

Age Differences in the Legibility of Symbol Highway Signs as a Function of Luminance and the Presence of Glare: A Preliminary Report

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ABSTRACT

Three experiments were conducted to investigate the effects of adults aging upon the legibility of simulated symbol highway signs. Each experiment employed a different set of lighting conditions: (1) daytime luminance, (2) nighttime luminance, and (3) nighttime luminance with glare. Young (ages 18-25) and middle-aged (ages 40-55) observers demonstrated small reductions in legibility when luminance was reduced from daytime to nighttime levels. However, older (ages 65-79) observers demonstrated marked losses in legibility distance with reductions in sign luminance. The introduction of a glare source (equivalent to approaching automobile headlights at 30 m) reduced sign legibility distance for the older observers but had no deleterious effects upon their young and middle-aged counterparts. The relative magnitude of the observed age, luminance and glare effects appeared to be equivalent across all signs examined.

INTRODUCTION

In 1988, the Transportation Research Board (TRB) published the two-volume Special Report 218 which was titled *Transportation in an Aging Society: Improving the Mobility and Safety of Older Persons* (TRB, 1988). The reviews and recommendations contained in Special Report 218 have served as a *blue print* for guiding research and development on older driver issues at both the Federal Highway Administration (FHWA) and the National Highway and Traffic Safety Administration (NHTSA). One of those recommendations called for the study of how symbol (i.e., "pictorial") highway signs might be improved to accommodate the visual deficits which accompany advanced adult age. Pursuant to this recommendation, the FHWA sponsored a comprehensive research initiative known as the *Symbol Signing for Older Drivers* project. This large-scale, multi-site project examined the nature of age-differences in symbol sign visibility and comprehension, explored the factors mediating these age-differences and developed computer-based techniques for optimizing the visibility of symbol highway signs. Data collection and analyses have just recently been completed on the project (see Dewar, Kline, Mark and Schieber, 1994). Currently, numerous reports are under preparation for sharing the results of this work with the research and engineering community. This

report presents preliminary findings from one segment of the project; namely, laboratory research examining age-differences in the maximum legibility distance of symbol highway signs as a function of daytime vs. nighttime viewing conditions.

The visual functioning of older adults - as quantified via the contrast sensitivity function - is highly dependent upon prevailing lighting conditions. For example, age-related losses in visual sensitivity are relatively minor given luminance levels which approximate daytime viewing conditions. However, the magnitude of these age-related losses is greatly exacerbated at low luminance levels and in the presence of a glare source - conditions which often prevail while attempting to read highway signs at night. For these reasons, age-differences in the ability to read symbol highway signs were examined under three widely varying lighting conditions: (1) daytime - i.e., high photopic luminance, (2) nighttime - i.e., low photopic luminance, and (3) nighttime luminance with the addition of a narrow angle glare source.

METHOD

Subjects. Each experiment employed three age groups consisting of: 12 young (ages 18-25), 12 middle-aged (ages 40-55) and 18 older (ages 65-79) adult volunteers. All subjects were community-residents, held a valid driver's license and were screened for good general and visual health.

Apparatus and stimuli. Test stimuli consisted of 18 modified or redesigned symbol highway signs selected to represent the range of legibility distances found in a previous study of the 85 symbol signs depicted in the Manual of Uniform Traffic Controls and Devices. These signs were digitized, scaled and stored electronically using an Apple Macintosh IIci computer system. The computer-graphic representations of the signs were presented - at programmably variable sizes - on an Apple 13-inch color monitor viewed at a distance of 5.5 m. The variable size signs were presented in the center of the monitor against a uniform white background maintained at a high photopic luminance of 77 cd/m² (i.e., daytime level). For both the nighttime and nighttime with glare conditions, the luminance of the screen was attenuated to 5 cd/m² with a large optical filter. The glare source was mounted 5 deg to the left of sign stimuli and consisted of a single 40 watt high-diffusion incandescent lamp which subtended a visual angle of 0.6 degrees. The lamp was mounted in a housing which prevented the extraocular mixing of the glare light with that emitted from the stimulus display monitor. At the entrance pupil to the eye, the illuminance of the glare source was 8 lux - approximating the intensity of a pair of automobile headlamps viewed at a distance of 30 m.

Procedure. After preliminary assessments of visual acuity and contrast sensitivity, the subjects were introduced to the experimental task using a practice sign. To simulate increases in a sign's angular size as it is approached by a driver, the size of the sign - initially too small to be described - was incremented in 7% steps. After each step, observer's were requested to identify all of the sign's features that they could discern. The smallest size at which the participant could describe the structure of all of the critical features of a sign, according to predetermined scoring criteria, was recorded as its

threshold. These threshold angular sizes were then geometrically transformed to yield the equivalent maximum legibility distance for each of the 18 sign stimuli. The signs were presented to a subject using one of six predetermined random orders.

RESULTS AND DISCUSSION

Preliminary analyses revealed that reducing luminance from daytime to nighttime levels had a small but significant effect upon the legibility distances achieved by young and middle-aged adults (see Table 1 below). The addition of the glare source, however, failed to yield reliable reductions in performance for either of these age groups. Large losses in legibility distance were observed for the older subjects when luminance was reduced from daytime to nighttime levels. The magnitude of this age-related performance decrement was deepened given the introduction of the glare source. Yet, the size of the glare effect was relatively small. The nature of these age-related deficits is depicted in Figure 1 which presents the “gold standard” performance of the young observers under daytime luminance conditions along with the performance curves for the old groups under daytime, nighttime, and nighttime with glare lighting conditions. Although the figure shows wide sign-by-sign differences in legibility distance, the size of the age, luminance and glare effects appear to be of the same order of magnitude regardless of which sign is observed (Note the roughly parallel nature of the performance functions in log legibility distance space).

In order to convey the general magnitude of the effects of age and lighting conditions upon symbol sign legibility, a relative legibility factor - normalized to the average legibility of all signs viewed under daylight conditions by the young group - was calculated for each experimental condition. That is, the average legibility distance across all 18 signs was calculated for each of the 9 performance functions (i.e., (3) age x (3) lighting conditions). Each of these averages was then expressed as a ratio to the average performance of the young observers under daytime viewing conditions. These relative legibility factors are presented in Table 1. Hence, Table 1 depicts the relative reduction in general sign legibility distance observed as age was increased or lighting quality was decreased.

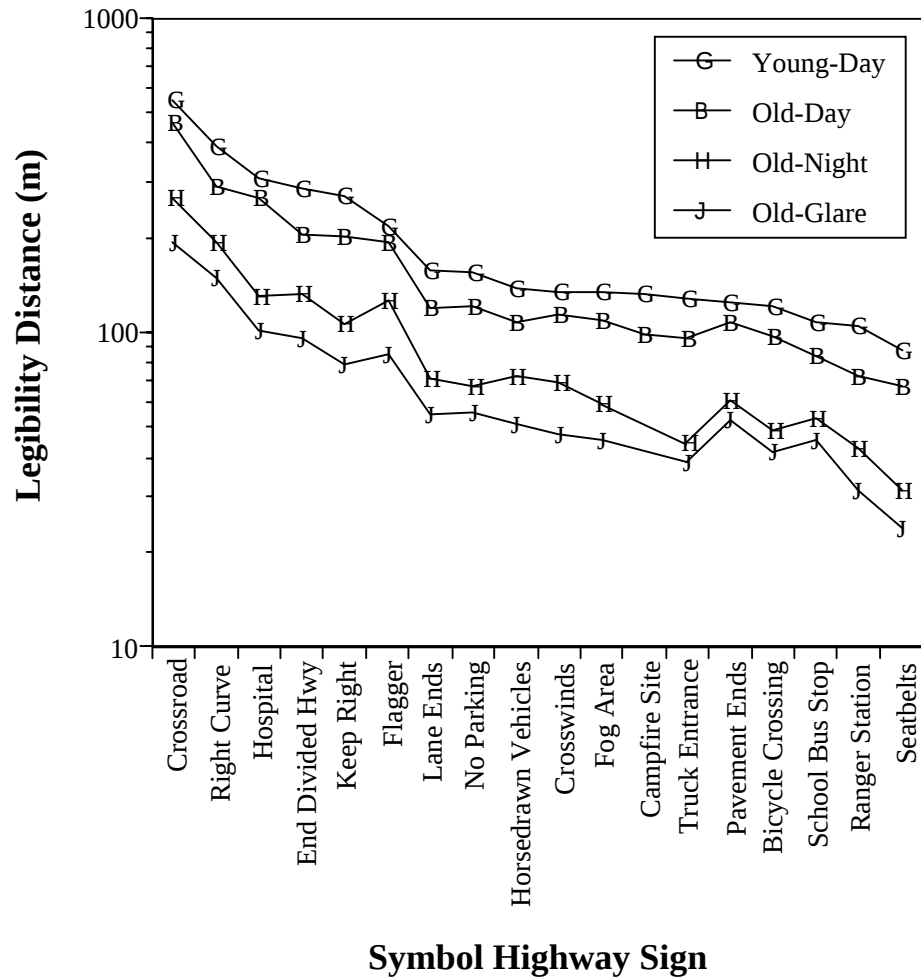


Figure 1. Legibility distances of older observers for a set of 18 symbol highway signs as a function of lighting condition. The ordinal position of the highway signs was determined by their rank-ordered legibility distances obtained from the sample of young observers under daytime viewing conditions.

Lighting Condition

<i>Age Group</i>	Daytime	Nighttime	Nighttime + Glare
Young	1.00	0.70	0.69
Middle-aged	0.88	0.60	0.60
Old	0.80	0.46	0.34

Table 1. Relative reduction in average sign legibility distance as a function of observer age and lighting condition (Normalized to average performance of young observers under daytime viewing conditions).

CONCLUDING REMARKS

The Symbol Signing for Older Drivers project has generated much new information about the effectiveness of symbol highway signs for drivers of all ages. The project has generated data supporting the application of new techniques for predicting and optimizing the visibility of this class of signs and related materials. The project team, headed by Bob Dewar, Don Kline and Frank Schieber, is currently engaged in preparing the results of our research for widespread public dissemination.

REFERENCES

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