

Age and Glare Recovery Time for Low-Contrast Stimuli

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ABSTRACT

The purpose of this study was to obtain a rigorous experimental estimate of the time required to recover from the deleterious effects of glare. Low contrast test stimuli were employed to increase the potential sensitivity of the procedure. Multiple age groups were sampled since susceptibility to glare effects is known to increase with advancing years. Glare recovery time assessments were collected from 12 young, 12 middle-aged and 16 older adults. Subjects were presented with 10 sec exposures to an intense glare source under highly controlled experimental conditions. Upon the offset of the glare exposure period, the time required to regain sensitivity for low contrast test stimuli was measured. Relative to their younger counterparts, older subjects required 3-times longer to recover from glare exposure. These findings suggest that the dynamic components of glare effects must be considered when designing environments - especially where older observers involved.

INTRODUCTION

Disability glare occurs when the introduction of a stray light source reduces one's ability to resolve spatial detail. Advancing adult age is known to be associated with significant increases in the susceptibility to the deleterious effects of glare. Most models of disability glare attribute these effects to intraocular light scatter (Schieber, et al., 1991; Schieber, 1992). Such off-axis scattering of light within the eye covers the retina with a "veiling luminance" which effectively reduces the contrast of stimulus images formed upon it. For this reason, Schieber (1988) has proposed that low contrast optotypes are better suited for the quantification of disability glare effects than high contrast optotypes which are traditionally employed in glare assessment procedures.

One aspect of disability glare which remains poorly understood is the time required to recover visual sensitivity following a transient exposure to a brief glare source (e.g., exposure to oncoming headlights while driving at night). There is ample anecdotal evidence that the time needed to recover from glare increases with age. However, little systematic work has been done to substantiate this claim (see Olson and Sivak, 1984). The purpose of this study was to obtain rigorous estimates of the time needed to recover from the deleterious effects of glare and to examine how this index differs as a function of advancing adult age.

METHOD

Subjects. Letter contrast sensitivity and glare recovery times were collected from 12 young (ages 18-24), 12 middle-aged (ages 40-55) and 16 older (ages 65-74) adult volunteers. All participants were in reported good health and demonstrated visual acuities of 20/25 or better.

Apparatus and stimuli. Stimulus generation and control was accomplished with an IBM PC/AT computer equipped with a Metrabyte CTM-5 programmable clock module which was used to record response times with millisecond precision. The system also contained a modified Matrox PIP-1024 image processing board which enabled stimuli to be presented upon an Electrohome high-resolution monitor (white phosphor) with a gray-scale resolution of 12 bits (i.e., over 4000 unique gray levels). Test stimuli for both the contrast sensitivity and glare recovery assessment procedures consisted of the 26 letters of the alphabet which subtended 2-degrees of visual angle at the 6 m viewing distance. Test letters were presented in gray-on-white format against a constant background of 22 cd/m². The glare source consisted of a pair of 50W incandescent flood lamps which were mounted 5 degrees to the left and the right of the center of the display monitor. The glare lamps were mounted in hooded enclosures which prevented the extraocular mixing of light from the stimulus monitor and glare sources. Illuminance of the glare sources - measured at the entrance pupil to the eye - was 78 lux.

Procedure. *Letter contrast sensitivity* was assessed first so that a “challenging” - yet visible - low contrast target level could be established for each observer in the glare recovery time procedure. Following an 8 min dark adaptation period, the assessment was begun. Subjects were presented with a random pair of letters and asked to identify them. The first set of letters was shown at 50% contrast. Letter contrast was reduced in 0.1 log unit steps and a new randomized pair of letters was presented until the observer made an error reporting one or both of the stimuli. At this point, stimulus contrast was incremented in 0.03 log unit steps until the observer could correctly report both items in the randomized stimulus letter pair. The contrast at this point was recorded as the letter contrast threshold (1/threshold = sensitivity). The odds of correctly reporting a randomized letter pair by chance alone were 1 in 380.

Glare recovery time was measured next. Subjects experienced a 10 sec exposure to the dual glare sources. During the glare exposure phase, subjects were required to shadow (i.e., name aloud as quickly as possible) high-contrast letters which periodically appeared in the center of the stimulus display monitor. This assured that all subjects were looking directly between the dual glare sources. At the end of the 10 sec exposure, the glare sources were extinguished and a randomized pair of low contrast test letters appeared simultaneously on the display screen (The letter stimuli used to assess glare recovery time were presented at a luminance contrast which was 0.1 log units higher than each observers previously determined letter contrast threshold). The subject was instructed to press a button as soon as the letters could be recognized. When the button was pressed, the test letter stimuli disappeared and the subject was required to report which letters had appeared on the screen. Following the opportunity for a few practice trials, the time between the offset of the glare source and the button press signifying stimulus recognition served as a highly reliable index of glare recovery time. Three glare recovery time trials were collected and averaged. If a recognition error was made the trial was repeated.

RESULTS

Reference to Figure 1 reveals that advanced adult age was associated with an increase in the amount of contrast required to identify large stimulus letters. An analysis of variance revealed this age-related elevation in letter contrast threshold to be statistically significant ($F(2,37) = 5.62, p < 0.01$). Glare recovery time for suprathreshold low contrast letters was found to slow with increasing age ($F(2,37) = 12.66, p < 0.0001$). Reference to Figure 2 indicates that glare recovery time slowed progressively for both the middle-aged as well as the oldest group of observers. Statistical analysis support this impression: middle-aged observers required significantly more time to recover from glare than young observers ($F(1,22) = 7.06, p < 0.01$) but significantly less time than old observers ($F(1,26) = 8.52, p < 0.01$).

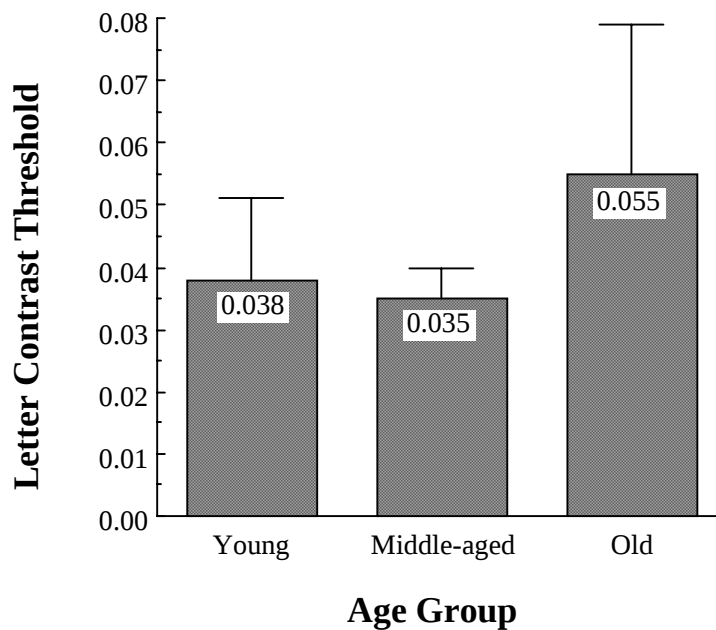


Figure 1. Letter contrast threshold as a function of age group.

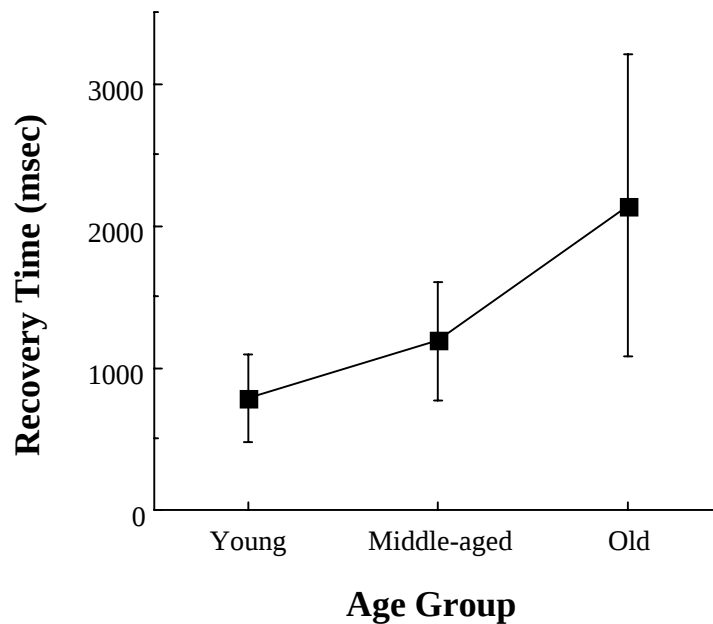


Figure 2. Glare recovery time as a function of age.

DISCUSSION

The observed age-difference in letter contrast threshold was consistent with previous observations of late-life declines in contrast sensitivity (Adams, et al., 1988; Schieber, et al., 1992). The more interesting findings involved the demonstrated age-differences in the time required to recover contrast sensitivity for large objects following exposure to an intense glare source. Older subjects required nearly 3-times longer to recover than their young counterparts (i.e., 2142 vs 790 msec). This difference occurred despite the fact that older observers - on average - were tested using stimuli presented at higher levels of luminance contrast (viz., 0.1 log units above their “elevated” letter recognition thresholds). Age-differences in simple motor response time cannot begin to account for the sizable magnitude of the observed increase in glare recovery time. That is, past research suggests that age-related differences in simple reaction time paradigms like the one employed here would be on the order of 50-100 msec (see Kausler, 1991) - far smaller than the 1352 msec age-difference observed here. Perhaps the most surprising result was the significant increase in glare recovery time required by middle-aged observers (i.e., 1189 msec) - despite the fact that they demonstrated letter contrast thresholds equivalent to those of the youngest subjects.

The observed age-related increases in glare recovery time for low contrast stimuli have design implications for nighttime driving environments. The target luminance level (22 cd/m²) was chosen to represent the adaptation state experienced by a nighttime driver facing oncoming low-beam headlight traffic at a distance of approximately 150 ft (Olson and Aoki, 1989). The intensity of glare source (79 lux) represented the challenge offered by an approaching (or closely

following) vehicle using high-beam headlamps (Olson and Sivak, 1984; Olson and Aoki, 1989). Under these conditions, older drivers would lose visual contact with targets having contrasts in the 0-10% range for a period of over 2 sec following exposure to a challenging glare source. Most rural and secondary roads without delineation treatments have effective contrasts which fall within this range of transient invisibility. Perhaps this is one of the reasons why older persons universally report problems with nighttime driving (e.g., Schieber, et al., 1992). On the other hand, it should be noted that the glare recovery time for high contrast targets approached zero for healthy adult observers regardless of age. That is, all of our observers could identify the high contrast letter targets which were presented while the glare source was exposed (Although this would not have been the case for some older adults had we not screened subjects for the ocular pathology such as advanced cataract). This clearly indicates the potential benefits which may be realized by older drivers following the broad application and maintenance of high-contrast roadway delineation treatments such as retroreflective roadway edge lines.

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