Vision at Levels of Night Road Illumination

IX. Literature 1963

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•TWELVE years ago the first of these reports (66) was written to make pertinent information on vision available to the members of the Night Visibility Committee. At that time there was a general opinion that accidents were mainly the result of seeing failure and that proper testing for visual efficiency would ameliorate the situation. Endeavors to relate specific seeing attributes to accidents had little success and some voices were raised to discount the role of seeing in accidents. Now there is a more balanced viewpoint that vision is the major port of entry into the individual of information ncessary for good driving, but that other factors are concerned with the use of the information and also with triggering an accident.

Walton (75) recognizes two visual tasks in driving: "First, the driver must be able to see to control his vehicle; second, he must see and react to what is happening around him." He believes the problems of depth and distance need investigation with regard to driving at night. Byrnes (19) discusses the visual task of driving in terms of space and time and gives recommendations to the ophthalmologists as to what vision tests should be made on drivers. He proposes a basic license for daylight driving requiring 20/40 acuity, 140° fields and no diplopia. Night driving privileges should be given or withheld as deemed desirable. The greatest need is for a good test for night seeing. Seeing against glare should be tested after 50 years age.

The ophthalmological problems facing the physician concerned with certifying the ability to drive are also under active consideration in Germany. Hager (40) reports that drivers with impaired vision are involved in more accidents, and Piper (58) presents clinical cases in his discussion of the doctor's problem.

The equipment used for screening vision at Staten Island is described by Smith (71). Ungar (79, 80) is surveying the motorist's vision requirements in Great Britain. Attempts to evaluate the Smith-Cummings-Sherman training system for drivers reveal clearly the difficulties of the task and the problems are of interest even though the work of Payne and Barmack (56) could not unequivocally demonstrate this system to be effective.

Rashevsky (62a) has applied mathematical methods to the analysis of the driving problem. While night driving has not yet entered the equations, the approach is novel and promising. Of special interest is the use of information from the Greenshield's Drivometer (59) in the mathematical analysis (62b). Platt's (59) investigation should be extended to night driving.

Some general items on vision are: the new edition of Judd's (46) "Color, etc.", Blackwell's (13) and Boynton's (15) summaries, and the Armed Forces-Optical Society symposium (57). The Lewis (52) review has little on night driving seeing.

Connolly (21, 22) has criticized Buick and Plymouth automobiles from the human engineering and seeing viewpoints. Other items in his series of papers (20, 23-26) give information and opinions from his experience and files. Allen (2) shows how various parts of the car produce glare and make seeing difficult for daytime driving; some of which are also handicaps for night driving. Another paper (6) considers seeing from a Volkswagen.

The new roadway lighting standard is described by Edman (32). Rex (64) summarizes and rates many of the problems of good road lighting. An improved luminance

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meter is described (8). Eastman and McNelis (31) report finding no significant differences in threshold contrasts using filament, mercury and sodium lighting and suggest that the increase in acuity associated with monochromatic light may account for de Boer's better seeing with sodium lighting. Performance tests by Smith and Wendell (72) at illuminances of 0.25 to 1 fc as compared with 45 fc are of interest. At the lowest level of lighting, depth perception was markedly reduced and newspaper reading difficult.

Bergsjo (10) proposes adding an inertia switch to turn on a red stop light whenever the vehicle slows down, to help reduce rear-end collisions. A parking red light would be used to distinguish a stopped from a slowing car. He also suggests prohibiting all red lights along a highway that could be confused with traffic signals. Johansson (45) found that dipped asymmetrical headlights give longer visibility distances than symmetrical ones, but that speed had to be reduced to keep braking distances within seeing distances. As dipped headlights are said to be unnecessarily glaring, Jehu (44) suggests reducing their intensity to about one-tenth by a switch which would add a resistance into the lamp circuit when less light is desirable. Dipped lights could show a moving vehicle by contrast with the side lights of a parked vehicle.

Incandescent, fluorescent, mercury and sodium lamps have the same dazzling influence on contrast sensitivity according to Jainski (43), but for equal surrounding luminances and intensity of glare illumination, readaptation time was longest after glare from incandescent and shorter from sodium light. Flamant (33) also reports longer recovery time from white than from yellow light and still greater from blue light.

Pabst (55) reviewed the dazzle problem of night driving, and points out the greater susceptibility of the fatigued driver. Glare resistance should be measured on drivers having difficulty in seeing at night. He indicates that increasing the road lighting is the only effective solution of the glare problem and that this is an economic and engineering rather than an ophthalmological problem. The letters to the editor following Pabst's article showed no uniformity of British opinion on the glare problem. In a study (17) of stress in the use of driving simulators, glare produced the greatest effect on vehicle following and no effect on time to coincidence judgments.

Blackwell (11, 12) and Fry (35) give methods for evaluating glare and prescribing illumination levels. Severin et al. (70) measured recovery using an intense source for flash exposures of 0.15 sec. Estimating from their curves a bright headlight glare of 3,500 fL would require about 0.14 min to recover to an adaptation level of 0.06 fL and 0.4 min to a level of 0.013 fL; for 500 fL exposure about 0.1 and 0.2 sec, respectively. Auto drivers are exposed to glare for longer times, so while the data are of interest they cannot be applied directly to night driving seeing.

According to Stevens and Stevens (73) brightness in Brils, $\psi = k(L - L_0)^\beta$, where L is the luminance and L_0 the absolute threshold. The values k, L_0 and β change with the adaptation level; β being 0.33 for the dark adapted eye and 0.44 for the eye adapted to 1 L. The perceived brightness increases as a power function of the photometric brightness (luminance). There may thus be increased gain from better road lighting and illumination engineering should also consider brightness. Reaction times are longer for a light imaged on the retina at increasing distance from the fovea, or when the light is less intense and Rains' (61) data would be more useful if they were replotted in the form of a retinal map.

Boynton and Miller's (16) work on the effect of sudden changes in illumination on seeing are now available and should be useful in graduating changes in lighting, as at tunnels. Hazel (39) shows that tone and texture can be used to aid transitional lighting and states that one-tenth the lighting could then be used within the tunnel.

Kostka (50) favors using reflective materials to improve the seeing of signs at night and discusses the need for better signs. Experience with signal lights in aviation is discussed by Projector et al. (60) with respect to night road traffic. Lights are judged farther away at near distances and nearer than they actually are at distances greater than about 80 ft, in their experience.

Allen and Lyle (4, 5) describe their night vision test which also gives information on retinal luminance and for determining the light needed for seeing low contrast objects. Guth (38) is measuring size, contrast, time and luminance with a new apparatus to determine what can be seen, in another approach to the night driving seeing problems. Richards (65) showed interrelations between luminance, acuity, contrast and age and described improved equipment being used to measure seeing at night driving luminances.

Flom et al. (34) found that bars arranged to be adjacent to a Landolt C presented to one eye, impaired detection of the C presented to the other eye; presumably a supraretinal effect. Such a loss from contour interaction could decrease the information obtainable from signs, maps and topography.

The California project program on dynamic visual acuity is outlined by Ball (9). Cutler and Ley (28) using an improved method, found an initial fall in kinetic visual acuity (even at very low speeds) to a level which remains fairly constant or improves to a critical rate of about 60°/sec when rapid deterioration of vision occurs. Below 60°/sec with monocular vision much variation was found between individuals. Binocular is markedly better than monocular dynamic visual acuity. Larbus (84) reports that for satisfactory perception the velocity of the moving object should not exceed 100 - 150°/second.

Eye movements used in examining a picture are examined by Webb et al. (77) and a similar technique should provide useful information about the task of seeing when driving at night.

Objects along the road stimulate a tendency to steer away from them. Michaels and Cozan (54) show that this depends on the ability of the eye to detect the rate of change of the visual angle subtended at the eye between the object and the road axis. A small object can generate a greater relative visual velocity than a larger one. An example cited is that a vehicle seen only by the reflection from an unlighted taillight is placed as outside the path of travel, but inside the path when it is seen fully lighted by a street light. These effects should be added to the mathematical analysis of driving by Rashevsky (62) and others.

The illuminated dashboard panel area may not be large enough to stimulate accommodation and avoid the empty field lack of stimulation (29). Three aged subjects did not accommodate. Younger subjects accommodated to a small degree (0.25 - 1.75D). The same amount of accommodation was found by Doesschate (29) at 1.2 and 500 lux (0.1 - 47fc).

The Pulfrich effect resulting from less light reaching one eye than the other eye can lead to a miscalculation of relative distance and an accident. The dialation of one eye by an ophthalmologist resulted in the case reported by Gramberg-Danielsen (36). This points out also danger from unequally matched sunglasses or tinted contact lenses. Night vision sensitivity did not increase from its seasonal peak during the three months cruise of the Triton from the prolonged restriction from sunlight (Kinney, 49).

Weale (76) believes that senile reduction of accommodation is due to a progressive change in the balance of the elastic forces in the capsule and lens matrix, to a reduction of zonular tension due to the continuing growth of the lens and to a similar reduction in growth of the ciliary body.

Vibration from larger road vehicles, according to Hornick (42), of 1 to 7 cps does not decrease vision. Higher frequencies of 10 and 40-70 cps do decrease seeing. Lange and Coermann (51) report a decrement in seeing for 10 of 12 subjects at 5 cps, another at 7cps, and a constant decrement from vibrations over 12 cps. They give resonance frequencies for the human body. Rathbone (63) discusses sensitivity to vibration. Definite information on the effects of vibration on the seeing ability of the auto driver seem yet unavailable for either day or night time.

Able (1) calls attention to the small fields of view and lack of binocular vision often resulting from the corrective glass worn after a cataract operation and advises instead correction with a contact lens before driving is resumed. This applies also to pedestrians. Richards (67) warns against wearing tinted contact lenses at night when there is sufficient absorption to decrease seeing, which prohibits all but the palest tints. Fletcher and Nisted (81) also advise against wearing tinted contact lenses at night and state: "Spectacle correction may well be superior to contact lens correction at night," because edges or surface transitions tend to disturb vision when the pupil is large.

Allen (3) emphasizes that wearing sunglasses cannot be permitted at night, even in yellow tints. He also states: "No known sunglass can possibly improve the ratio of useful to glare light at night" and ". . . tinted windshields offer a real handicap at night with no visual benefit in daytime." D'Orsay's (30) letter to the editor agrees with Allen and notes another hazard from spectacles which continually slip down the wearer's nose. It would seem to the reviewer that driving glasses should have temples that fit properly around the ears. Safety glasses, possible increased minus for the near sighted and a spare pair of glasses are advised in a good editorial (7). Threshold measurements of intensity show higher thresholds for detection when wearing sunglasses both with and without glare than without sunglasses (86).

Color sensitivity for red-green mixtures were measured by Connors and Kinney (27) for various positions on the retina and the earlier conflict between information from changing size of stimulus and retinal location is resolved by the finding that the green sensitivity passes through a maximum and then decreases. MacAdam (53) concludes that psychrometric scale values are nonlinearly related to chromatic differences, even when adjustments are made for the anisotropy of the chromaticity diagram.

Prolonged treatments of arthritis with chloroquine can result in changes of the cornea, in the color sense, and pigment degeneration in the retina of the eye (48, 68, 82). Amphetamine activates and barbiturates depress accommodation in moderate therapeutic doses and the latter changes distance heterophoria towards esophoria, near heterophoria toward exophoria, narrows the fusional range, and causes a recession of the near point according to Westheimer (78). George (37) found blurring of vision in a 53-year-old man within two days after taking chlorpropamide (Diabenese). Scott (69) states that retinal pigmentation can occur from thiridazine therapy beyond a safe dosage. General summaries of drug effects on vision have appeared (18, 41, 47, 74, 83). It is time for the medical profession to give consideration to the dangers from medication and possible excessive usage of tranquilizers and stimulants that may effect driving ability. A small decrease in seeing and the ability to respond can be a factor in the increased accidents at nighttime. Bohné (14) found that cigarette smoking slightly improved dark adaptation, caused questionable dilation of the retinal blood vessels and had no significant effect on visual fields. Fatigue problems in aviation (85) may also be of concern in auto driving.

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