Human Factors

by Joseph E. Badger

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The debate over what accident reconstructionists should use in their time-distance calculations has been around for years. Attorneys delight in dwelling over the fact that none of us knows exactly what someone else's perception or reaction time was for a particular event. So what do we do? Do we run a zillion tests and consider a norm? The mean? Do we use the eighty-fifth percentile?

What would the average person's perception and reaction be? Wait.

"There is no such person as the average driver or the typical 85th percentile driver, as any individual will vary with respect to different abilities." This according to Robert Dewar, who has a Ph.D. in Experimental Psychology, is a psychologist at Western Ergonomics, Inc. "Someone good at one thing might be poor at something else."

Ergonomics is another way of saying human factors. I rather like the term Biotechnology, "the application of the principles of engineering and technology to the life sciences" (American Heritage Dictionary) or "the study of the relationship between humans and machines" (Random House College Dictionary). For the student of crashes, those "machines" are motorized vehicles.

At the Institute of Police Technology and Management (IPTM) in Jacksonville last April, one of the featured speakers at its Special Problems in Accident Reconstruction seminar was Canadian Robert Dewar who holds several degrees and who has published numerous works in all areas of human response in traffic accident reconstruction. Over 250 (IPTM's largest crowd to date) police officers, former police officers, engineers and private reconstructionists spent half a day under the excellent tutelage of Dr. Dewar and his topic, "Human Factors in Traffic Accident Reconstruction."

Dewar discussed diverse elements that one must consider when attempting to ascertain a person's perception and reaction time. Among them are:

AGE

Age is a good place to start. Very young people may see something sooner than older people, yet not distinguish it as a hazard; whereas those of us chronologically-gifted individuals may more quickly recognize something as a hazard but lack the muscle tone to move briskly enough.

Generally, "older" drivers come in two groups. Dewar defines "young-old" as those in the 60 to 69-year-old range; those 70 and older are "old-old."

Younger drivers tend to drive fast; older drivers tend to drive slow. However, statistics bear out that the younger drivers (16-25 years of age) often play games while driving, are unfamiliar with the driving experience, are less apt to drive safely after a few drinks, are easily distracted by conversation and others inside the vehicle, and frequently operate faulty equipment.

Novice drivers' perception of risk is poorly developed and many young people are underskilled and overconfident. They possess that feeling of invincibility, the "Superman Syndrome." Their reaction may be faster than a speeding bullet, but the need to react--that is, their perception--may take an inordinately long time while they try to figure out what response is necessary.

ALCOHOL

Alcohol (and other drugs) affect every one of us. Expert toxicologists agree that, though there are certain equations and instruments for determining a person's blood-alcohol level and how much ethyl alcohol is in a person's system given a particular BAC, no one can say for certain what sort of effect a given quantity of alcohol has on a specific individual at a particular time.

What does alcohol do? It not only slows reaction time and increases risk-taking, it also dulls judgment, slows decision-making and presents peripheral vision difficulties. Any police officer who has followed drunk drivers knows that drinking manifests itself in steering difficulties and tends to make motorists drive faster than normal or slower than normal.

EXPERIENCE

This runs the gamut from education, through practice, to training. Even veteran NASCAR race drivers practice. You can't have too much driving experience behind the wheel.

FAMILIARITY

Familiarity (with the road and the vehicle) is important. Most people are more likely to drive faster on a road they're used to than some strange street in an unfamiliar town. And how many of you have driven a rental car--or a new vehicle home from a dealership--and when it started to rain you couldn't figure out how to turn the windshield wipers on? Or have you ever needed to honk the horn and after having spent several seconds banging on the air bag housing did you realize that the horn could be activated only by pressing those little buttons down by the cruise control switches?

MEMORY

You might ask what does memory have to do with driving. Well, you passed a speed limit sign a couple miles back; what did it say? Do you know how to get where you're going? What were those directions? People's memories of signs are not very good. Regulatory signs are more easily remembered than warning or information signs.

VISION

An old person may have 20-20 vision; a young person may require Coke-bottle-bottom eyeglasses. There are all sorts of eye afflictions (e.g., myopia, astigmatism), each takes its own toll on vision. Vision factors include (1) the ability to judge the speed of objects moving toward and/or across one's field of view; (2) being able to discriminate colors [Dewar notes that certain types of street lights will distort colors, making green signs look black and causing some cars to appear the same color as the roadway, thus reducing their conspicuity]; (3) Judgment of distances (depth perception); (4) the faculty to focus and recover from the effects of glare; and (5) the ability to detect objects in one's periphery.

WEATHER

Besides alcohol, weather probably does more to adversely affect one's driving than any other one thing. Wet weather can make the roads slick; icy cold wet weather makes the roads even worse. Fog, haze, glare. How foggy was it? How wet is wet?

Picture this: A little old lady who is used to her 5,000-lb. 1971 Buick LeSabre Centurion Estate Station Wagon is tonight poking along in her grandson's brand new Suzuki Samurai - in the rain - on an unfamiliar road after spending four hours drinking fuzzy navels at her 50th class reunion at Neil Cosgrove's Friendly Bar & Grill.

Compare her to the 13-year-old who swiped Dad's keys and is now piloting his 1988 Alfa Romeo Spider at Mach II down the same stretch of unfamiliar road. These two unlikely individuals inadvertently attempt to occupy the same space simultaneously. Yet you certainly can't apply the same perception and reaction times to both drivers.

Accidents result from "specific human direct causes." According to Dewar, "In-depth accident investigations reveal that approximately 40% of all traffic accidents involving human error have as possible contributory factors difficulties in information processing, perception, or decision making." Among them are improper lookout (18-23%), excessive speed (8-17%), inattention (10-15%), internal distractions (6-9%), and false assumption (5-8%).

In Psychology on the Road (Wiley, New York, 1978), D. Shinar states that "... most accidents are caused by lapses in attention and impairments in the other information-processing tasks, rather than poor vehicle-control capabilities."

Consider for a moment that you're working an accident where a driver blew a stop sign. We know how the accident occurred; the driver failed to yield the right-of-way. Why? Rest assured, the driver will give you some reason - the one he or she wants you to believe; however, there are at least as many as seven reasons that drivers don't stop at stop signs.

1. They don't see the sign. (Either because something obscures the signs, they are improperly angled or because the driver looks beyond them.)
2. They don't see the sign in time to stop.
3. They see the sign but think it is safe to continue.
4. They see the sign but they're in a hurry.
5. They see the sign but consciously decide to disobey it.
6. They see the sign but run it on a dare from passengers.
7. They saw the sign but did not understand it. They could be driving in Quebec where the sign reads

Arret (instead of Stop). [Yes, French-speaking Quebec uses the traditional octagonal-shaped stop sign.] Some people are, according to Dewar, exposed to "information overload." Such a situation may exist when you approach "Sign-City" area where there too many signs or too much data on one sign.

As discussed in our piece on human factors in nighttime collisions (LAW and ORDER, October 1995), drivers operate with certain expectations. Dr. Dewar also notes that such expectancies include the fact that exits on freeways will be on the right side of the roadway. Put one on the left side and you have messed with the driver's mind. Drivers expect there to be advance warnings of hazards and that other drivers will obey traffic rules. "[A]nd if these expectancies are violated there is the potential for an accident." If you work an after-dark collision involving road crews or highway repairs, keep in mind that nighttime construction activity is generally unexpected by drivers.

Motorists often find it difficult, when confronted with a single light (especially when flashing), to tell what it's on. That is, is it on a sawhorse barricade, a delineator post, a parked car? Therefore, as a rule, increased illumination may be required during hours of darkness.

You can erect all the "Reduce Speed Limit" and "Construction Ahead" signs you want to, but most people drive normally in work zones until they see activity (workers, moving construction equipment, etc.).

According to Dr. Dewar, problems arise because of "the perceived appropriateness of the control, especially speed reductions." He cites a Texas study of work zones where motorists had difficulty with the signs. "Road Construction 500 feet." One fourth to one third of those in the study thought the sign meant that the work started at the sign and goes 500 feet.

"Lane Ends" symbol. Makes sense to me and 78 percent of the motorists in the survey. But that means twenty-two people out of a hundred did NOT know what it meant.

Bernard Abrams lists four components of PRT (perception-reaction time): Detection, Identification, Evaluation and Reaction. Dewar's list comprises Search, Detection, Recognition, Decision, and Action. Follow these items with Vehicle Response because the vehicle still needs added time and distance to skid or slide or swerve.

Many accident reconstructionists have long used one second for perception and .75 seconds for reaction. The PRT used in AASHTO design standards--for "average" drivers--includes 1.5 sec. for perception and decision and 1.0 sec. for reacting. Dewar cautions that PRT can increase 30-50% in unexpected situations, and that it will increase with fatigue, alcohol consumption, age of the driver, and with the speed of the vehicle. As pointed out by Lerner, Huey, McGee and Sullivan (in their paper "Older Driver Perception-Reaction Time for Intersection Sight Distance and Object Detection"), "It is not meaningful to talk about a general value for reaction time that is representative of human response across a variety of tasks. The observed times are highly task specific. Furthermore, older people are generally more affected by those task variables that lengthen reaction time; that is, there is an age-by-task interaction."

Researchers Lerner et al. refer to T. Neuman's 1989 "New Approach to Design for Stopping Sight Distances" where Neuman questioned a PRT of 2.5 s in certain situations. "He argued that depending on the physical state of the driver (i.e., either alert or fatigued), the complexity of the driving task, and the location and functional class of the highway, PRT values could vary from 1.5 s to 5.0 s."

How well can you perceive a problem and react to it if you can't tell how far away it is or how fast it's going? Of additional concern is not just how fast it is going, but how fast are YOU going? Dr. Dewar confirms that "witnesses are quite unreliable." Most people underestimate their speed after they've slowed from a fast speed. According to some unscientific tests, motorists underestimated speeds by 6-9 mph (10-15 kmph) during daylight and 2-6 mph (3-10 kph) at night. Estimates were less accurate at higher speeds and poorest for motorcycles; best for vans.

Nighttime distance judgment is far worse than in daylight. Witnesses are usually way off when judging "How far ahead was that vehicle when it started to brake?"

Another factor that affects perception and reaction--one that may become more prevalent in the future--is the car phone, even the "hands-off" type. It's not so much the physical aspect (looking at the numbers, dialing, driving with one hand) but the main concern of mental distraction. The very nature of the conversation is meaningful. Talking about a big real estate deal worth tens of thousands of dollars is more of a distraction than talking with one's child or spouse regarding mundane matters.

Beware of using reaction times based on clinical tests or laboratory simulations. As Lerner et al. noted "Most of these 'simulations' have not really tried to simulate the driving per se, but rather just looked at the time it takes someone sitting in a car-like environment to step on a brake pedal, in response to some simple signal (e.g., a red light display)." They recognize that "the absolute values of the times observed for all age groups are much faster than those actually observed in on-the-road driving, so that it is difficult to project the implications of these findings for actual driving."

I've often discussed perception and reaction when it comes to tractor-semitrailer side and rear underride accidents. I bring it up here because now that the federally-mandated 55 mph speed limit has been lifted and many states have or are contemplating raising their speed limits, the instance of rear-end collisions is certain to rise also. As noted by Dewar, a large number of rear-end crashes occur on the open road under good visibility conditions. It's not so much being able to see a vehicle ahead. "The most important cue is considered to be the rate of change of the size of the visual image of the lead vehicle on the eye of the following driver . . . Drivers are relatively poor at estimating the velocity of a vehicle ahead of them and also the relative velocity of a vehicle ahead of them and their own vehicle."

At night, many drivers tend to fixate. Drinking drivers may fixate on a car's tail lights. Occasionally, drunks run into stopped vehicles because they have fixated on the lights and drove straight in to them (commonly called the "moth to the flame" syndrome). Some drivers fixate on windshield wipers which puts objects on the roadway out of focus.

As you meet vehicles at night, on simple two lane roads, how long does it take one's eyes to adjust to the glare of the oncoming headlights? Dewar asserts that, especially for the elderly, it can take six to seven seconds to recover from glare. In six or seven seconds at 50 miles per hour (80.5 kilometers per hour, 73.3 feet per second, 22.34 meters per second) a vehicle travels 440 to 513 feet (134.1 to 156.36 meters). What kind of perception or reaction could occur under such circumstances?

If you're working a nighttime or early morning truck accident, consider fatigue as a primary factor. The American Automobile Association estimates that in 41 percent of truck accidents, fatigue was a primary/probable cause. Only 18.4% of the drivers in the 221 accidents studied had been driving less than nine hours.

I was the only accident reconstructionist in the country invited by the Federal Highway Administration (FHWA) to attend their March 1995 Truck and Bus Safety Summit in Kansas City. From its Report of Proceedings, seventeen issues were determined to encompass the top concerns affecting the safety of motor carriers. The leading issue was, and is, fatigue.

Fatigue affects a driver's ability to perceive and react in several ways. Constantly drooping eyelids temporarily close out vision. Senses are sluggish. Your timing is off, you become lethargic; reaction slows.

What of one's perception and reaction in pedestrian accidents? Fortunately, the rate of pedestrian accidents in North America is among the lowest of many nations, presumably because with our love of motorized vehicles we have less pedestrian traffic than most countries. Of children, three to eight-year-olds have the greatest accident rate; boys more than girls.

In a study of 2,100 pedestrians accidents, dart-out (not at an intersection) accounted for twenty-four percent. Interestingly enough, the "intersection dash" accounted for only nine percent. For one reason, drivers have more of an expectation that someone might be crossing at an intersection. Quoting Dewar: "It often comes as a surprise to learn of the high proportion of pedestrians who are intoxicated when they are killed in traffic accidents. One report that examined data from the Fatal Accident Reporting System (FARS) indicates that 40% of adult (over 14 years of age) pedestrians were intoxicated when fatally injured. Of these, three out of five were at very high blood alcohol levels."

RAILROAD-GRADE CROSSING ACCIDENTS

We have about 225,000 public and 140,000 private grade crossings at which there are 600 deaths per year. Part of the problem: DRIVER EXPECTATION! The low expectancy of a train increases the time to detect it.

As most rail cars are black, and at night the visibility of trains is poor. Large objects appear to be moving slower than they are (note how a 747 airplane seems to almost hover as it comes in for a landing at several hundred miles an hour). Because of the angle between the motorist and the train (sometimes motorists must look nearly backwards over a shoulder), drivers misjudge the train's speed.

On the approaches to grade crossings, pavement markings are often badly worn. Likewise, painted turn arrows and other lane markings rarely get refurbished soon enough. What makes this meaningful is a conclusion outlined by Lerner et al.: "There are normally multiple cues to [decision sight distance] situations, such as signs, markings, site geometry, traffic patterns, parked vehicles, signal heads, and so forth. Older drivers were less likely to report use of roadside signs as a cue, and showed more reliance on pavement markings. . . . Pavement markings [however] are usually placed much closer to the actual hazard or complex situation. If older drivers, particularly those 70 and older, do in fact have a tendency to rely on pavement markings rather than signs, it means they will often be alerted to upcoming situations much later than younger drivers and will have less time to respond with appropriate maneuvers."

Lerner et al. believe that "no change to the current 2.5-s standard is being recommended." However, that

figure has to do with highway design. That does not mean that drivers need only 2.5 seconds to perceive and respond to unexpected, exigent circumstances about which highway design has no influence.

SUMMARY

So what's a reconstructionist supposed to use? Sadly, there's no definitive answer except that 1.75 sec (daytime) and 2.5 sec (nighttime) are probably good places to start. Dr. Robert Dewar, who has conducted research on human factors in traffic safety since 1971, sums it up best this way. "The proper 'reconstruction' of a traffic accident must take into account the various potential human factors that could have contributed to the accident. After all, driver error (and pedestrian error) becomes a contributing factor in the vast majority of traffic accidents."

Some studies indicate that at night, because of restricted vision and driver expectation, that the time to perceive, react and maneuver is considerably longer. In a video presentation prepared by the 3M Company, "The Beauty of Conspicuity," a section on Decision Sight Distance explains that the Federal Highway Administration (FHWA) commissioned Biotechnology to study the time/distance situation regarding nighttime rear-end accidents.

The study results show that a driver "with average reflexes, eyesight, decisiveness and sobriety, driving an average car" [at 60 miles an hour] will take almost three seconds to see and recognize a hazard, almost seven seconds to decide on a course of action, and almost four-point-five seconds to complete a maneuver."

This is not to say, the study goes on, that the rule to allow 100 feet of stopping distance for each 10 mph, is entirely invalid. But at night, when a tractor-semitrailer is blocking the road, motorists must identify the problem when they are one-quarter mile away.

Therefore, in the 14.5 seconds necessary to see, perceive (recognize), decide what to do, and then do it, a vehicle will travel 1,276 feet. If the recognition begins a quarter mile away (1,320 ft), the motorist has a "cushion" of 44 feet.