Reaction-Time and Traffic Behavior

Tests Reveal Importance of Personal Characteristics in Driving a Motor Vehicle

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THE modern automobile is marvelously easy to control, responding to the slightest action of the driver with a burst of speed or a quick stop. But it is not a complete automatism in itself; it cannot, like the faithful horse, react to its surroundings. The driver must see the curve ahead and turn the wheel, feel the roughness of the road and lessen the pressure of his foot on the accelerator, or hear the policeman's whistle and bring the brakes into action. The brief interval between the happening of something in one's environment and the time when a certain response is made to it is called "reaction-time." This interval may be, for example, that between the time a pedestrian steps into the street and the time the steering wheel is turned to avoid him.

In general, the speed of all forms of reaction varies from one person to another and from time to time in the same person. It changes gradually with age, very young and very old people being slower in their reactions. The reaction to hearing is quicker than to seeing. A person is more certain to react to a strong stimulus than to a weak one, although by straining he may be able to react more quickly to the weak stimulus ("Reaction-Time Measurements," by H. M. Johnson, in Psychological Bulletin, Vol. 20, 1923, pages 563-587). The stimulus, of course, may be so weak as to cause no reaction at all. Extreme fatigue decreases the ability to respond. The effect of alcohol varies with the individual—it does not necessarily lengthen reaction-time, but an excess amount makes the reaction-time more uncertain. All of these statements except the first might be open to question, but the first is of paramount importance in considering traffic behavior.

In a moving automobile, the driver must always react in the time and space available. Failure to do so accounts for the appalling number of accidents and deaths that occur on our highways every day. The higher the speed, the more important become time and space, those basic factors of highway safety.

REACTION-TIME AND SPACING

While making some traffic studies in Michigan in 1933, I first became interested in reaction-time as a factor in automobile driving. It was observed that in a queue of vehicles there tends to be a certain minimum spacing, which at two or three miles an hour averages about 5 or 6 ft. At greater speeds the spacing is increased by an amount equal to 0.75 times the speed in feet per second. That is, \[ S = 6 + 0.75V \], where \( S \) is the spacing in feet, and \( V \) is feet per second. Perhaps because of distractions, drivers in city traffic allow themselves about 0.95 sec to react ("Studying Traffic Capacity by New Methods," by Bruce D. Greenshields, Civil Engineering for May 1935).

The equation means that the variation in the minimum spacing depends entirely upon the factor 0.75. This is about the average time in seconds that it takes a driver to bring his brakes into operation when the occasion arises. Two vehicles with equally good brakes, traveling at the same speed, will not collide if the driver in the rear car has time to apply the brakes. After the brakes are applied the vehicles decelerate at the same rate, and hence come to a stop in the same distance.

The time of 0.75 sec should be compared with the reaction-time obtained under actual road conditions by the Massachusetts Accident Survey of 1934. The average for the 2,245 persons tested in this survey was 0.64 sec. This is less than the 0.75 sec spacing factor. But 20 per cent of the drivers required at least one second.

View on the Worcester Turnpike in Massachusetts

In Crowded Traffic, Vehicles Maintain Spacings Which Depend Upon Their Speeds and the Reaction-Times of the Individual Drivers

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A per cent more than one second. Obviously, for any a person must allow for his longest reaction-time rather than for his average.

Reaction-time is an essential consideration for the highway engineer. If it can be reduced by a more convenient location of the brake and accelerator pedals, or the innovation of a hand control (for the hand is less steady than the foot), vehicles will travel with shorter times between them, traffic will be accelerated, and an economic saving will be effected. But let us not draw conclusions too quickly.

In the summer of 1934, the traffic bureau of the Ohio State Highway Department took observations of the vement of traffic in order to secure a measure of highway capacity. In this study it was revealed that the average driver allows himself 10 to 11 sec and 1,000 to 1,050 ft for passing ("Distance and Time Required to Overtake and Pass Cars," by Bruce D. Greenshields, Proceedings, Fifteenth Annual Meeting of the Highway Research Board, pages 332-342). The driver's reaction-time must be included in this 10 sec. Thus the person with reaction-time of 0.5 sec has an advantage over the one who takes one second to act, but if he allows self one-half second less time for passing, he has no greater margin of safety.

A more recent study conducted in Ohio for determining point at which crowding commences to cause interference has furnished some additional information on reaction-time. This investigation indicated that vehicles or together than a spacing of 31 to 40 ft (center to center of car) are usually in the act of passing. The average variation in speeds was found to be over nine miles per hour. This occurs at a spacing approximately 200 ft, the point at which drivers react to the presence of the car ahead and make ready either over or down to the same speed or to pass. Undoubtedly, this point is related in some way to reaction-time.

LABORATORY TESTS OF REACTION-TIME

The laboratory type of test has also furnished valuable information concerning automobile driving and reaction-time. Safety division of the traffic bureau, Ohio State Highway Department, designed and constructed, for measuring brake reaction-time, apparatus which was used at the Ohio state fair in August 1935 and in which the same year at the Columbus automobile show. The results of tests made on this apparatus showed that brake reaction-time of 3 sec with the distance the foot travel from the accelerator to the brake pedal. Racetrack drivers and others who keep the foot in contact with the brake were found to react most quickly. The average time for drivers was 0.294 sec, while average for those who drive in usual way was 0.496 sec.

The apparatus, shown in one of the photographs, consisted essentially of the facsimile of the front of an automobile, a short miniautoadway containing an intersection with a traffic light and a toy automobile which ran on the road. Chronoscope (stop watch) g to 0.01 sec. In taking it to determine his reaction the subject sat facing the miniature traffic light on the roadway. When the red light in the traffic signal came on and a bell started to ring, this assured the observer that the person taking the test had the accelerator down and that he was ready to react to the flashing of the red light in the traffic signal.

After the subject had had his foot on the accelerator for 2 sec or longer, to allow him to get ready, the test supervisor pressed a button which simultaneously changed the traffic light from green to red, started the stop watch, and released the toy car at the top of the small incline so that it started to roll down the roadway toward the traffic signal. Seeing the red light, the person taking the test removed his foot from the accelerator as quickly as possible and depressed the brake. The action broke electrical circuits, stopped the chronoscope, and turned off the traffic light, while a center strip in the road rose and stopped the toy car. The place where the miniature car stopped showed the approximate reaction-time for the benefit of the spectators. The reaction-time was then read and recorded. When the car was replaced at the top of the incline, all was in readiness for another test. The toy car helped to attract attention to the apparatus.

Although 1,461 people took the test, only 284 filled out questionnaires giving their accident records. Of this number, 4 admitted having been involved in accidents causing fatal injuries, 70 in accidents involving personal injury, and 13 in accidents not involving personal injury. There were 145 who reported no accidents over a period of 10 years, and 52 who furnished no information. The fact that approximately one-third admitted being involved in accidents indicates that it is possible to secure records of driving experience by the use of a questionnaire. While the tests of those furnishing accident records were too few in number to give definite proof,
The 87 persons with accident records had an average reaction-time of 0.477 sec, and the 145 with no accidents had an average reaction time of 0.476 sec ("Reaction-Time in Automobile Driving," by Bruce D. Greenhields, Journal of Applied Psychology, June 1936).

Tests on over 50,000 persons were made during 1934 by Frank R. Olmstead, accident research engineer of the Michigan State Highway Department. In these tests approximately 26,000 data cards were tabulated and the factors affecting reaction-time correlated. From the results of his study Mr. Olmstead concluded that accidents are in direct proportion to driving mileage, and that all motorists, regardless of their reaction-time, are equally subject to accidents. Those who react quickly are involved more frequently than those who react slowly. But the former drive more miles and at higher speeds, and are consequently exposed to more situations which may result in accidents ("A Study of Factors Influenced by Automobile Brake-Reaction Time," by Frank R. Olmstead, Proceedings of the 22nd Annual Highway Conference, Michigan State Highway Department, pages 16-27).

Tests made on a thousand drivers in Nova Scotia show that people with a slow reaction-time drive more slowly, as is indicated in Table I. This bears out the findings of Mr. Olmstead.

REACTION-TIME AND DRIVING ABILITY

The conclusion to be reached from these data is that reaction-time is not in itself a criterion of driving ability. The numerous reaction tests set up at automobile shows and state fairs and in various population centers during the last two or three years have attracted much attention, and no doubt they have a great deal of educational value. But until correlated with actual driving experience, such tests have little or no value as a measure of driving ability.

Accuracy in estimating one's own reaction-time is of prime importance. The slow-reacting driver who always makes ample allowance for his slowness is a safer driver than the quicker but more heedless person. The drunked driver is not more dangerous because his reactions are slowed but because they are more likely to stray from the normal. From a mechanical standpoint the wide, straight roads and the powerful, smooth-riding, and easily controlled cars of today are safer than the older roads and the outmoded vehicles. But although 275,000 fewer cars were registered in 1935 than in 1929, there were 5,242 more deaths in 1935. This represents a decrease of 1.04 per cent in registration and an increase of 17.0 per cent in accidents, and illustrates the fact that while safety can be built into the highway and into the vehicle, the factor of traffic behavior must be taken into account.