Vision at Levels of Night Road Illumination

IV. Literature 1957-58

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● LEBENSOHN (35) states that "the prime reason for the excess of night accidents is inadequate vision." Visual field defects (including one-eyed drivers), unreliable visual clues, glare, errors in judgments, age, senescence, fatigue, and better testing methods are discussed. Richards analyzes and summarizes the basic problems of night automobile driving (57) and reviews (56) the 1956-57 literature. Windau (65) lists references on motorists' vision. Hirsch (28) considers the night accident problem. The Armed Services Symposium on visual factors in automobile driving brought together people and information, but a last-minute shift in ground rules did not help the organization of the material (6, 9). Night driving received attention. Form discrimination is thoroughly discussed (66) and the NIH symposium is of interest (44) although neither specifically considers night visibility.

The American Standards Association Z7. 1 on Illuminating Engineering Nomenclature and Photometric Standards is being revised (31) and the CIE International Lighting Vocabulary is available in English, French, and German (15).

Pirenne Marriott and O'Doherty (49) have measured night vision efficiency. Variation between individuals is considerable. Thresholds for flash area and Landolt C tests are similar, for the same amount of light and training is necessary to find and use the most sensitive part of the retina. Information is available for use at mesoptic levels encountered at the lower levels of night driving.

Blackwell (10) summarizes his 1957 work on rate of seeing, contrast, illuminance and probability of seeing and reports a decrease in the amplitude of accommodation and in accommodation vergence with decreasing illumination. Crouch (17) describes the Blackwell research and includes the new lighting recommendations of the Illuminating Engineering Society. Noting the curve for a 4-min subtence target, a visual capacity of 5 assimilations per second, 99 percent accuracy, and a 15X safety factor, a contrast of about 1. 3 is required at 4 ft-L and 170 at 0. 03 ft-L. The lack of such contrasts at these levels of illumination, commonly found in night driving, re-emphasizes the difficulty of seeing at night with inadequate light.

Putnam and associates (53, 54) report on discomfort glare at adaptation levels within the night driving range. The information should be useful in planning highway lighting. Adaptation to glare could not be predicted according to Simonson (60) from the continuous decline of light sensitivity under glare and the speed of glare adaptation reveals a considerable range of individual variation. Russel (58) compares the glare from upper and lower beams at various distances from the driver. Differences in visibility of objects are considered. Light road surfaces are better for showing obstacles with dipped (lower) beams. Glare sensitivity increases with age. Case, Davey and Spooner (14) investigated the effect of putting a green light in the car to raise the dark adaptation of the driver. This higher threshold makes resistance to glare easier and recovery from glare is more rapid, but at the higher level one cannot see dim objects as well. With little oncoming traffic lessening the dark adaptation is a handicap. They conclude that it is doubtful whether the gain in ability to resist glare is worthwhile, should that gain in central vision be accomplished by reduction of peripheral sensitivity.

Dynamic visual acuity, measured with a moving test object, seems to have little or no relation to visual acuity measured with a stationary target and considerable research is directed toward the problems of visibility of moving objects. For the high speeds of jet aircraft the eye-body reaction sensitivities are no longer adequate to prevent collision with the distances at which they may be seen (8). Brown (13) reports an upper speed threshold for a line flashed on a screen by a moving disc of about 4 log µL and about 3. 3 log minimum visual angle per second. The visual acuity needed to see a checkerboard target at different exposure times from 1/500 to 1 second are given by Zanen and Klaassen-Nenquin (67). Van den Brink's dissertation (11) provides data on retinal summation and the visibility of moving objects. The data are analyzed primarily in terms of their fitting of van der Velden's two quanta theory for vision. He also reports static and dynamic visual acuities to be different.

Ludvigh and Miller (37) have examined dynamic visual acuity with pursuit movements and conclude that the loss in dynamic visual acuity is due to decreased contrast from blurred images. With greater illumination the acuity is better. Another paper (41) indicates that the illumination must be increased appreciably to obtain the same dynamic visual acuity with increasing velocity of movement. Hulbert and others (30) have made an analysis of dynamic visual acuity and its effect on motorists' vision. Two types of studies are reported; one using motion pictures of signs made at a constant speed of 33 mph, and the other using an acuity target moving on a screen. They report that the critical speed which seems to separate static visual acuity from dynamic visual acuity probably lies between movements of 60 deg per second and 120 deg per second, and conclude that there probably is a previous unmeasured aspect of vision underlying dynamic visual acuity that is not correlated with static acuity. These studies show that for night vision at higher speeds, either more lighting, or better and larger signs are required. If this cannot be done driving speeds must be reduced sufficiently to compensate for the difference in dynamic visual acuity.

An alternative is properly lighted signs having better readability. Prince (51) shows that certain reading material can be read 20 percent faster when the spacing of the letters is at a substance of two min and that astigmatism causes less loss of vision for the greater letter spacing. Allen (1) reports that letters with a visibility in daytime of 88 ft per in. can be seen at 34 ft per in. at 0.1 ft-L at night, a loss of over half the distance.

The general problem of the visibility of road markings is discussed by Warner (63). Some of the signs seen on his trip were inadequate and his stress on color contrast with the different colors of soil and surround is important. Colored roads (5) are among recent highway experiments. One county in California has a law limiting colors for signs that may compete with traffic signals and Finch (21) has devised a color meter for the measurement of these colors. It must be remembered that color fails to give information from dim light to darkness and that it may be confusing or misleading for the eight or so percent of humans with deficient color vision. Walls' (6) recommendation that signs use form or shape instead of color to convey information should be followed.

Lorimer (36) points out the advantage of reflectorized license plates to reveal the presence of a car, especially an oncoming car with only one front light. Vertically or horizontally oriented objects are more visible than objects at 60 or 120 deg to the horizontal (45).

The problems and the instruments available for measuring visibility on the roadway at night are discussed by Finch and Palmer (22). Below 30 ft-L Hopkinson (29) found the same relation as did Stevens between brightness and luminance, that is, psychological brightness equals a constant times the luminance (photometric brightness) raised to the 0.3 power. Perceived brightness depends on the amount of light reaching the retina of the eye and the activity of the central nervous system and is the input which triggers the response of the driver. The same road lighting is dimmer for older drivers (7, 33, 40). There is much to be learned on individual variation and this knowledge will likely be the guide for the highway lighting engineers of the future.

The iris of the eye regulates the light reaching the retina and Seitz (59) has measured the ability of the pupil of the eye to dilate with respect to age. Sex and the color of the iris have no effect, but the pupil dilates less as the person becomes older. The maximum width of the pupil was reached in about 2-min of dark adaptation, but the pupil opening varied considerably with individuals. Another study (32) reports no differences in sex or with iris color, but that the mean error of the pupil response to dark adaptation also increases with age. The nature of the reflex of the pupil response is being investigated by Stark and Campbell (61). The small fluctuations in pupil area of about 10 percent probablv do not affect visual acuity. They conclude that there is no need for better control and that this may be an economy in the evolution of organisms.

Lauer (33) believes night vision is sufficiently different from day vision that both photopic and mesoptic vision should be measured with proper equipment for evaluating night driving vision. Fovea-cortex relations are investigated by Dzn (20). Detail in a grating pattern of 5 min of arc or less is detected by the cones in the retina and larger detail by cones and rods or by rods (12). Swartz and Dimmick (62) publish scales for conversion of Snellen to Orthorater scores and vice versa. Otero (48) finds that night myopia remains after breaking the binocular convergence and that this latter is no longer an explanation for the night myopia.

Movements of the eyes affect vision and their relation to the stability of the visual world is discussed by Gregory (25). Electroretinographic studies are summarized by Granit (24). Eye movements and the timing of muscular adjustment are reported by Miller (41). Eye movements must play a part in dynamic visual acuity. (Cf. also, 10).

Intermittent illumination may be helpful under certain conditions and Nachmias (43) has confirmed and extended Sender's conclusions. Collins (16) reports on the variation of flicker fusion and Geratherwol (23) determined that light flashing three times a second and twice as bright as the surround had great conspicuousity.

Improved lighting of roads with polarized, low light is proposed by C.R. Marsh (39) and visibility in fogs is discussed by Pritchard and Blackwell (52).

Weymouth (64) has reported that visual gradients from the fovea out seem to be linear for 20 to 30 deg for a number of visual capacities. Two groups of chauffeurs averaging 23 and 53 years were tested by Baumgartner and Bernard (7) showed that for a Landolt C the average threshold for perception was 32 percent greater and for orientation 34 percent greater for the older than the younger drivers. Decreases in vision with age are summarized by McFarland and Domey (40).

Ogle published a brief review (46) of the present status of knowledge of stereoscopic vision and that the same acuity is found at 0.5 and 10 meters (47). Contrary results of other observers are explained. The problems of stereo image decentration on apparent size have been investigated by Renshaw (55). The dearth of studies of stereoscopic vision at night driving levels is obvious and this would be a possible field for research.

Problems of human dimensions and convenience of automobile and truck driving compartments might well consider some of the dimensions given in Pores' article (50). Comfort is important for good night driving (57).

Discussion continues as to what motorists' vision should be and on licensing problems. Two editorials from The Optician summarize work done in other countries (3, 4). For bus drivers in England, visual acuity must be 6/9, 6/12 without glasses, although 6/12, 6/24 does not disqualify if glasses cannot correct to at least 6/9, 6/12. About 10 percent were rejected for eye defects. They implied that a 6/12, 6/24 minimum is required for uncorrected vision and 6/9, 6/36 with glasses for safe driving. Lebensohn (35) summarizes American requirements in different states. Lauer (34) also surveys various state requirements and he notes that the examinations are getting more and more complicated in form and that the time has come when he believes that the examining procedure should be simplified. Requirements for drivers in motor racing are summarized in an editorial in The Optician (2).

Davey comments about automobiles on viewing a motor show, particularly on the Continental and American cars with windshield curvatures of 7 to 8 diopters and considerable distortion (19). Various features of automobiles which would help or hinder seeing are mentioned.

The problems of prescribing for drivers are discussed by Hardy (27) who favors single vision lenses, although he notes that there are occasions when near vision is required and that bifocals are not necessarily fraught with danger. He does not favor the use of yellow glasses although he states that there is some evidence that weak neutral filters have improved efficiency of driving on long runs without unduly reducing acuity in poor light. Maximum acuity for distance is important and an adequate horizontal field of vision is essential. Special care should be given to fitting comfortable frames with freedom from blind spots. His point is well taken that the best glasses can be nullified when the windshield or glasses are dirty. Crundall (18) discusses the problem of the moving eye and a stationary spectacle lens in terms of the prism powers involved. Lebensohn (35) points out that the Purkinje shift from 555m μ to 510m μ requires about -0.5 diopter and recommends spectacles in night driving be corrected by this amount. Marsh (38) summarizes how vision specialists can help people who must drive at night.

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