Dynamic Visual Acuity–Effect on Night Driving And Highway Accidents

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●IN RECENT MONTHS there have been several instances where an article titled "Study of Visual Acuity during the Ocular Pursuit of Moving Test Objects" has been very briefly noted in the optometric literature. This fine piece of research conducted by Elek Ludvigh of the Kresge Eye Institute and James Miller of the U.S. Naval School of Aviation Medicine, is probably the most important work relating to motorist vision that has been completed in recent years. There is a relationship with the visual problems facing anyone in a moving vehicle.

The following quotation from the summary of the original report serves as an introduction to the calculations and conclusions made herein:

"Visual acuity may be measured during the voluntary ocular pursuit of moving test objects. This visual function has been referred to as dynamic visual acuity. The apparent movement of the test object is produced by rotating a mirror in the desired plane of pursuit by means of a wheel and disk type variable speed drive. The range of angular velocities utilized is 10^0/ to 170^0/sec at the nodal point of the tested eye. It is shown that visual acuity deteriorates markedly and significantly as the angular velocity of the test object is increased. It is shown further that the relationship between visual acuity and the angular velocity of the test object may be described satisfactorily by the semiempirical equation $Y = a + bx^3$. It also is pointed out that individuals possessing similar static acuity may differ significantly in their dynamic acuity. The possible causes for the observed deterioration of acuity are discussed and it is concluded that imperfect pursuit movements of the eye result in a continued motion of the image on the retina. This motion results in reduced intensity contrast, which is a factor in producing loss in acuity.

"It was demonstrated that the manner in which visual acuity deteriorates as the angular velocity of the test object increases is similar regardless of whether the motion is produced by moving the target vertically, horizontally, or by rotating the observer in a horizontal plane. It was shown also that the semiempirical equation $Y = a + bx^3$ describes satisfactorily these three types of movement. It was pointed out that individuals having a low acuity threshold in the vertical plane of movement will be likely also to have a low threshold in the horizontal plane. It was shown that although 5 to 10 foot-candles may be sufficient illumination when the test object is stationary, visual acuity is substantially benefitted by increases up to 125 foot-candles when the observer is rotated."

In the foregoing equation Y = visual acuity in minutes of arc, x = angular velocity in degrees per second and a and b are parameters which have been determined by curve fitting using the method of moments (a is a measure of the static visual acuity, b is a measure of the dynamic acuity).

To a person driving a car, all objects outside of his car are moving with a certain angular velocity, the nearer the object the greater the angular velocity. If 60 mph is changed into angular velocity at various distances, there is a vast and rapid drop in visual acuity for approaching objects. This could be a cause for the correlation between increase in driving speed and increase in accident occurence.

The article also points out that there is little if any correlation between static and dynamic acuity—this means that checking the static acuity in relation to driving ability is comparable to checking only the distance acuity in school children when their near vision is very important.

For convenience, the subjects tested were divided into three groups, because the dynamic acuity is not the same for all individuals. To some subjects visual acuity deteriorates very rapidly with increasing angular velocity, whereas in others the deterioration is much less rapid. Table 1 gives the results of calculations changing the velocity of an automobile in miles per hour into various angular velocities. In all cases if the angular velocity is zero, the visual acuity is 20/20 Snellen.

TABLE 1

60 MPH					30 MPH			
Distance to Object (ft)	Angular Velocity (deg/sec)	Visual Acuity GR 1	GR 2	GR 3	Angular Velocity (deg/sec)	Visual Acuity GR 1	GR 2	GR 3
1,000	5.0	20/51	20/48	20/38	2.5	20/51	20/48	20/38
500	10.0	20/51	20/48	20/39	5.0	20/51	20/48	20/38
100	47.5	20/64	20/54	20/42	24.75	20/53	20/48	20/29
80	57.5	20/73	20/59	20/45	30.75	20/54	20/49	20/39
60	72.5	20/96	20/70	20/52	40.25	20/59	20/51	20/41
40	95.5	20/154	20/99	20/70	57.5	20/73	20/59	20/45
20	131.0	20/317	20/317	20/121	95.5	20/154	20/99	20/70

These calculations indicate that when driving at 60 mph and looking at an object located 20 ft from the car, the driver's visual acuity will be between 20/121 and 20/317 depending on how rapidly his dynamic acuity changes. When driving at 30 mph, looking at the same object, his visual acuity would be between 20/70 and 20/150. There is a definite advantage to reducing driving speed.

Further investigation by Ludvigh and Miller indicates that dynamic visual acuity is greatly increased by increasing the illumination falling on the object of regard. Under conditions of static vision, increasing illumination more than 10 foot-candles has little value but increases up to 125 foot-candles are usable for increasing dynamic acuity. This information should be very helpful in planning the lighting of streets and highways. Here is dynamic evidence that the proper lighting of streets and highways, by improving dynamic visual acuity, may help to reduce the hazards of night driving. It seems to indicate that roads cannot be illuminated too much to suit the human visual system.

In this age of increasing tempo, dynamic visual acuity—its measurement and implications—may one day replace static acuity in position of importance. Screening out poor driving risks by checking their static acuity only, or increasing static acuity by modification of highway illumination (with no regard to acuity in a moving vehicle or to the increase of dynamic acuity produced by very high foot-candle levels), can no longer be considered adequate.