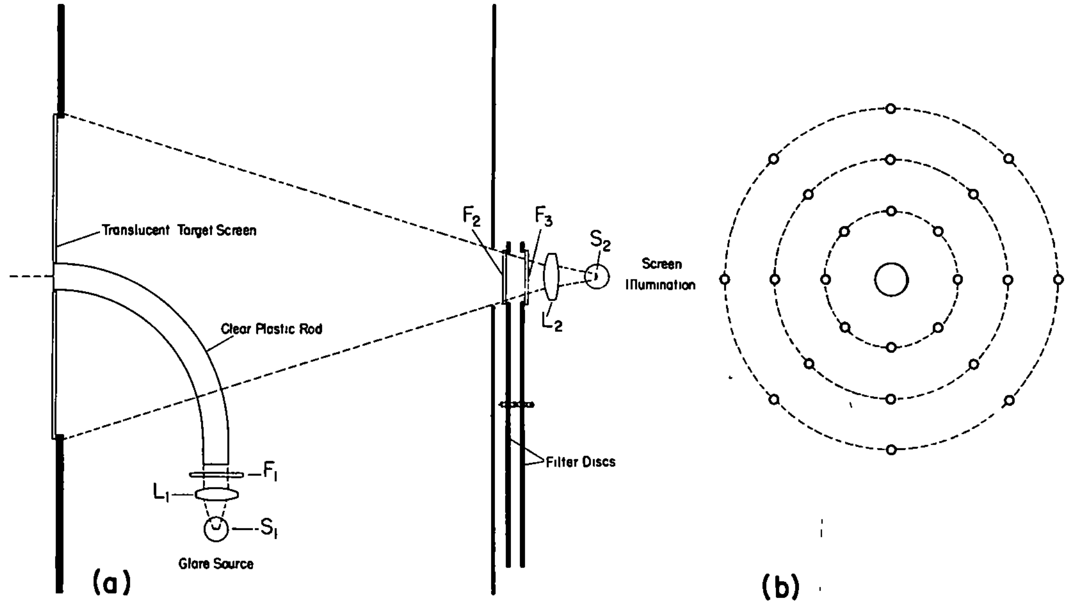

Figure 1. Diagram of (a) apparatus for testing visibility of visual targets at various distances from a glare source; and (b) target screen with circles indicating positions of targets in relation to glare source.

The observer is seated in front of the test instrument and his head held in position with the aid of a chin rest so that the eyes are at the same level as the glare source. During the test, however, he is permitted to move his eyes at will and to fixate and examine each symbol on the screen.

The tests are performed in a darkroom. When the glare source is turned on and the target screen is only weakly illuminated, all targets are invisible. The luminance of the target screen then is gradually increased until the details (the gaps in the Landolt rings) in the targets of the outer circle become visible. Then the illumination is further increased until the details of the targets of the middle circle become perceptible; finally, the luminance is increased until the details of the targets of the inner circle can be recognized. The measurements thus obtained represent luminance values for perceiving targets of fixed size at various distances from the glare source while, in addition, the luminance of the glare source may be varied between 1 and 15,000 millilamberts.

The first tests were carried out on a group of 19 college girls age 18 to 22 yr and not selected for high visual acuity. Several of the group wore glasses for correction of myopia and/or astigmatism. A second group consisted of 10 college men ranging in age between 19 and 26 yr and selected for 20/20 vision uncorrected. The results obtained with the two groups were surprisingly uniform, except that for the non-selected group the deviation from the mean was greater. When, however, individuals of advanced age were studied, it was found that the luminances required to see the gaps in the split rings were about ten times those needed by the individuals of college age.

For further studies, glare tests were carried out on more than 200 individuals ranging in age between 5 and 85 yr. The subjects were picked from the out patient depart-

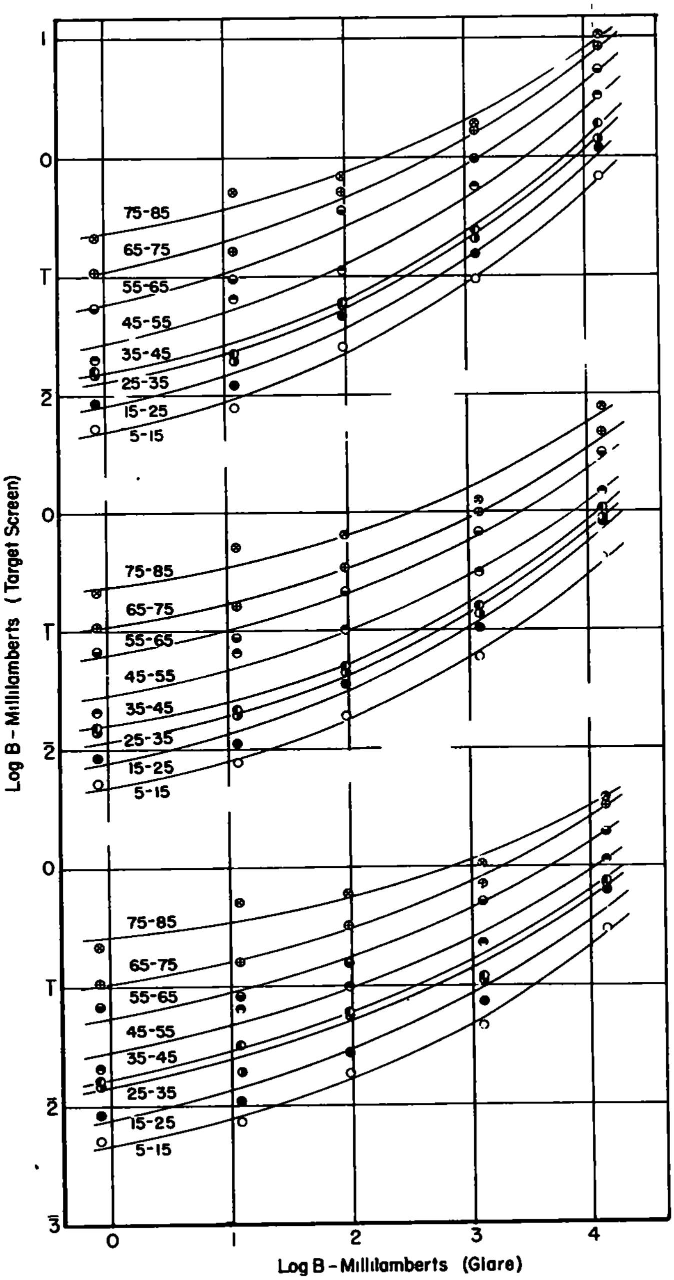

Figure 2. Relations of log. threshold luminances of target screen and log. glare luminances for nine groups of individuals in the age range between 5 and 85 yr. Top: thresholds for target recognition in the inner circle; middle: for target recognition in the middle circles; bottom: for target recognition in the outer circle of the target screen.

ment of the Mass. Eye and Ear Infirmary. With their clinical records available it was possible to use the information concerning their eye conditions and their corrective requirements. Cases in which pathological conditions prevailed were not included in this study.

In Figure 2 the results obtained in these tests are plotted on a coordinate grid, the abscissae representing the logarithms of glare luminance and the ordinates representing the logarithms of target screen luminances required for seeing the splits in the rings at angular distances of 10 deg (bottom), 7 deg (middle) and 4 deg (top) from the glare source. At low glare luminances the critical details are seen equally well at the three distances from the glare source, but when glare luminance is increased to 100 millilamberts and above, the luminance of the target screen must be made much brighter to see the targets 7 deg and 4 deg from the glare source than 10 deg from the glare source.

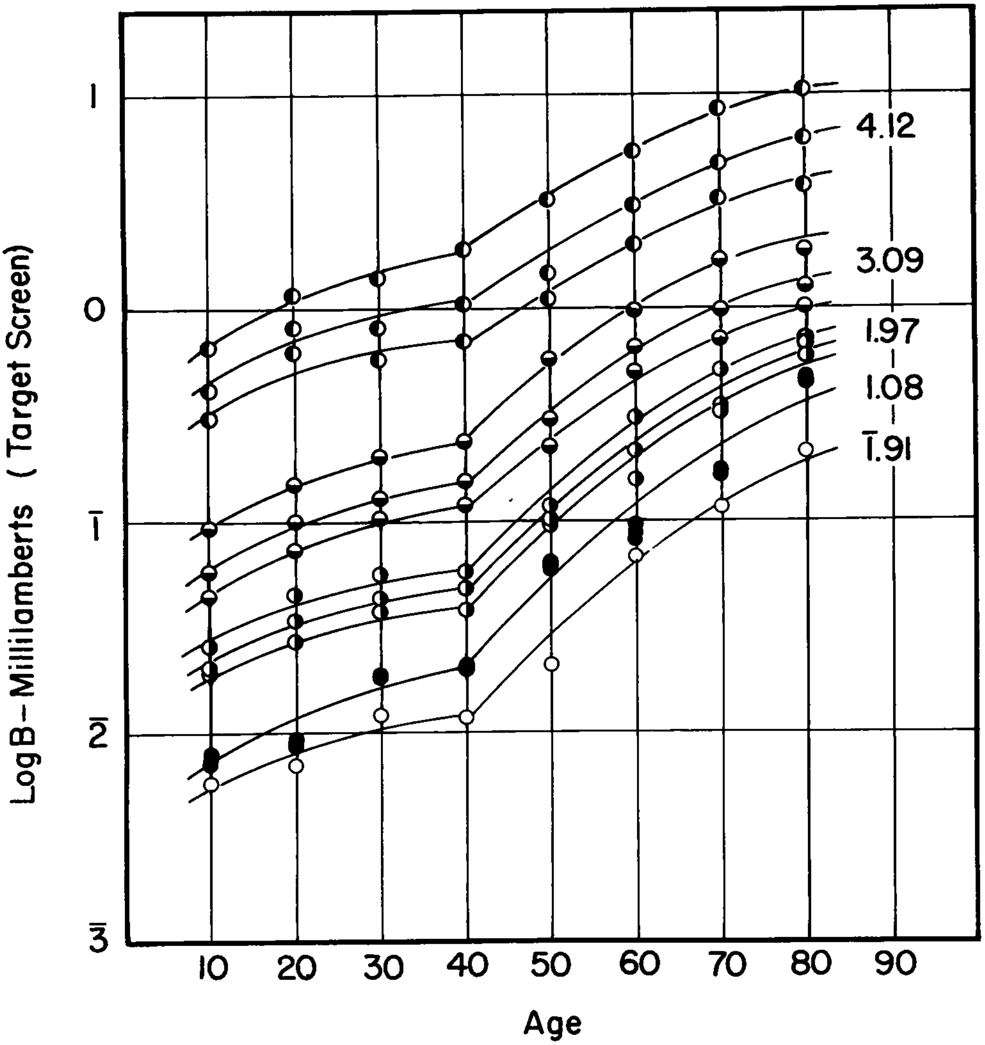

Figure 3. Log. threshold luminances for target recognition in relation to log. glare luminance plotted against mean age levels. The rise in log. target screen luminance shows a discontinuity at age 40.

Each curve represents the mean luminances for an age range of 10 yr; that is, 5 to 15 yr, 16 to 25 yr, 26 to 36 yr, etc., up to 76 to 85 yr. As age increases, the curves shift progressively to higher target screen luminance levels. The shift, however, is not the same for each 10-yr period, indicating that the increase in luminance required for seeing under glare conditions is not directly proportional to age.

This is shown more clearly in Figure 3, when plotting the logarithms of target screen luminance at various glare levels against age. The resulting curves rise slowly up to 40 yr, then suddenly change their slope and rise much more steeply in the range between 40 and 85 yr. The eye must therefore undergo some changes which make it progressively more difficult to cope with glare.

For a better understanding of the increase in glare sensitivity, especially above the age of 40 yr, the study of patients who have developed cataracts is extremely helpful. When in advanced age vision has been severely affected due to the fact that the lens has become opaque, this condition can be corrected by surgical removal of the lens. Tests on such patients before surgery yield glare curves which lie at excessively high levels of target screen luminance. After lens extraction, however, their glare curves fall back to, or below, the level characteristic for their age. This suggests that the opacities of the lens are responsible for producing the sensation of glare. To support this notion it should be mentioned that in eye examinations with an ophthalmoscope and slit lamp microscopy a noticeable increase in opacity of the ocular media is found as age advances.

Changes in visual function in relation to age have also been found in studies on dark adaptation (10, 11), and in determinations of critical flicker frequencies (12, 13). In both types of visual responses, a marked change in sensitivity above the age of 40 yr is indicated. These findings support the assumption that in the normal process of aging, the pace of change is accelerated above age 40. Measurements on the opacity of the lens and other ocular media which produce scatter of light resulting in the sensation of glare are now in progress and promise to yield a direct relationship between glare sensitivity and light scatter in the media of the eye. All evidence available at present justifies the assumption that glare is an entoptic phenomenon which must be regarded as a physiological problem for whose solution all the complex phenomena of the living human organism must be taken into consideration.

ACKNOWLEDGMENT

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