Proceedings of the Iowa Academy of Science

Volume 56 | Annual Issue Article 37

1949

Effect of So-called Night-driving Glasses on Visual Acuity - A Preliminary Study

A. R. Lauer
Iowa State College

Edwin D. Fletcher
Iowa State College

Paul Winston
Iowa State College

Effect of So-called Night-driving Glasses on Visual Acuity — A Preliminary Study

By A. R. Lauer, Edwin D. Fletcher and Paul Winston

Introduction

Evidence from various studies such as those of Cobb (1914), Ferree and Rand (1923), Fry and Bartley (1933), Hecht (1935), Graham and Cook (1937), Bartley (1941) and more recently by Lauer and Silver (1945) and others have indicated that brightness contrast, as a function of stimulus illumination and consequent retinal stimulation, is one of the basic factors in visual acuity. It is a safe assertion that seeing efficiency and acuity are closely related, up to a certain level of illumination. At higher levels of illumination this perhaps does not hold.

In certain quarters an opinion persists that filters which narrow down the wave band of light will greatly increase acuity by clearer definition of the stimulus object and by penetrating certain conditions of fog and haze in the atmosphere or transmission medium. This belief is based on certain theoretical grounds which may be predicated on false assumptions.

The error is in logic rather than in basic factual data. It has been shown that because of chromatic aberration of the eye, true monochromatic light will give a finer definition of the retinal image and consequently, greater acuity of discrimination at or near the threshold. This principle has long been recognized in industry, although there is considerable evidence that continued use of restricted bands of spectral illumination may induce undue fatigue and be detrimental to the eyes.

It should be further pointed out that for objects of larger size this slight fuzziness at the edge of the image due to differential refraction is of no great consequence in the act of seeing and visual efficiency.

A further erroneous conception is that any filter of a given wavelength will transmit only the corresponding bands, or dominant wavelengths determining the characteristic color of the filter. This is not at all true as most ordinary filters transmit wide bands.

Also it is well known that the retina is most sensitive to wavelengths of about 555 mμ or 555 mμ using physical notation. It is reasoned that a filter or colored glass which gives a high relative transmission at, or near, this wavelength will aid visual acuity at night. Altho complicated somewhat by the duplicity theory, since both photopic and scotopic vision are involved, this line of reasoning has some merit and it is known that a sodium-arc light of about 589 mμ will prove a very economical illuminant for highway lighting purposes. Whether it will fatigue the eyes prematurely is another problem.

Consequently, certain smaller optical companies have reasoned according to their own dictates and interests in order to establish the fact that bluish glasses, orange glasses, yellow glasses or other colors are beneficial to the eyes under conditions of night driving. It suffices to say that a number of types of so-called "night-driving" glasses have been manufactured and attempts made to sell them to commercial companies employing drivers, although the practice is not recommended by the larger optical companies, scientists or technologists closely associated directly with the problems involved.

THE PROBLEM

Thus the problem arises out of a request by industry that experimental studies be set up to ascertain the facts relating to the use of such lens for use in night driving. Strangely enough there seems to be a favorable psychological effect produced by certain lens. Particularly from use of yellowish lens, as a subjective check made by 93 drivers in the Los Angeles area shows by actual road driving tests made. The data summarized yield the following results:

Eighty-two drivers were favorable to the glasses
Eight drivers gave unfavorable reports
Three drivers were undecided as to their value

Herein lies the problem. Against the combined weight of scientific evidence and opinion the product is sold to the public and apparently stands on its own subjective merits. That is to say most drivers are convinced that such lens help them at night. This study is a report on a preliminary series of investigations to determine the objective facts.

METHOD AND PROCEDURE

To obtain objective data involved an experimental design of the conventional control-test type. The null hypothesis may be inferred altho not stated since there seems conflicting views on the subject.

Since a driver is constantly meeting bright lights involving a combination of scotopic and photopic vision, it was thought advisable to set up the experiment to include test conditions both with and without an opposing light source. The order of presentation was reversed each time to avoid any systematic errors due to blinding or adaptation effects from an opposing luminaire.

Three filter substances had been brought in for testing along with a number of devices of the screen type. Since our primary interest here deals with the transmission filters, only data relating to these will be presented. Partial screening devices present another type of problem but were generally not acceptable to drivers.

Three series of experiments were set up and will be described in more detail under the respective headings. The procedure was practically the same in each excepting that in Series B both binocular and monocular tests were made.

Each subject was carefully measured for acuity, using his normal correction as the standard. He was then given tests using filters before the eyes and tests without the filters. The tests were made both in complete darkness and with an opposing light source set to the left of the subject at an angle of 5° declination and on a level with the line of vision. The light at the eye was set at 2.5 foot candles which is approximately the maximum amount usually experienced from an oncoming headlight since the "hot spot" of the beam is focused directly in front of the car and does not ordinarily reach the eye of a passing driver.

APPARATUS USED

A standard clinical type of Clason Acuity Meter (the letter-image is projected on a screen and gradually enlarged until read by the subject) was used in a darkened room. The subject was placed in a standard refraction chair at a distance of twenty feet from the projection screen. A small ophthalmological lamp was mounted at a six-foot distance and set at a five-degree angle as described.

Other apparatus consisted of the three types of materials described as follows:

Orange plastic blanks of 60.3 per cent transmission. The exact transmission characteristics were not available but the dominant wavelength was about 5600 Å units or 560 mμ.

One pair of Nite-Lite glasses, the same as used for the regular road runs. These show a transmission maximum at a wavelength close to that of the maximum sensitivity of the human eye. (Figure I — Transmission curve of Nite-Lite.)

Blanks of same for use in standard trial frames as needed.

One pair of Quality Lens glasses as prescribed for night-driving purposes.

Blanks of same for use in standard trial frames.
(Figure II — Characteristics of Quality Lens transmission)

One pair of standard trial frames and special light-meter with Weston photo-electric cell having a Viscor filter.

One refraction chair with special table for supporting the Clason Acuity Meter.

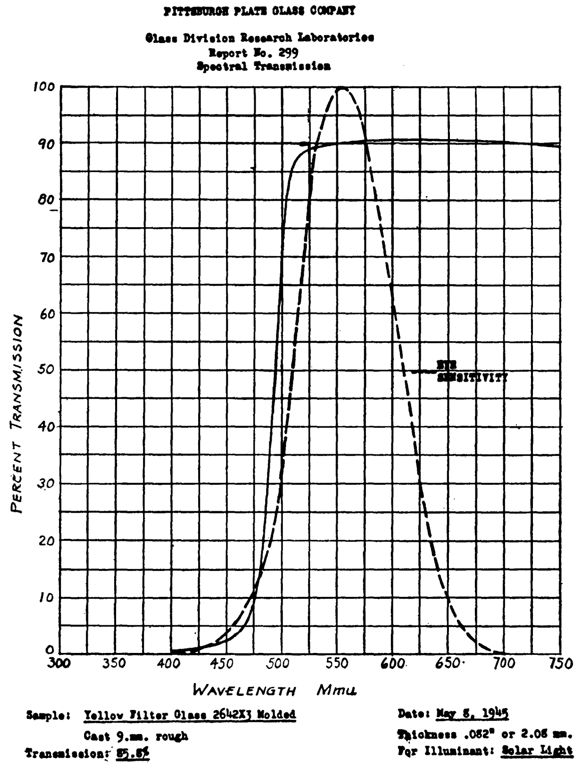

Figure I Transmission characteristics of Nite-Lite

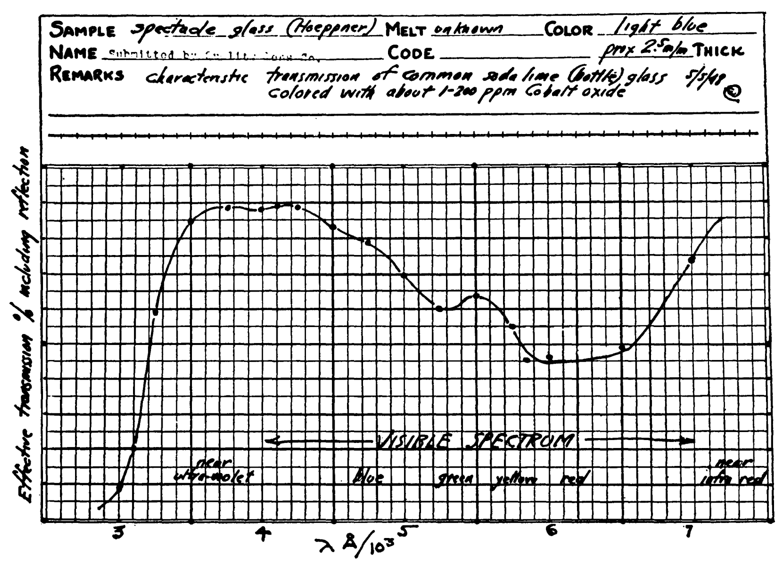

Figure II Transmission characteristics of blue Quality Lens

SERIES A

The primary purpose of this experiment was to check the effect of the orange plastic material developed for use as a cover over the headlights during foggy weather. Blanks were cut and the experiment set up to measure the effect of this filter on visual acuity under two conditions, without glare from an opposing light and with glare.

Six subjects were used and the mean of five readings for each setting was taken as a measure. The reliability of the readings taken in this manner is known to be about +.96 as determined from previous studies. Four conditions were imposed without opposing light and two with opposing light, as described below:

1. Without opposing light.
   a. Normal correction only, if used.
   b. Normal correction and filters.
   c. Normal correction without filters before the eye but with filter set in path of projected beam from the Acuity Meter.
   d. Normal correction plus conditions described in b and c.
2. With opposing light set at 5° to left of subject and 6 feet distance. A rheostat control made precise setting of 2.5 foot candles of light at the eye possible.
   a. With normal correction.
   b. With normal correction and filters before the eyes.

A brief summary of results obtained in this series will be described in Table I. Since the transmission factor of the material was 60.3 there were four conditions of illumination imposed, 100 per cent, 60.3, 60.3 and 36.36 per cent respectively. While a spectral analysis of the transmission characteristics of the material was not available it resembles somewhat that shown in Figure I giving characteristics of Night-Lite.

TABLE I

Mean visual acuity readings of six subjects used in Series A

Conditions imposed	Relative Intensity brightness	Without opposing light	Gain or loss	With opposing light	Gain or loss
Normal correction	100.00	103.17*	.00	93.6*	.00
Correction plus filters	60.30	97.41	— 5.80	88.5	—5.76
Correction plus** filter over beam	60.30	86.70	—15.96	----	----
Correction with filters on beam and over eyes	36.36	67.75	—34.33	----	----

* The reading with correction and with filters was used as a standard for each column. Losses are indicated in Clason units.

** Some loss here may be attributed to imperfection of the material. Only a high grade optical glass will not distort slightly.

SERIES B

This was an exploratory series to ascertain the best ways of pursuing the procedure when considering time factors, fatigue, monocular or binocular presentation and other conditions. Altho several type of filters were used only two will be considered here.

Four trained subjects were given tests almost identical with those described in Series A, except that no filter was interposed in the path of the projected beam. Both Nite-Lite (yellow) and Quality Lens (blue) were used as test filters.

The results of this experiment are summarized as Clason Acuity Meter units of loss or gain using the visual acuity of each subject with correction but without glare as a standard of comparison. In this way the figures from subject to subject and from one condition to another are directly comparable.

The data are shown in Table II with comparisons summarized.

TABLE II

Summary of data from Series B by lens and by conditions of glare. All subjects and all trials. Clason units.

Normal Correction				Nite-Lite				Quality Lens			
Monocular		Binocular		Monocular		Binocular		Monocular		Binocular	
Without	With	Without	With	Without	With	Without	With	Without	With	Without	With
—12.67	—28.1	S (Standard)	—13.7	—20.6	—30.8	—9.6	—19.3	—14.5	—26.7	—18.4	—23.7

Net loss from glare alone	—15.40
Net loss from Nite-Lite	—11.00
Net loss from glare with Nite-Lite	—13.60
Net loss from both glare and Nite-Lite	—24.60
Net loss from Quality Lens	—16.45
Net loss from glare with Quality Lens	—8.75
Net loss from both glare and Quality Lens	—26.20

The results obtained show individual losses in every instance except two measurements in which there was no difference. The means all indicate losses of around 10-15 Clason units for filters of the type used.

SERIES C

Since commercial drivers had been used in all road tests it was thought advisable to make laboratory tests using them as subjects. To expedite the experiments monocular measurements were excluded. Otherwise the procedures were the same as described before using normal correction, if used, without opposing light as the standard for each subject. The two filters, Nite-Lite and Quality Lens, were used. The results are shown in Table III.

TABLE III

Summary of data from Series C by subject and by lens used with and without opposing light.

Subject	Normal Correction				Nite-Lite				Quality Lens			
	Without Opposing Light	Gain or Loss	With Opposing Light	Gain or Loss	Without Opposing Light	Gain or Loss	With Opposing Light	Gain or Loss	Without Opposing Light	Gain or Loss	With Opposing Light	Gain or Loss
A	82.1	S*	74.9	—7.2	73.2	—8.9	77.6	— 4.5	76.4	—5.7	82.6	+ 0.50
B	87.7	S	87.2	—0.5	81.6	—6.1	75.4	—12.3	82.2	—5.5	75.8	—11.9
C	83.7	S	80.7	—3.0	82.6	—1.1	81.0	— 2.7	78.0	—5.7	77.8	— 5.9
D	77.8	S	79.0	+1.2	74.6	—3.2	85.3	+ 7.5	82.0	+5.8	73.0	— 4.8

* Standard

SUMMARY OF TABLE III

Normal correction average loss in Clason units		—3.2
Nite-Lite —	Net loss from lens	—4.8
	Net loss from glare	—3.0
	Loss from both lens and glare	—7.8
Quality Lens —	Net loss from lens	—3.7
	Net loss from glare	—7.3
	Loss from both lens and glare	—11.0

SUMMARY AND CONCLUSION

A preliminary study of three types of filters presumed to penetrate fog and increase general visual comfort and efficiency for night driving was made. Subjective accounts on Nite-Lite available from 93 drivers indicated a favorable impression in the use of a yellow lens in 82 cases, unfavorable in 8 cases and undecided in 3 cases. On the basis of these reports there seems to be some psychological effect from a yellowish type of filter. No data were available on the bluish lens. An experiment was designed to test the validity of this apparent effect on visual acuity by objective measures.

By objective tests using refined optical instruments there was a consistent deleterious effect from three types of lens used having transmission factors of from 60-85 per cent under the experimental conditions set up. The mean effects ranged from approximately —4 to —16 Clason units. Drivers used to facing blinding lights showed less loss when subjected to opposing lights than an unselected group altho the numbers were too small to warrant statistical evaluation. The degree of consistency running through the three Series indicates quite reliable results.

Subject to limitations of the number of cases, the experimental conditions set up and the criterion used, the following tentative conclusions seem warranted:

1. Filtering lens reduce acuity in low-level illumination; according but not in direct proportion, to their transmission factors.

2. While they may subjectively appear to reduce the blinding effect of oncoming headlights when used there is a net loss in visual acuity on the average under controlled experimental conditions.

3. Certain exceptions to the above statements were found among individuals but there may have been a bias effect which tended to influence results, particularly in the case of professional drivers. The yellow glass particularly may lead to erroneous subjective judgment due to the misleading effect of color.

4. Since evidence from various sources indicates that night driving is more hazardous because of insufficient illumination, anything which further reduces seeing efficiency is not to be recommended in the present state of knowledge.

5. It is conceivable that fatigue effects may further emphasize the wisdom of conclusion four since differential effects have been noted by other investigators.

References

Bartley, S. Howard, Vision 1941, D. Van Nostrand Co. Inc. pp. 337.
Cobb, Percy W., The effect on fovial vision of bright surroundings; II Psychol. Rev., 1914, *21*, 23-32.
Ferree, C. E. and Rand, M. G., Flicker I. The theory of flicker photometry; Trans. Illum. Eng. Soc. 1923. 151-207.
Fry, G. A. and Bartley, S. H., The brilliance of an object seen binocularly. Amer J. Ophthal., 1933, *16*, 687-693.
Graham, C. H. and Cook, Carolyn. Visual acuity as a function of intensity and exposure time. Amer J. of Psych. 1937, *49*, 654-661.
Hecht, Selig, A theory of visual intensity discrimination. J. Gen. Physiol. 1939, *22*, 593-612.
Luckiesh, Matthew, Light, Vision and Seeing. D. Van Nostrand Co. Inc. pp. 276.
Lauer, A. R. and Silver, E. H. Certain factors influencing the tolerance of light and visual acuity. Proc. Iowa Academy of Science. 1945, *52*, 265-270.

Department of Psychology
Iowa State College
Ames, Iowa