In the eyes of the beholder

Your client crashed into a stopped vehicle on a straight road under clear skies. So is she at fault? Not necessarily. The science of human perception can help you show how a seemingly avoidable collision was anything but.

DAN CHRISTENSEN

As the Jones family sat in my office and told their story, none of us could understand how the collision that killed their relative had happened.[1] Just a few nights earlier, Susan Jones had been driving home late at night and ran directly into the side of a tanker truck that had jackknifed, leaving its trailer blocking both lanes of the road.

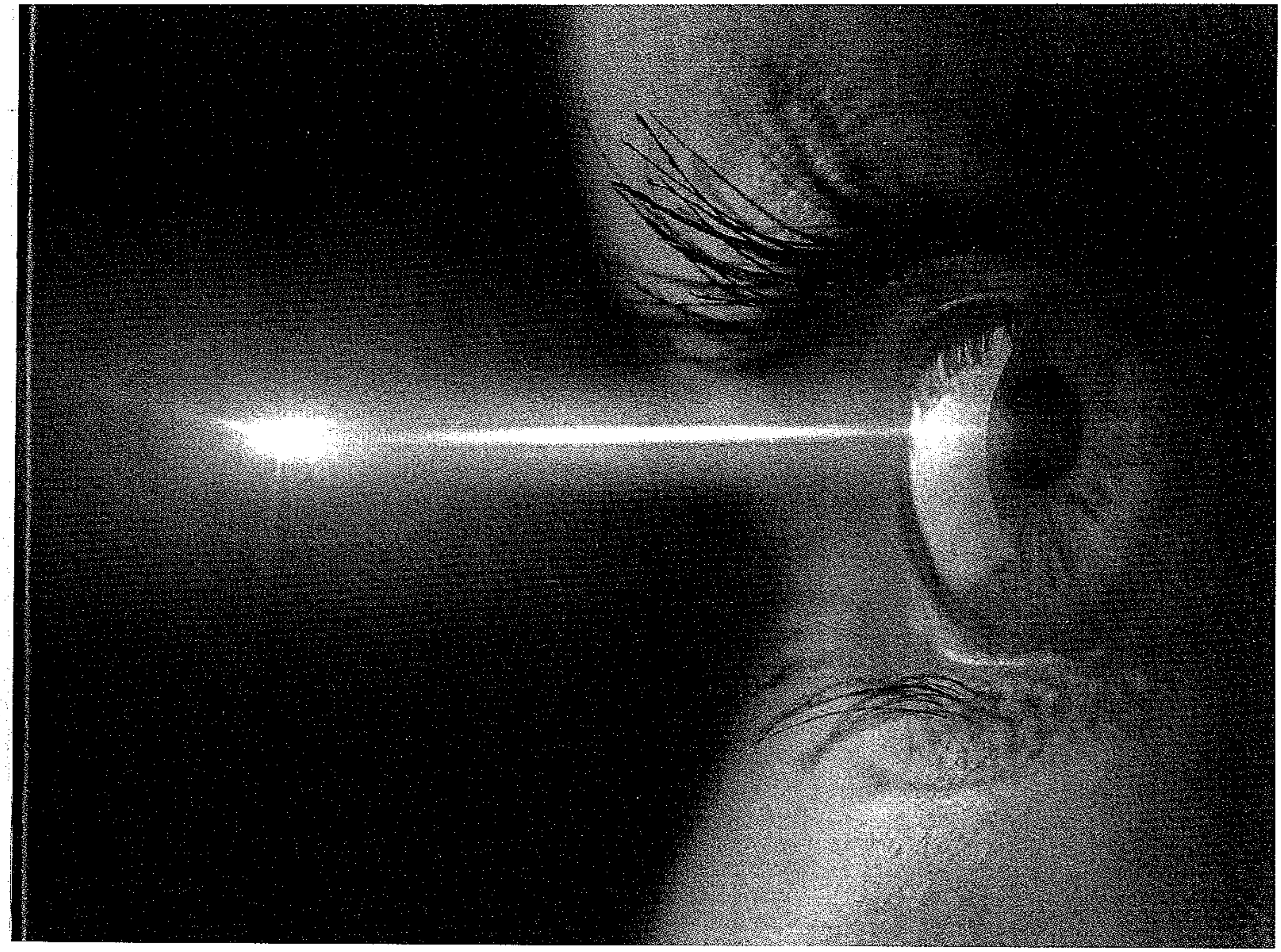
The tractor had all the required lighting equipment, and the bright chrome trailer displayed more than 40 feet of red-and-white retroreflective tape. The road was flat and straight for hundreds of feet in each direction. The weather on the night of the collision was perfect, and the moon was out. Under these circumstances, how could Susan not have seen the 60-foot chrome cylinder right in front of her in time to stop?

She was killed instantly in the collision, so we can never know for sure what happened during those critical seconds before impact. But the crash scene provided some insight. For example, the only evidence that Susan took any evasive maneuvers was a pair of skid marks beginning just 25 feet in front of the tanker. The crush damage to her vehicle revealed that the speed of the impact was over 40 mph. Combined, these facts made it clear that Susan simply did not see the tanker until she was so close to it that collision was unavoidable. Our mission was to show the jury why.

As plaintiff lawyers, we often handle cases that leave us wondering how someone might not have perceived a hazard in time to avoid it. By understanding the science of how people perceive and react to hazards, we can better explain to juries how accidents occur and why the victim is not at fault.

To understand hazard perception, we must begin with a basic understanding of the anatomy of the human eye. (And my apologies to any physicians, optometrists, or human-factors experts who may be reading this gross oversimplification of the physiology of human sight.) The cornea is the outside of the front of the eye where light enters. The pupil is the dark circle in the center of the eye. The iris is the colored portion of the eye that controls how big the pupil is, which determines how much light is allowed to pass through the lens. The retina is the area on the inside of the back of the eye. As light enters, the lens focuses light onto an area of the retina called the fovea.[2]

The retina has two types of receptor cells: rods and cones. Rods, which are present everywhere in the retina except in the fovea, function primarily in low-light situations and do not provide color vision. Cones are found mostly in the fovea, operate in situations where more light exists, and provide color vision.



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The fovea covers a very small area of the total field of vision, so most of a person's vision is peripheral. For this reason, a hazard usually is initially *detected* within the periphery and then *identified* when the person's eyes shift and the object falls within the area covered by the fovea. But to cause this shift, the object must be conspicuous enough to attract the person's attention. In general, the farther away the object is from the foveal area, the harder it is to detect.

When a visual image is projected onto the fovea, neurosignals speed the image to the brain. The brain identifies the object by comparing it to images stored in the person's memory and conveys this information to the nerves that control motor function, causing the person to react physically.[3] The brain at this last action stage is a serial processor, meaning it can process only one thing at a time. In short, a person can be aware of—that is, process—many things at once, but can react to only one at a time.

Perception and reaction

A driver's perception-reaction time typically refers to the amount of time that passes from when an object is visible to when the driver initiates a response. It normally does not include the time it takes to execute the response.

The perception-reaction process has four phases. The detection phase represents the time from when an object first becomes visible to when the person is consciously aware of it. The identification phase is the time it takes to recognize the object as a hazard and understand its meaning. The decision phase is the time it takes to determine what action, if any, is necessary. And the response, or action, phase is the time it takes to begin to execute whatever action the person determines is necessary.

The duration of any one of these phases can vary greatly depending on several factors relating to the driver, the environment, or the object itself.

Factors relating to the driver are

- Age. Generally speaking, older people have more difficulty than younger people perceiving and reacting to hazards.[4]
- Gender. Women typically perform worse on perception-reaction tests than men do.[5]
- Driver expectation. The more unexpected the stimulus, the longer a driver may take to perceive and react to it.
- Fatigue. Driver fatigue will lengthen perception-reaction time. Studies have shown that sleep deprivation af-

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fects drivers' perception-reaction time as much as intoxication does.[6]

- Stress. While low levels of stress can increase attentiveness, high levels of stress due to a particularly threatening or urgent situation will typically lengthen perception-reaction time.[7]
- Intoxication. Not surprisingly, intoxication due to alcohol or other substances will diminish a person's ability to perceive and react to an object.[8]

Factors relating to the environment include

- Lighting. Generally, the less light available, the more difficult it is to perceive and react to a stimulus.

An intense stimulus may be easier to detect and identify, but it may also create so much stress in the person perceiving it that his or her ability to respond is diminished.

- Headlight glare. Glare from the headlights of oncoming vehicles can cause temporary blindness.
- Background. Visual clutter or a lack of contrast between the object and its background will lengthen perception-reaction time.
- Weather conditions. Weather can affect visibility and the reflective properties of the road surface. For example, visibility is diminished when it rains. Even after the rain has stopped, the wet road will appear significantly darker than a dry road and will increase headlight glare from oncoming vehicles.
- Speed. In general, the faster a person is moving, the more difficult it is for him or her to perceive and react to an object.

Factors relating to the object are

- Size. Smaller objects may be more difficult to detect.
- Movement. Unless they are moving extremely fast, moving objects may be easier to detect.
- Conspicuity. How clearly an object stands out from its surroundings will affect a person's ability to detect it.
- Identifiability. How obvious it is that an object is a hazard will greatly affect the duration of the identification phase.
- Intensity. A very intense stimulus (such as a life-threatening obstacle suddenly appearing directly in a driver's path) may be easier to detect and identify, but it may also create so much stress in the person perceiving it that his or her ability to respond is diminished.
- Complexity of the decision. What options, if any, the object presents to the driver may influence how long it takes him or her to decide how to react.

To support your argument that a loss of perception-reaction time was a factor in an accident, you will need the assistance of experts—typically, a human-factors expert and an accident reconstructionist. The human-factors expert conducts testing to determine if and when the object in question was detectable and why the driver did not respond in time. He or she can explain to the jury why certain phases of the perception-reaction process took more or less time during the incident.

The accident reconstructionist can determine what actions the driver took and when, and how the vehicle responded. This expert tells the jury whether the collision was avoidable under the circumstances.

Case in point

By working backward from the impact site, you can calculate when a driver would have had to detect the hazard in order to avoid it. In Susan's case, we started by computing her speed at impact from the crush of her vehicle, which we determined to be about 45 mph. Then, by measuring the length of the skid marks and testing the drag of the road surface—among other things—we determined that her speed before she began braking was about 70 mph, or 103 feet per second.

Based on these factors, we deduced that to come to a complete stop before striking the truck, Susan's brakes would have had to have been locked when she was at least 200 feet from the tanker. Because she was driving a passenger car, not a commercial vehicle with air brakes, her brakes would have responded almost instantly.[9]

We continued our analysis by working backward through the perception-reaction process. Unless she "froze" from stress or fear, Susan would not need an extraordinary amount of time to make a decision about what to do. She had only one option—to brake—and that is what she did.

The identification and detection phases, though, probably took longer. Several factors may have affected her ability to perceive and react to the tanker.

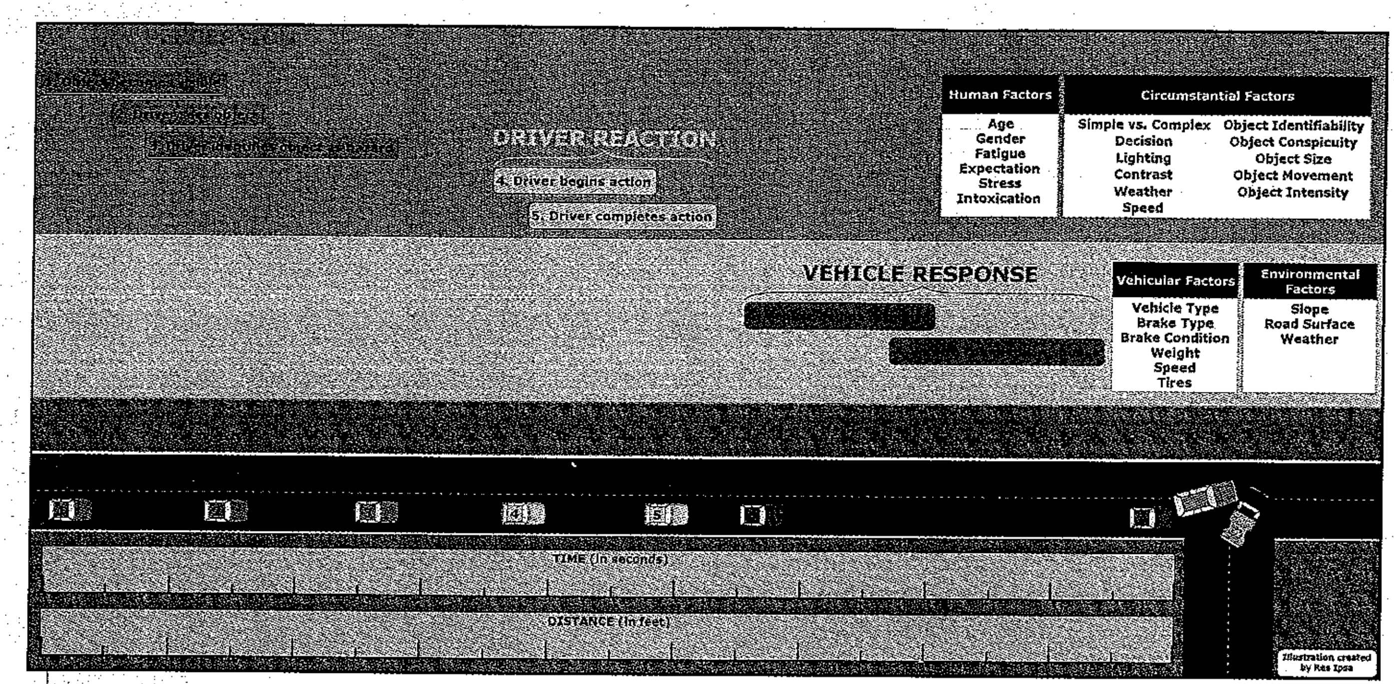
Age. Susan was 58 years old. Visual acuity peaks when a person reaches about 15 and then steadily declines. At 80, a person has about one-third of the visual acuity he or she did at 15.[10]

One of the reasons for this is that with age, a person's iris becomes less flexible, which reduces maximum pupil diameter. This means older people will have more difficulty seeing in low-light situations. While everyone's visual acuity is affected by low illumination, the problem is significantly worse for older people. An older, less flexible iris also means that the time it takes for the eye to readapt to changing light is longer.

Aging also causes the lens to become less flexible and more dense. This can cause a person to lose visual acuity for nearby objects. A person's lens may also yellow with age, which can reduce the amount of light reaching the retina. Finally, an older person's oxygen supply to the retina is not as great as that of a younger person.

While age alone will not result in poorer perception-reaction skills,[11] it can help explain why Susan was not able to perceive the tanker in sufficient time to react and avoid the collision.

Gender. Being a woman, Susan probably had a longer perception-reaction time than most men. Again, the studies do not allow specific conclusions about



A clearly labeled demonstrative exhibit like this one can show the perception-reaction process in a way that can help jurors understand it and apply it to the facts in a case. (Chart by Res Ipsa, Austin, Texas.)

an individual's response time solely because of gender,[12] but they do offer a potential explanation for why Susan did not react in time.

Expectation. A tanker stretched across two lanes of traffic was completely unexpected to Susan—as it would be to most people. Many studies have tested reaction to a stimulus using test subjects who were told what to look for and what to do when they saw it. These studies are misleading because the subjects are typically able to detect and react to the stimulus at twice the distance people would under real-world conditions.[13]

While all drivers should drive defensively and be prepared for emergencies, it is unfair to impose on any driver the duty to expect all possibilities at all times. In reality, most people expect that other drivers will act lawfully and rationally, and when they don't, it creates an unexpected emergency.

Stress. Because of the nature of the hazard facing Susan and the lack of any good options, seeing the tanker no doubt caused her to feel enormous stress. In general, people react worse during extremely stressful moments and may even "freeze" under the pressure.

Environmental factors may also have affected Susan's ability to perceive and react to the unexpected emergency.

Lighting. This collision took place at night, and low-light situations affect a person's ability to perceive and react to hazards. Object identification occurs when the object is within the foveal area of the person's field of vision, but the fovea consists mostly of cones, which do not function in low-light situations. This means a person has to rely primarily on their rods—which function mostly to detect objects in a person's peripheral view and do not provide color vision.

Visual acuity, in general, decreases as less light is available. A person with 20/20 vision in daylight may only have 20/30 or 20/40 at night. This degradation is more severe for older drivers.[14]

At the time of the collision, Susan was driving with her low-beam headlights on. Low beams shine more to the right and down than high beams. Approximately 50 percent of people using low beams will detect an object on the right about 150 feet away and an object on the left at a slightly closer distance.[15]

These studies, however, were conducted with drivers who were instructed to expect a stimulus. Therefore, to correct for driver expectancy, the distances should be significantly reduced when applied to real-world situations.

Headlight glare. Without question, the most significant factor in Susan's case was the glare she experienced from the tanker's headlights. Headlight glare happens when the eye is not able to adapt quickly enough to a change in lighting. Excess light enters the eye and is scattered across the retina, reducing the person's ability to see contrasts.

Adapting to changes in lighting takes time, and it takes more time to adjust to a change from a light environment to a dark one. It can take 30 minutes or longer for a person's eye to readapt and reach maximum sensitivity after going from bright sunlight into complete darkness. Adapting from complete darkness to bright sunlight might take 10 minutes.[16]

Most people have experienced temporary blindness after an approaching vehicle has passed with its headlights on. How long this temporary blindness lasts, while the eye adapts to the change in lighting, varies depending on many factors.[17] These include whether the approaching vehicle had its high beams on, the driver's age, the length of exposure, the type and condition of the road surface, and the existence of any other sources of light.[18]

Our investigation of Susan's case revealed that the tanker driver's headlights were on high beam and facing directly into Susan's lane. Also, because the tractor portion of the truck was jackknifed on the shoulder with its rear wheels stuck in the mud, it was not level, causing the headlights to shine even higher than they normally would, so they were even more blinding.

By plotting the exact location of the tanker, we were able to determine that Susan would have exited the tanker's headlight glare at only about 175 feet from the tanker. She would have been blinded by the glare for at least a second or two. Traveling at 103 feet per second, she never had an opportunity to avoid the collision.

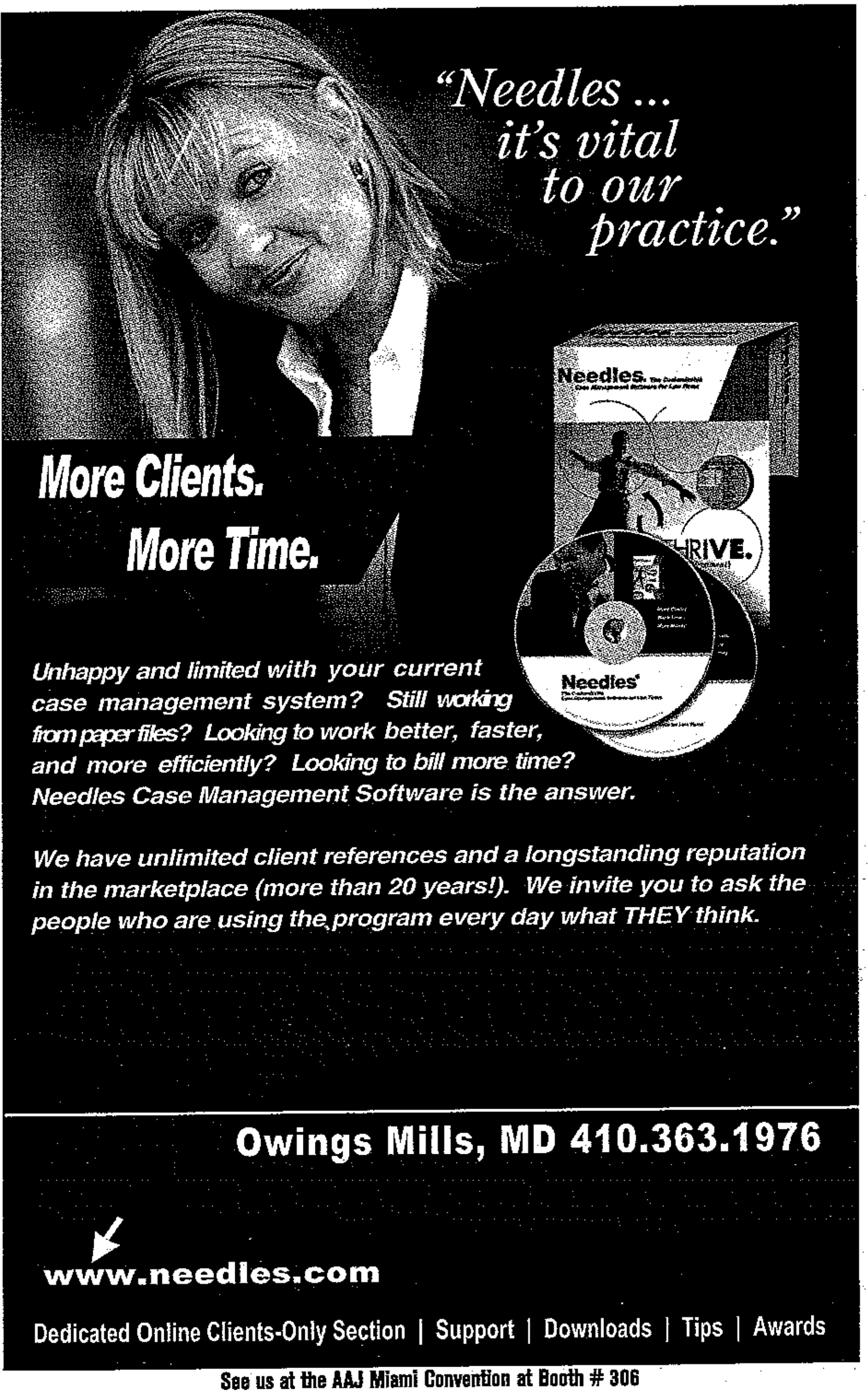
Finally, several factors related to the tanker itself may have affected Susan's perception-reaction time.

Identifiability. Even if the tanker's headlight glare had not affected Susan's ability to detect the truck, the situation would have been confusing to her as she approached. A vehicle coming from the other direction, stopped in the road on the other side of the tanker, was waiting for the truck to move. The vehicle's headlights were on low beam, shining under the tanker—again, directly toward Susan. This would have added slightly to the headlight glare and greatly to Susan's confusion.

Also, when we inspected the truck, we discovered that the retroreflective tape on the tanker was about nine feet from the ground and was cracked, dirty, and in disrepair. It would not have provided much reflection of Susan's low-beam headlights.

Combined, all these factors helped explain Susan's lengthened perception-reaction time. If we assumed that she could see the tanker past its high-beam headlights, an expert concluded that it could take her three seconds to perceive and react to it.

The question then became: How far away from the tanker would she need to have been to spot it in time, step on the



brake, and avoid impact?

Traveling at 70 mph, she would have had to brake at least 200 feet before the tanker. During the three seconds it took her to go through the perception-reaction process, Susan would travel about 300 feet. So she would have had to detect the tanker from about 500 feet away to avoid hitting it. Susan's headlights simply did not reach that far.

Defense moves

The defense in the Jones family's case argued that Susan would have had plenty of time to avoid the collision because the "standard" perception-reaction time is 1.5 seconds.[19] Most people do begin to respond to simple stimuli within 1.5 seconds, with the fastest response time probably being around .75 seconds.

But the studies that support this general rule were based on tests of straightforward situations that required predetermined, simple responses. Also, the tests did not measure the time it took the subject to execute the action. We argued that such studies are not appropriate for calculating perception-reaction time under the conditions that existed during Susan's accident.

The defense also attempted to compare Susan's perception-reaction time to an "average" or "norm" reported in older studies. We countered this by showing that recent, more accurate studies reported their results as percentiles, not as averages or medians.

Because the median or average does not take into consideration the scatter of the data, using percentiles produces a more accurate figure when determining the meaning of a particular result. For example, if Susan's results were at the 85th percentile, it would mean that 85 percent of the test subjects responded in that amount of time or less. That is certainly a better indicator of what is "normal" or "prudent" than the average of the results. (Note that the question is not how Susan performed as compared to an "average," but whether her performance fell within a range associated with representative individuals performing the same sort of task.)

By better understanding the perception-reaction process and the factors that can affect it, you can explain to a jury why the defendant's conduct created an impossible situation for your client. Demonstrative aides help the jury to graphically relive the final, critical seconds before impact and to appreciate the predicament the unfortunate plaintiff faced. Also, knowing how to interpret the literature in this area will let you stop the defense from holding the victim to misapplied, outdated, or inappropriate standards. ■

Most people have experienced temporary blindness after an approaching vehicle has passed with its headlights on. How long this blindness lasts, while the eye adapts to the change in lighting, varies.

Notes

1. The facts in this example are based on an actual case, but the parties' names have been changed to protect their privacy.

2. Frank H. Netter, *Atlas of Human Anatomy,* plate 82 (Ciba-Geigy 1989).

3. Paul I. Olson, *Forensic Aspects of Driver Perception and Respomse* 41 (Lawyers & Judges Publg. Co. 1996).

4. *See* Michael Sivak et al., *Effect of Driver's Age on Nighttime Legibility of Highway Signs,* 23 Hum. Factors 59 (1981); *see also* Geoff Der & Ian J. Deary, *Age and Sex Differences in Reaction Time in Adulthood: Results from the United Kingdom Health and Lifestyle Survey,* 20 Psychol. & Aging 62 (2006).

5. *See* Jos J. Adam et al., *Gender Differences in Choice Reaction Time: Evidence for Differential Strategies,* 42 Ergonomics 327 (1999); Paul Olson, *Driver Perception Response Time,* Socy. Auto. Engrs. Paper No. 890731 (1989).

6. Nelson B. Powell et al., *A Comparative Model: Reaction Time Performance in Sleep-Disordered Breathing Versus Alcohol-Impaired Controls,* 109 Laryngoscope 1648 (Oct. 1999); *see generally Fatigue and Driving: Driving Impairment, Driver Fatigue and Driving Simulation* (Lawrence Hartley ed., Taylor & Francis 1995).

7. Alan Traviss Welford, *Choice Reaction Time,* in *Reaction Times* 73-128 (Alan Traviss Welford ed., Academic Press 1980).

8. Herbert A. Moskowitz et al., *Driving-Related Skills Impairment at Low Blood Alcohol Levels,* in *Alcohol, Drugs, and Traffic Safety T86: Procs. of the 10th Intl. Conf. on Alcohol, Drugs, and Traffic Safety, Amsterdam* 79 (P.C. Noordzij & R. Roszbach eds., Excerpta Medica 1987); *see also* Herbert A. Moskowitz et al., *Marijuana: Effects on Simulated Driving Performance,* 8 Accident Analysis & Prevention 45 (1976).

9. If Susan's vehicle had been equipped with air brakes, there would have been a short delay from the time she executed her braking maneuver to when the brakes responded fully.

10. Olson, *supra* n. 3, at 122; *see also* Carl W. Lunchies et al., *Effects of Age, Step Direction, and Reaction Condition on the Ability to Step Quickly,* 57A J. Gerontology M246 (2002).

11. *See* Der & Deary, *supra* n. 4; *see also* Am. Automobile Assn. Traffic Engr. & Safety Dept., *Age and Complex Reaction Time,* Rep. No. 41 (1952).

12. Am. Automobile Assn. Traffic Engr. & Safety Dept., *Reaction Time as Related to Age,* Rep. No. 69 (1966); *see also* Olson, *supra* n. 5.

13. Paul Olson, *Minimum Photometric Properties of Retroreflective Signing Materials,* Transp. Research Rec. 1247, 1256 (1989); V.J. Roper & E.A. Howard, *Seeing with Motorcar Headlamps,* 33 Illuminating Engr. 417 (1938).

14. *See generally* Am. Med. Assn. & NHTSA, Physician's Guide to Assessing and Counseling Older Drivers chap. 3 (2003), www.nhtsa.dot.gov/people/injury/olddrive/OlderDriversBook/pages/Chapter3.html (last accessed Jan. 3, 2007).

15. Olson, *supra* n. 3, at 104.

16. *Id.* at 33.

17. When evaluating studies that have tested driver adaptation after experiencing headlight glare, be sure the study has employed U.S. headlights and not European headlights. U.S. headlights are more glaring and can extend the readaptation time from approximately 2 seconds to 10 seconds. *Compare* Ottlander, *Adaptation Time after Glare,* in *Lighting Problems in Highway Traffic: Procs. of a Symposium Held at the Wenner-Gren Ctr., Stockholm, Sweden* 111-19 (Erik Ingelstam ed., MacMillan 1963) (testing European headlights), *with* Rudolf G. Mortimer & Paul Olson, *Development and Use of Driving Tests to Evaluate Headlamp Beams,* Rep. No. UM-HSRI-HF-74-14 (Hwy. Safety Reseach Inst. 1974) (testing U.S. headlights), http://deepblue.lib.umich.edu/bitstream/2027.42/755/2/30376.0001.001.pdf (last accessed Jan. 3, 2006).

18. Wet pavement appears darker than dry pavement. This is because water fills the tiny voids in the pavement and makes it smooth, like glass. The driver's headlights reflect forward, which reduces the light available for the driver and causes more glare for oncoming vehicles.

19. *See* Texas Dept. Pub. Safety, *Texas Drivers Handbook* 8-1 (2004), www.onlinedmv.com/TX_drivers_manual.html (last accessed Jan. 3, 2007).