Sometimes the Rules Are Wrong

Questioning Common Sense

By Dave Curry, John Meyer and Mary M. Pappas

IN BRIEF

- Many safety rules related to driving exist and are accepted without critical evaluation.
- When examined, many of these safety heuristics are predicated on what appears to be common sense or tribal wisdom, but actually conflict with existing scientific and technical research.
- The prudent safety professional must look at the underlying research to determine whether available scientific data supports or refutes the rules before relying on them, even if those rules may have been codified into law or official policy.
- Official bodies' adoption of incorrect information does not improve the quality of that information; tribal wisdom should never be confused with empirical fact.

The public looks to safety professionals for guidance as experts in risk avoidance and hazard mitigation. This is reasonable as they are ostensibly trained in that area and, thus, in a better position to evaluate the risks inherent in different activities and to assess what can and should be done to alleviate or reduce those risks to an acceptable level. As such, it behooves safety professionals to be aware of not only safety-related heuristics that are presented to the public, but also the research that underlies that guidance to assess the appropriateness of the various safety rules that are promulgated to address potential hazards. In the real world, however, ostensible safety experts often simply accept these rules as representing appropriate, normal or typical behavior based on longevity, common sense or the simple frequency with which they are expressed.

One example of this (with which most parents are likely familiar) is the "5-second rule": the idea that food dropped onto the floor and quickly retrieved is still safe enough to eat. The rationale seems to be that bacteria requires a longer time to transfer from the floor surface to the food. In a study by researchers at Rutgers University involving multiple foods, surfaces and contact durations over 2,500 measurements, it was discovered that, while longer contact times result in more bacteria transfer, other factors (e.g., nature of the food, surface onto which it is dropped) are of equal or greater importance (Miranda & Schaffner, 2016). The study concluded that bacteria were found to instantaneously contaminate the dropped food, debunking the idea that eating food quickly retrieved from the floor was safe.

Another example is the adage that one should wait at least an hour after eating before swimming. The professed rationale for this practice is to avoid the potential for cramps. This admonishment has existed since at least the 1950s and is actively promulgated today. In reality, the medical community has actually been scornful of this guidance since at least 1961, when exercise physiologist Arthur Steinhaus took a position against it in *Journal of Health, Physical Education and Recreation*. Currently, the authors are aware of no safety organization that espouses this particular "rule," although it has become conventional wisdom and continues to be ubiquitous to this day.

There is certainly nothing wrong with employing an abundance of caution, but it should be recog-

Dave Curry is chief scientist for Packer Engineering Group, where he heads human factors and safety practice. He holds multiple graduate degrees in experimental, human factors and cognitive/perceptual psychology; industrial engineering and business. His experience includes over 30 years of work in incident investigation, product design and development, operational testing and analysis, and laboratory and field research in the control/display, aviation and surface vehicle arenas.

John Meyer, Ph.D., P.E., is founder and principal engineer of Edison Engineering. He regularly consults on matters involving complex incident investigation and reconstruction; mechanical engineering issues involving machine design, risk assessment and mechanical failure analysis; and intellectual property disputes. Meyer earned Ph.D. and S.M. degrees in Mechanical Engineering from the Massachusetts Institute of Technology, as well as a B.S. in Physics from Bethel College.

Mary M. Pappas is a technical/research assistant for both the Packer Engineering Group and Edison Engineering. Her expertise is focused in the automotive/mechanical engineering and human factors/behavioral science technical arenas.

nized that most individuals take sufficient caution to reduce risk to a level that they are comfortable with and consider reasonable. For example, when crossing the street, one could choose to wait until no approaching vehicles are in sight in either direction, but a more common practice is to ensure that approaching vehicles are sufficiently distant to allow the individual to cross at a normal pace with some walker-chosen safety margin. The first practice is clearly safer, but the second is far more expedient and common in practice.

Webster's New World Dictionary defines *negligence* as "failure to use a reasonable amount of care when such failure results in injury or damage to another." Black's Law Dictionary similarly defines it as "failure to exercise the standard of care that a reasonably prudent person would have exercised in a similar situation." The latter source also states that a reasonable person is one who "acts sensibly, does things without serious delay and takes proper but not excessive precautions." Heuston (1977) says:

> The reasonable man connotes a person whose notions and standards of behavior and responsibility correspond with those generally obtained among ordinary people in our society at the present time, who seldom allows his emotions to overbear his reason and whose habits are moderate and whose disposition is equable. He is not necessarily the same as the average man—a term which implies an amalgamation of counter-balancing extremes.

The sum total of these statements is that an assertion of negligence must be based on the normal behavior of the members of the subject population. Declaring a normal behavior to be somehow negligent inherently conflicts with the common understanding of the word among the general public.

Often, during court proceedings, a purported safety expert will be called on to opine on the potential negligence of the actions of one party involved in a lawsuit. Rather than basing his/her testimony on the actions of the party with regard to the normal range of behavior of the population at large, the safety expert's opinion is frequently based on compliance with a "safety" heuristic that in fact has no basis in either science, safety or typical behavior. As such, the pertinent question becomes, how many safety rules are predicated on things that seem like common sense, but in fact conflict with existing scientific and technical research evaluating their viability or normal behavior? Further, how many OSH practitioners take the time to read the underlying research, rather than simply relying on such rules exactly as they learned them? The answer, the authors suspect, is very few.

This article explores several common safety heuristics and compare them to actual research data. Such comparison is enlightening. Examples are chosen from the arena of driving safety, since this is likely an area with which most readers are abundantly familiar.

ONANDTER_SEAN/ISTOCK/GETTY IMAGES PLUS

Mirror Glances

Based on an examination of current state driving manuals, 12 of the 50 states admonish drivers to check their mirrors on a regular basis. Most of these manuals provide little more than nebulous guidance (e.g., "every few seconds"), while others specify an increment of time ranging from "every 2 to 5 seconds" (California) to 10 seconds. The Smith System of Safe Driving, routinely taught to commercial vehicle operators, cautions students to check their mirrors (note the plural) every 5 to 8 seconds. While it is obviously a good idea for a driver to maintain situational awareness all around the vehicle, the question arises of exactly what a driver should do even if s/he determines that an unsafe event is unfolding to the rear.

If being overhauled rapidly in the lane of travel, it is possible that the appropriate action would be to switch to the adjacent lane to avoid being rear-ended, but what would be the result if the overhauling driver intended to switch into that lane while passing? It would seem to be a more prudent action to simply sit tight and let the faster driver decide how to handle the evolving situation, rather than to potentially create a situation in which each driver is trying to outguess the other. At best, the necessity of checking all the vehicle's mirrors with the frequency cited in many drivers' manuals is open to question, and at worst it is a task that actively removes the driver's attention from the vehicle's forward path of travel (representing a considerable distraction).

The timing suggested for the recommended frequency of mirror checks is incompatible with published research on the time required to perform such glances.

Regarding the recommended frequency of mirror checks, the timing suggested is incompatible with published research on the time required to perform such glances. Taoka (1990) studied the time required for this activity based on existing research. He found that a typical glance to the inside rearview mirror of an automobile took 0.75 seconds, while a glance to the driver's side mirror required 1.10 seconds (Taoka, 1990). Given the greater degree of head rotation required to check the passenger side mirror, 1.5 seconds would be a reasonable estimate for the average time required for that activity. On a passenger vehicle, checking all three mirrors would then require about 3.5 seconds.

The typical commercial truck has between four and six side mirrors (typically a double mirror on each side and often one on each fender). The authors have been able to find no validated time for checking a double mirror, but a typical eye fixation requires approximately 300 milliseconds (Pelz & Rothkopf, 2007). Assuming that the commercial vehicle had only four mirrors and that the driver elected to check both side mirrors in one glance, this would require a minimum of 1.4 seconds for a left-side mirror check and 1.8 for the right-side mirror check, resulting in a total of 3.2 seconds (ignoring the time required to shift the point of gaze between the right and left mirrors). The time required increases to about 4.7 seconds if fender-mounted mirrors are included in the total.

Thus, the rules promulgated by many states' driver manuals suggest that a passenger vehicle operator should spend somewhere between 35% and 175% of his/her time looking rearward of the vehicle while driving. The Smith System in turn suggests that a safe commercial vehicle operator should spend a minimum of 40% and 65% of the time looking rear-

TABLE 1

Distance Ahead at Which Drivers Typically Focus

Preview distance (ft)	Straight roadways (%)	Right curves (%)	Left curves (%)
> 500	2	5	4
250-500	13	15	10
100-250	33	32	28
50-100	26	27	29
25-50	8	8	17
< 25	18	13	12

Note. *Adapted from Eye Fixations of Drivers as Affected by Highway and Traffic Characteristics and Moderate Doses of Alcohol, by R.G. Mortimer and C.M. Jorgeson, 1972, Proceedings of the 16th Annual Meeting of the Human Factors Society, Santa Monica, CA.*

TABLE 2

Distance Ahead at Which Drivers Typically Focus (Excluding In/Near-Vehicle Glances)

Preview distance (ft)	Straight roadways (%)	Right curves (%)	Left curves (%)
> 500	2	6	5
250-500	16	17	11
100-250	40	37	32
50-100	32	31	33
25-50	10	9	19

Note. *Adapted from Eye Fixations of Drivers as Affected by Highway and Traffic Characteristics and Moderate Doses of Alcohol, by R.G. Mortimer and C.M. Jorgeson, 1972, Proceedings of the 16th Annual Meeting of the Human Factors Society, Santa Monica, CA.*

ward. Such a position is clearly unsupportable. In reality, research has demonstrated that the typical passenger vehicle operator during baseline driving spends approximately 4.7% of his/her time looking at the rearview mirror, 2.1% of the time looking at the left mirror and 0.2% looking at the right mirror, for a total of 7% (Olsen, Lee & Wierwille, 2005).

Fixation Distance

Twenty-seven out of 50 state driving manuals authoritatively state that safe drivers fixate between 10 and 30 seconds in front of the current position of the vehicle. Such a categorical statement is puzzling in many respects. Over the course of more than 20 years' work in the automotive safety field and reading thousands of research articles in the area, the authors have seen no empirical research that supports such a figure. Indeed, if one were to focus the gaze at such an extreme distance ahead, it is difficult if not impossible to maintain either lateral lane position within the lane or to adhere to a stable intervehicle interval from cars directly ahead of one's position.

Given the perception-reaction time lag and the time required for a vehicle to respond to driver input to the controls, fixating the gaze at some distance ahead of the vehicle is necessary. Similarly, an occasional glance 10 to 30 seconds ahead may certainly be prudent, however, the cited values do not correspond to normal driver behavior in any way. Assuming a typical highway speed of 70 mph (103 ft/s), a driver employing the average braking force used to stop for a stop sign (0.35 g or 11.25 ft/s) will stop in about 470 ft (equivalent to a preview distance of about 4.6 seconds). Examining the more moderate speeds typically found on urban roadways, at 45 mph (66 ft/s) a vehicle comes to a stop using stop sign braking levels in less than 200 ft (equivalent to a preview distance of slightly under 3 seconds).

Obviously, the response of a typical driver to an emergency event is not to brake at the same level as for a stop sign. In reality, research has demonstrated that drivers typically change their point of fixation to scan along the path of travel, rather than fixating at some point in the far distance. This is logical as focusing at the distances recommended in the driver's manuals would make it difficult if not impossible to negotiate curves successfully, follow other vehicles at a constant separation or simply maintain a normal lateral lane position.

Table 1 presents data on the percentage of time spent by drivers traveling at 60 mph (88 ft/s) on straight and curved sections of freeway focusing at various distances ahead based on published research (Mortimer & Jorgeson, 1972). The "< 25 ft" category in Table 1 represents glances either inside the vehicle itself or just over the hood of the car. Table 2 presents the same data excluding glances inside or immediately in front of the vehicle.

Examination of the data suggests that the actual average preview distance is about 2 to 3 seconds ahead of the driver's current position (depending on whether the mean or maximum value is used for each category). This is also greatly affected by the presence or absence of a lead vehicle. Olson, Battle and Aoki (1989) show that on straight roadways without a lead vehicle, drivers spend about 40% of the time looking into the "far field" (defined by the authors as being more than 300 ft ahead) on straight sections of roadway, while the percentage with a leading vehicle on a straight road dropped to less than 5%. At night, regardless of the presence or absence of a lead vehicle, glances into the far field amounted to less than 5%.

These values do not compare favorably with the average surprise reaction time of 1.5 seconds noted earlier, as it provides limited time for a driver to react and respond to a relatively stationary hazard ahead. It does, however, provide adequate time to react and respond to most evolving threats such as lead vehicle sudden braking events. For suddenly appearing static threats, more preview time is necessary. As an example, using a highway travel speed of 70 mph (103 ft/s), employing a generally acceptable level of passenger vehicle heavy braking (0.50 g or 16.1 ft/s), and incorporating the average perception-reaction time for a surprise event (1.5 seconds), a preview distance of 4.7 seconds would be necessary to bring the vehicle to a halt without contacting the threat. For a speed of 45 mph, the same computation results in a preview distance of 3.5 seconds. In short, there is little reason for a driver to attempt to focus his/her attention far ahead, although occasional glances into the far distance are helpful (and normal).

Overdriving Headlights

Nighttime drivers are routinely admonished not to overdrive their headlights. While a laudable goal, such an exhortation ignores the simple fact that the distance at which an object can be detected by a driver is a direct function of the reflectivity of the object. It is possible to avoid overdriving headlights only if the nature and reflectivity of the obstacle that will be encountered is known in advance to the driver so that s/he can adjust speed appropriately.

For the average driver, the detection distance under low beam headlights ranges from more than 3,300 ft for retroreflective marking tape to as little as 75 ft for a dark-clad pedestrian standing to the left of the vehicle's path of travel (Curry, Nielsen, Kidd, et al., 2007; Olson, 2007). When one considers that the normal range extends from the 15th to the 85th percentile driver, the lower value drops to less than 50 ft. Given that the driver does not know in advance the hazard s/he will encounter, to avoid overdriving the headlights, a worst-case analysis would have to be assumed (i.e., a dark-clad pedestrian). For the 50th percentile detection range, assuming a 1.5 second surprise reaction time and 0.7 g braking, this would result in a maximum nighttime driving speed under low-beam illumination of just over 22 mph. For the 85th percentile detection range (the low end of the normal range), this would equate to a maximum speed of slightly under 17 mph. It should also be noted that the pedestrian detection distances used in this computation are based on an upright pedestrian (not always the case) and subjects who were aware that a target was present. Such expectancy typically increases the detection distance by a factor of two, suggesting that the maximum speed under low-beam headlights for the average driver would drop to 11 mph and that for an 85th percentile driver would be 8.5 mph.

Since the ability of a driver to detect a particular target is complicated by multiple factors such as age and contrast level, the "safe" speed to avoid overdriving the headlights for the typical driver would be the lower, not the higher, value. For reference purposes, typical walking speed for an adult pedestrian is approximately 3.5 mph and low-beam headlights are used approximately 97% of the time during night driving by typical drivers (Mefford, Flannagan & Bogard, 2006). Experience suggests that most drivers operate at speeds considerably higher than this when traveling at night.

Driver Age

It is frequently contended that the licenses of older drivers should be revoked after a certain age based on their greater propensity to be involved in fatal and injury crashes. At first glance, available data appear to support this contention. A report from AAA Foundation for Traffic Safety (Tefft, 2012) displays data on the involvement rate in fatal and injury-only crashes for drivers broken out by age group. The figures seem to indicate that the frequency of fatal or injurious crashes increases steadily after age 70. However, what the figures actually show is that the rate of injuries or fatalities to drivers increases as a function of being involved in a crash. To contend that the data show that older drivers have a greater involvement in crashes based on these numbers is akin to arguing that since more china plates break when dropped on a tile floor than do paper plates, this indicates that more china than paper plates are dropped. In truth, the data simply reflect the greater fragility of older drivers as compared to their younger counterparts. The appropriate statistic to examine with regard to crash propensity is the number of crashes, not their outcome for the vehicle occupants.

The report also shows the relative frequency of crashes of all types broken out by driver age (Tefft, 2012). The data still reflects an increase in the likelihood of being involved in a police-reportable crash per 100 million miles driven beginning at approximately age 70. The likelihood of an individual driver being involved in a crash, however, levels out at the minimum level across the lifespan beginning at about age 60 and remains static thereafter. After examining the data, the report states:

> Population-based crash involvement rates were highest for drivers ages 18 to 19 and decreased monotonically with increasing age thereafter. Driver-based crash rates were highest for drivers ages 16 to 17 and decreased until ages 60 to 69, at which point they essentially leveled off. Mileage-based crash rates were by far the highest for the youngest drivers, decreased with increasing age until ages 60 to 69, and increased slightly thereafter, such that drivers in their 70s were involved in approximately the same number of crashes per mile driven as drivers in their 30s, drivers ages 80 to 84 had mileage-based crash rates similar to drivers ages 25 to 59, and drivers ages 85 and older had mileage-based crash rates similar to drivers ages 20 to 24. Rates of driver injuries, and injuries and deaths of other people outside of the driver's vehicle (occupants of other vehicles, pedestrians, etc.) tended to follow patterns similar to those of overall crash involvement. Drivers ages 85 and older had the highest rates of (their own) death per driver and per mile driven; however, this was largely due to their diminished ability to survive a crash rather than to their increased crash rate. In relation to the amount of driving that they did, drivers aged 85 and older posed about as much risk to other people outside of their vehicle as drivers in their early 20s did. In relation to their share of the driving population, fewer other people were killed in crashes involving drivers ages 85 and older than drivers of any other age. (Tefft, 2012)

In short, if it is too risky to allow elderly drivers to remain on the road, logic dictates that the same must be true of drivers younger than their mid-20s, since the risk is the same.

Travel Speed

Public service announcements frequently remind the public that "speed kills," which is often interpreted by some experts as meaning that speeding per se equates to unsafe behavior. In practice, this is sometimes true and is heavily dependent on the circumstances involved. According to Federal Highway Administration (FHWA), all states and most local agencies claim to use the 85th percentile

TABLE 3

Speed Limit Determination Factors Used by State & Local Agencies

	Percent of time used	
Factor	By state agencies	By local agencies
85th percentile speed	100	86
Roadside development	85	77
Accident experience	79	81
10 mph pace	67	34
Roadway geometrics	67	57
Average test run speed	52	34
Pedestrian volumes	40	50

speed of free-flowing traffic (i.e., the speed below which 85% of the traffic is traveling under conditions when not obstructed by other traffic) as the primary factor in establishing speed limits (Parker, 1985). The basic intent of speed zoning is to identify a safe and reasonable limit for a given road section, and the 85th percentile speed reflects a safe speed as determined by a large majority of drivers. This value is then modified based on other criteria. Table 3 presents the basic criteria reportedly used to guide speed limit determination (Parker, 1985).

Indeed, the Manual of Uniform Traffic Control Devices (MUTCD) requires that:

> Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices. The engineering study shall include an analysis of the current speed distribution of free-flowing vehicles. (FHWA, 2009)

It also states that even after adjustments for other considerations, "When a speed limit within a speed zone is posted, it should be within 5 mph of the 85th percentile speed of free-flowing traffic" (FHWA, 2009). While there is no mandatory national consensus method of conducting such an engineering study, that specified by the state of Kansas is relatively typical:

> Radar is used to collect speed data from random vehicles on a given roadway. Off peak hours are normally used in conducting a spot speed study with the speed of approximately 50 free flowing vehicles in each direction obtained. On low volume roads where it would be difficult to obtain a sample of 100 vehicles, the study may be terminated after a study period of one hour. Vehicles are selected at random from the free flow of the traffic stream to avoid bias in the results. (Kansas Department of Transportation, 2017)

Other states such as Missouri and Texas use the same basic process but mandate a higher number of subject vehicles to be sampled. The methodology as normally employed involves the calculation of the 85th percentile speed based on the sample, then rounding up to the nearest 5 mph increment (i.e., if the calculated 85th percentile speed were 68 mph, then the posted limit should be 70 mph).

The 85th percentile speed method is based on the assumption that the majority of drivers are attempting to drive in a safe and reasonable fashion and that those within one standard deviation of the average represent the bulk of that normal population. In many jurisdictions, however, speed limits are frequently not set using any type of objective methodology, but rather are based on legislative fiat. It should be noted that the latter method is not necessarily based on any type of objective safety criteria. For roadways that use statutory rather than empirically determined speed limits, studies have repeatedly demonstrated that the posted limit frequently does not represent the maximum or even average speed of travel of vehicles using it.

A set of studies conducted by FHWA involved testing at more than 150 locations in multiple states to examine actual driver compliance with statutory speed limits (Tignor & Warren, 1990). The results indicated that more than 70% of motorists exceeded the posted speed limits in urban areas, with some sites having compliance rates as low as 3%. Fewer than 10% of the sites tested had compliance rates of greater than 50%. The report concluded, "Our studies show that most speed zones are posted 8 to 12 mph below the prevailing travel speed and 15 mph or more below the maximum safe speed." Another study focusing exclusively on highway speeds in Arizona concluded that for the 56 locations surveyed, speed limit compliance rates ranged from 30% to 55% dependent on the speed limits in place at those locations (Skszek, 2004). In short, traveling above the posted speed limit represents normal, not extraordinary, behavior on the part of vehicle operators.

Speeding in such situations, rather than being inherently dangerous, is normally safer than complying with posted limits. Contrary to popular belief, speed in and of itself is not a major contributor to crash likelihood. Research has repeatedly demonstrated that crash frequency depends less on the absolute speed of travel and more on the variation of speeds between vehicles within the stream of traffic. To use a prosaic example, any fan of auto racing is aware that it is rare to see any type of crash occur while the cars are under a yellow flag, despite the fact that the vehicles may be separated by only inches and still traveling at 85 mph. It is when vehicles are traveling at different speeds that crashes become probable.

Drivers in the U.S. have been inundated with the mantra that "speed kills" for many years and there is a limited truth to this statement, although it must be placed into proper perspective. The basic equation regarding the kinetic energy involved in a crash between two vehicles or a vehicle and a stationary object is:

$$KE = \frac{1}{2} m{v_{cl}}^2$$

where m is the mass of the moving object and v_{cl} represents the difference in velocity between the colliding entities.

Examination of the equation shows that the energy involved in a collision varies with the square of the difference in velocity, rather than varying directly with it. As such, in a collision between a vehicle traveling at 50 mph and a stationary object, a speed increase of 5 mph (10%) results in more than a 20%

increase in the total energy at impact. The faster one travels, the more potential energy is involved in the collision and the greater the likely damage or injury to the vehicle and its occupants should one occur.

One cannot, however, focus exclusively on the relationship between speed and potential impact energy. To do so would result in the conclusion that the safest vehicle is one that does not move at all (an obvious non sequitur). What must be borne in mind is that the potential for injury is a function of not only the speed of the vehicle, but more importantly the likelihood of the crash occurring at all. If the probability of a crash is reduced by a given percentage, then the probability of injury drops proportionally as well. Even given the fact that prevailing roadway speeds normally exceed posted limits, it may be surprising to some that the average speed of travel does not correspond to the lowest probability of crash.

Research has repeatedly demonstrated that travel at the 85th percentile speed, rather than the average speed, results in a lowest likelihood of crash involvement. This relationship was first demonstrated by Solomon (1964) in a study conducted for Bureau of Public Roads (FHWA's predecessor) and is referred to colloquially as the Solomon Curve. These results were independently corroborated by Cirello (1968).

West and Dunn (1971) had similar results regarding crash likelihood, although their results indicated that crash likelihood as a function of vehicle speed was not significantly different within a 15 mph range around the average travel speed on roadways involved in their testing. Various theories exist regarding why a higher average speed is related to a lower incidence of crashes, but no complete consensus. It may simply represent the fact that travel at the 85th percentile speed or above requires a higher degree of driver attention/concentration than does simply driving with the flow of traffic (i.e., less potential for driver distraction from the vehicle operation task itself).

In any case, if the end goal is increased safety on roadways, minimization of speed variance to reduce crash likelihood rather than simple speed reduction should be the focus of attention. The best way to accomplish such a goal is to adopt speed limits that are in line with the prevailing speed of travel on the associated roadway, rather than insisting that travelers comply with an unrealistic, unacceptable and arbitrarily determined value. It could be argued that if speed limits were raised to comply with the 85th percentile values cited in MUTCD (and advocated by Institute of Transportation Engineers), the result would simply be that drivers would increase their speeds to travel at even higher velocities above the newly posted limits. Research has shown that such is not normally the case in practice. Average travel speeds do rise, but rapidly level out at a new norm.

In locales where speed limits were raised to comply with engineering studies on the roadways in question (usually referred to as the adoption of "rational" speed limits), there was indeed an increase in the average speed of travel on the roadways, but not by the amount of the increase in the posted limit. In studies conducted in Virginia, an increase of 10 mph in highway speed limits resulted in an average speed increase of between 1.7 and 4.3 mph dependent on location, while noncompliance with the speed limit dropped from a level between 80% and 90% to one between 50% and 60% (the percentage of vehicles traveling more than 10 mph over the speed limit dropped from between 15% and 30% to between 3% and 5%) (Fontaine, Park & Son, 2007). Similar studies conducted in Mississippi indicated that although a small proportion of drivers continued to violate the rational limits by more than 10 mph after they were implemented, the number of such speed violations was reduced by three-quarters compared to that prior to the increase in speed limits (Freedman, De Leonardis, Polson, et al., 2007). The study also found no decrease in overall road safety accompanying the increased speed limits.

As noted, the driving public has been inundated with statistics such as the notion that speeding is associated with more than one-third of all fatal crashes. On the surface, this statistic may be true, but it requires further examination. As noted, more than half of the vehicles on a roadway are typically traveling over the speed limit. As such, it would be unsurprising if at least one-third of all vehicles were doing so at the time of a fatal crash. If most vehicles are traveling over the speed limit at any given time (a likely probability based on the preceding discussion), then the minority traveling at or below the speed limit are associated with two-thirds of all fatal crashes. In other words, traveling at or below the speed limit results in twice as high a likelihood of being involved in a fatal crash as does traveling faster.

To compound the potential confusion, the term *speed-related crash* is an incredibly question-begging one. National Highway Traffic Safety Administration (NHTSA) defines a crash as being speed-related if any driver involved in the crash is charged with a speeding-related offense or if a police officer indicates that racing, driving too fast for conditions or exceeding the posted speed limit may have been a contributing factor in the crash. It should be noted that this categorization is typically based on an ad hoc determination by the responding officer, not upon any sort of crash reconstruction (i.e., it is completely subjective).

Further, the term is applicable regardless of whether the speed involved was in any way causative of the crash. Moreover, based on the authors' discussions with several traffic control officers, *driving too fast for conditions* is frequently used as a catch-all citation employed by responding officers, which takes no note of the fact that the vehicles in the crash may well have been moving with prevailing traffic and well below the actual posted speed limits. Finally, the determination that one was driving too fast for conditions is frequently a post hoc conclusion based only on the fact that the crash occurred at all, with no regard for whether it could have been avoided even under ideal conditions or at a far slower speed. A study conducted by Great Britain's Transportation Research Laboratory revealed that "excessive" speed was a definite causal factor in less than 7% of crashes (Broughton, Markey & Rowe, 1998).

An additional interesting issue regarding speed limits relates to states that have mandated different speed limits for large commercial trucks and passenger vehicles. These limits typically differ by 10 mph or more. The intent of this practice seems to be an effort to reduce the kinetic energy involved in a collision, given that a loaded semi-trailer combination can easily out-mass a passenger vehicle by a factor of 20 or more. It is argued that a speed reduction from 70 to 60 mph reduces the impact energy of an 80,000-lb commercial truck by about 35%. What is overlooked in this argument is that if likelihood of the collision itself is eliminated by the vehicles traveling at a common velocity, that same energy is reduced by 100%. Most commercial vehicle operators intuitively understand this and attempt to flow with traffic, regardless of the speed limit. When speaking before the U.S. Senate's Highways and Transportation Committee in 2003, Julie Cirillo (former Assistant Administrator and Chief Safety Officer for FMCSA) explicitly acknowledged this fact:

> Commercial vehicle drivers are professionals. They know that operating with the flow of traffic is the safest operating speed. If the average speed of all vehicles on freeways is about 70 mph then commercial vehicles are behaving in a responsible and safe manner, although in violation of the law. . . . In summary, traffic operating at or about the same speed, regardless of speed limit, is the safest traffic environment. Jurisdictions should do whatever they can to encourage this operating scenario and should never require the opposite. (Cirillo, 2003)

It is unfortunate that many, if not most, states ignore the available data or at best only pay lip service to it, often instructing commercial traffic to "proceed with the flow of traffic" as long as they "do not exceed the speed limit." Given that, as noted earlier, average freeway travel speeds are typically faster than the speed limit for passenger vehicles; this places the commercial vehicle operator at a considerable disadvantage when trying to proceed with the flow of traffic, particularly if they are driving a vehicle equipped with a governor restricting them to a still lower speed.

This combination frequently places commercial vehicle operators in a catch-22 situation. If the vehicle allows them to drive at the safest possible speed to reduce the likelihood of a collision (i.e., the speed of prevailing traffic), if a collision occurs they will be vilified for traveling far in excess of the posted speed limit. If they travel at the speed limit, which may be far below the speed of prevailing traffic (particularly in states with split speed limits), they significantly increase their likelihood of being involved in a crash. It is difficult in the extreme to assess which is the "safer" course of action under such circumstances; it certainly cannot be done with reference to a generic rule.

Many of the safety maxims that we have been exposed to over the years are either incorrect, misleading or must be interpreted in light of particular situational factors.

Conclusion

The preceding examples make clear that many of the safety maxims that we have been exposed to over the years are either incorrect, misleading or must be interpreted in light of particular situational factors. Simply relying on an oft-heard manta without examining the underlying data is an easy way to go wrong with great confidence. Further, contending that compliance with such rules represents "normal" or "typical" behavior on the part of individuals, in many cases is not only incorrect, but wildly so. Contending that noncompliance with those rules constitutes negligence on the part of an individual is even more so. This is particularly true when the rules do not comport with behaviors that are in fact safer than those mandated by the "rules." Legal negligence may be statutorily defined, but when such behavior represents the norm and comports with greater safety, it is the law that is incorrect, not the behavior in question.

Institutionalizing incorrect information into laws, manuals or mantras does not turn it into wisdom, but rather results in confusion or distrust on the part of the general population. Before relying on conventional wisdom, even when codified into law or official policy, the careful safety professional must examine the underlying research to determine whether the available scientific data supports or refutes it. The authors, therefore, offer several suggestions when encountering conventional wisdom regarding safety and safe practices.

1) Vet sources. It is often critical to determine the ultimate source of information relied upon when either rendering opinions or providing guidance. Where possible, it is best to refer to original information sources rather than paraphrased or derived ones. Any source that does not provide the original source of critical information should be taken with a grain of salt. Often, derived sources will paraphrase, summarize or even incorrectly interpret the original meaning of information from more accurate technical sources.

One example of this is the case of a news report citing a significant finding from a research report without recognizing that, in a statistical analysis, *significant* refers to the reliability of a particular finding, while in the public lexicon, the term is more typically synonymous with *highly important* or *meaningful*. The two meanings are not equivalent, nor are they interchangeable. Likewise, material gleaned from a blog is not equivalent to material gleaned from a peer-reviewed publication.

2) Do not attempt to make too much stew from a single oyster. The fact that a particular data point is presented by a reliable source is important, but should not typically be relied on in isolation. Look for reliable confirmatory sources or at least sources that provide similar noncontradictory information where possible.

One example of the perils of relying on a single source is the purported connection between autism and vaccinations. The root source of this controversy appears to be a single 1998 technical paper presented in *The Lancet* (a well-known peer-reviewed medical journal). The paper in question was later retracted due to the data it contained having been falsified; the author's license to practice medicine was rescinded, but the retraction does not seem to have affected the promulgation of the findings contained within the paper over the past 20 years. The fact that no other papers present similar findings should be a strong indicator that the data in the original document is suspect and needs further review.

3) Differentiate between observations and conclusions. In any technical report detailing research, the reader should be careful to differentiate between findings from the research and conclusions that the researchers drew from it. The findings, within the confines of the methodology of the study, are empirical, observable fact. The conclusions that the researchers draw from those observations, however reasonable, may not be. For example, one of the authors of this article left a tooth beneath his pillow as a child, and found a quarter there the following morning. This is a fact. The conclusion that the coin must have been left by the Tooth Fairy is a conclusion, which, in retrospect, was incorrect (no matter how reasonable it may have seemed to a 6-year-old child).

4) Laws, rules and regulations are not authoritative sources regarding what is or should be "normal" behavior. They may or may not represent scientifically obtained data or findings. For example, according to numerous sources (including *Smithsonian*), a bill was introduced to the Indiana legislature in 1897 that would have made Pi equal to 3.2. While potentially laudable from the standpoint of mathematical simplicity, natural law cannot be mandated or changed by legislative fiat, no matter how well-intentioned. The same holds true for enshrining nonsense in the form of guidance documents produced by local, state or federal rulemaking organizations. Such documents are typically produced by potentially well-intentioned authors, but not technical experts in the field. Often, these guides promulgate information that seems reasonable to the writers at the time, but that is not vetted for technical accuracy. When subsequent versions of the same document are prepared, the original information is taken as a given and the new authors frequently seem to employ an "if a little is good, then more must be better" approach wherein they increase what may have originally been reasonable guidance, often to unrealistic levels. This results in guidance that end-readers should recognize as being unrealistic at best after reasonable, careful evaluation. That disregard for poor guidance may in turn reflect negatively on more realistic or accurate guidance provided elsewhere within the same document. **PS**

References

Broughton, J., Markey, K.A. & Rowe, D. (1998). A new system for recording contributory factors in road accidents. Berkshire, England: Transportation Research Laboratory.

Cirillo, J.A. (1968). Interstate system accident research: Study II, interim report II. *Public Roads, 35*(3), 71-75.

Cirillo, J.A. (2003, June 10). Testimony before the Senate Highways and Transportation Committee. Retrieved from www.landlinemag.com/story.aspx?storyid=60134#.Wlv1eainG70

Curry, D.G., Nielsen, E.A., Kidd, J.W., et al. (2007). Driver detection of roadside obstacles at night. *Proceedings of the Human Factors and Ergonomics Society 51st Annual Meeting, Baltimore, MD*.

Federal Highway Administration (FHWA). (2009). Manual on uniform traffic control devices for streets and highways, 2009 edition. Washington, DC: U.S. Department of Transportation, Author.

Fontaine, M.D., Park, B.B. & Son, H.D. (2007). Final report: Demonstration and evaluation of rational speed limits: Virginia Department of Transportation Evaluations.

Freedman, M., De Leonardis, D., Polson, A., et al. (2007). Field test of the impact of setting and enforcing rational speed limits; Final report for Gulfport, Mississippi—Demonstration community. Rockville, MD: WESTAT.

Haas, R.P., Inman, V.W. & Dixson, A.L. (2003). Use of ITS data to determine driver acceleration behavior. McLean, VA: Federal Highway Administration.

Heuston, R.F.V. (1977). *Salmond on the law of torts* (17th ed.). London, U.K.: Sweet & Maxwell.

Kansas Department of Transportation. (2017). Establishing speed limits a case of "majority rule." Retrieved from www.ksdot.org/bureaus/burTrafficSaf/brochures/establishingspeedlimits.asp

Mefford, M., Flannagan, M. & Bogard, S. (2006). *Real-world use of high-beam headlamps*. Ann Arbor, MI: University of Michigan Transportation Research Institute.

Miranda, R.C. & Schaffner, D.W. (2016). Longer contact times increase cross-contamination of enterobacter aerogenes from surfaces to food. *Applied Environmental Microbiology, 82*(21), 6490-6496.

Mortimer, R.G. & Jorgeson, C.M. (1972). Eye fixations of drivers as affected by highway and traffic characteristics and moderate doses of alcohol. *Proceedings of the 16th annual meeting of the Human Factors Society, Santa Monica, CA.*

Olsen, E.C., Lee, S.E. & Wierwille, W.W. (2005). Eye glance behavior during lane changes and straight-ahead driving. *Transportation Research Record: Journal of the Transportation Research Board, 1937*, 44-50.

Olson, P.L. (2007). Visibility with motor vehicle headlamps. In R.E. Dewar & P.L. Olson, *Human Factors in Traffic Safety* (2nd ed.). Tucson, AZ: Lawyers and Judges.

Olson, P.L., Battle, D.S. & Aoki, T. (1989). *Driver eye fixations under different operating conditions*. Ann Arbor, MI: University of Michigan Transportation Research Institute.

Parker, M.R., Jr. (1985) Synthesis of speed zoning practices (Report No. FHWA/RD-85/096). Washington, DC: Federal Highway Administration.

Pelz, J.B. & Rothkopf, C. (2007). Oculomotor behavior in natural and man-made environments. In R.P. Van Gompel, M.H. Fischer, W.S. Murray, et al. (Eds.), *Eye movements: A window on mind and brain*. Oxford, U.K.: Elsevier.

Skszek, S.L. (2004). Actual speeds on the roads compared to the posted limits. Tucson, AZ: Arizona Department of Transportation.

Solomon, D. (1964). Accidents on main rural highways related to speed, driver, and vehicle. Washington, DC: U.S. Department of Commerce.

Taoka, G.T. (1990, Oct.). Duration of drivers' glances at mirrors and displays. *ITE Journal, 60*(10), 35-39.

Tefft, B.C. (2012). Motor vehicle crashes, injuries and deaths in relation to driver age: United States, 1995-2010. Washington, DC: AAA Foundation for Traffic Safety.

Tignor, S.C. & Warren, D. (1990). Driver speed behavior on U.S. streets and highways. *ITE Compendium of Technical Papers*.

West, L.B., Jr. & Dunn, J.W. (1971). Accidents, speed deviation and speed limits. *Traffic Engineering, 41*(10), 52-55.