Customized driver feedback and traffic-safety culture

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Introduction

On September 11, 2001, also known as "9/11," 2,973 lives were lost in the United States (US) as the result of a terrorist attack on New York and Washington, DC (Wikipedia 2006). Of these fatalities, 2,602 occurred in the World Trade Center towers themselves. In the following five years many things changed. US citizens tolerated the expenditure of untold billions of dollars by the US government in efforts to prevent a reoccurrence of the 9/11 tragedy. As a direct result of this event, the US culture has noticeably shifted toward an antiterrorism perspective. As part of this shift in cultural perspective, US citizens routinely accept an increased level of screening and decreased level of privacy that they would not have tolerated prior to the September 11, 2001 attacks.

While most US residents have become acutely aware of the potential threat of another terrorist attack, they are seemingly blind to a significant threat to public safety that is ongoing and more costly in the loss of life than was 9/11; this threat is traffic crashes. On the same day as the 9/11 attacks, 205 people died in traffic crashes across the US (FARS 2006). In fact, during the week surrounding the attacks, 2,752 people died as a result of traffic crashes; more than the number of people killed in the World Trade Center towers. Indeed, for the entire 2001 calendar year, 42,196 people lost their lives as a result of injuries received in a traffic crash. This is equivalent to experiencing a 9/11 tragedy every 26 days.

Despite these disturbing statistics, 2001 was not a unique year for traffic fatalities, and the last five years have seen little progress in reducing US motor vehicle fatalities. Indeed, in 2005, the nation lost 43,443 people to traffic crashes. When yearly fatality figures for 2001 and 2005 are considered by driving exposure, 1.51 fatalities occurred per 100 million miles of vehicle travel (VMT) in 2001, which is not notably different from the rate of 1.47 observed in 2005 (FARS 2006). Given the lack of societal outrage over this tremendous, avoidable loss of life, one must assume that this level of traffic fatalities is acceptable to Americans. However, this assumption seems out-of-line with other manifestations of US cultural values for the defense and protection of the lives of US citizens that have been demonstrated in other circumstances, most notably in the response to the 9/11 attacks. The juxtaposition of the relatively low level of concern over motor vehicle crashes and the high level of concern and sacrifice in response to the 9/11 attacks demonstrates that the safety culture in the US is not uniform, but that the valuation of safety varies by circumstances, conditions, and source of the threat.

US safety culture as it relates to traffic safety (traffic-safety culture) was the focus of a recent panel workshop sponsored by the AAA Foundation for Traffic Safety (2006). This panel of traffic safety experts suggested that progress in reducing motor-vehicle–related fatalities in the US may be inhibited by the current traffic-safety culture and that in order to make significant reductions in traffic-crash–related deaths, the values inherent to the current traffic-safety culture of the US would have to change. This paper focuses on the role that customized driver feedback might play in shifting the US traffic-safety culture toward increased concern and greater action to reduce motor vehicle fatalities. Several definitions are necessary to explore this issue.

First, for this paper the traffic-safety culture is defined as:

> *The totality of socially transmitted behavioral patterns, arts, beliefs, institutions, valuations, and all other products of human work and thought regarding traffic safety and the incidence of motor-vehicle–related crashes, injuries, and fatalities that guide social and individual behavior and are propagated through processes of individual learning.*

This definition is necessarily broad, reflecting the inherent complexity of any cultural value system and the wide array of factors that influence and define a culture. This definition stresses that culture is conveyed through an individual process that is relatively uniform across society; that is, the norms and tenets of a culture are learned by individuals in a society and then employed by those individuals, thereby perpetuating the manifestation of that culture. Finally, because it is a traffic-safety culture, its focus is inherently on the promotion and maintenance, or neglect and disintegration, of traffic safety at the societal level.

Second, we define customized driver feedback as:

> *Any objective and credible information a driver receives about his or her mental state or driving performance. This feedback can come to the driver directly (e.g., from an in-vehicle warning system), indirectly (e.g., through a passenger, parent, or supervisor), or globally through feedback from the larger social context (e.g., how others drive, traffic-safety messages).*

The remainder of this paper is divided into three parts. First, because cultural values and related behaviors are learned, we focus briefly on the various mechanisms by which humans learn, factors important to the process of learning, and the social factors that influence learning. Second, because current driver feedback systems use modern technology, we discuss technological issues related to the provision of customized driver feedback. Finally, the paper is concluded by a discussion of the manner in which customized driver feedback, as currently available using modern technological devices, might improve individual driver safety, and the likelihood that customized driver feedback might positively influence American traffic-safety culture currently and in the future.

Individual elements of cultural change

Elements of learning

Given that complex elements that collectively define culture are learned, the main reason for providing customized driver feedback at an individual level is to teach drivers behavioral patterns that are congruent with the values of a traffic-safety culture. Relating this to cultural change, the purpose of customized driver feedback is to shift individual behavior in the direction needed for the traffic-safety culture to value higher levels of safety and lower numbers of injuries and deaths resulting from motor vehicle crashes. Thus, understanding how a person learns is important to understanding how customized driver feedback might promote a traffic-safety culture in which greater traffic safety is emphasized.

Learning processes

Following is a brief review of three learning processes that are relevant to traffic safety: classical; operant; and observational learning.

Classical learning, also know as classical conditioning, involves the simple association between a stimulus, such as the ringing of a bell, and a reflexive response, such as salivation as demonstrated by Pavlov (1927). However, there are many reflexive responses that might be triggered, including human emotions, such as fear, and there are many stimuli that can produce a reflexive response. Classical learning can use the stimulus response mechanism to teach a person to have either a reflexive response to a stimulus, or to change a natural response to one that is normally not present. For example, driving a car well over the speed limit might reflexively produce a fear response for a male teen driver, and in the absence of other stimuli, the response might naturally be to avoid high speeds and to maintain a speed closer to the limit. However, if exceeding the speed limit is paired with some other stimulus, a different response might be produced. For example, we know from research that teenage boys are more aggressive drivers in the presence of male peers (Simons-Morton, Lerner, and Singer 2005). This might result from the pairing of a stimulus, such as the presence of an influential male peer who is impressed by speeding, with a response such as the driver feeling more instrumental or more highly esteemed. Such a pairing might alter the driver's natural response to speed such that, over time, the driver learns through classical conditioning to enjoy speeding.

Three factors moderate the probability that classical learning will take place (Leahey and Harris 1997; Pavlov 1927; Ross and Ross 1971; Watson and Rayner 1920). The first factor is the frequency of the associative pairing of the stimulus and response. The more frequently that the male peer's being impressed by the driver's speeding is paired with the driver feeling positively about himself, the more likely it is that the driver will learn to enjoy speeding.

Second, as the interval between the stimulus and the initially unrelated emotional response is shortened, the probability that a behavior will be learned increases. Using the example of speeding, if the stimulus and response are paired immediately, as in the case that the peer is in the car when the driver is speeding, the probability that the driver will learn to enjoy speeding is more likely than in the situation where the driver speeds while driving alone and then later tells the peer about his speeding and experiences the response of feeling positively about himself.

Third, the probability of learning increases with the intensity of the reflexive response. Again referring to speeding, an example would be the presence of multiple peers in the car that are all impressed by the driver's speeding, resulting in a response that is greater than would be experienced if only a single peer were in the car. In this case, the driver is more likely to learn to enjoy speeding than if the response was less intense.

Although classical conditioning is a basic type of learning that deals largely with emotional or physiological responses, its influence on driving behaviors should not be discounted. Many driving behaviors might be learned through stimulus-response pairings that occur in situations where traffic safety is at issue. Recent research from the decision-making literature suggests that risk-based decision making may be strongly influenced by the emotions a person is experiencing when they make the decision (see e.g., Slovic et al. 2002). If the risk-based decisions impact traffic safety, the emotion that influences it may be the result of classical learning, or may be altered through the same process.

Operant learning involves a person *engaging* in some behavior that is then paired with the experience of a specific outcome of that behavior (Skinner 1938; Thorndike 1898). If the outcome is positive, then the behavior is more likely to be repeated. In this case the outcome is known as a positive reinforcer. An outcome can also be reinforcing if it removes something that is unpleasant, and in this case it is known as a negative reinforcer. On the other hand, if the outcome is negative, it is known as punishment, and the behavior is less likely to be repeated. As with reinforcers, the removal of something pleasant can also be experienced as unpleasant, and in that case it is known as negative punishment. A traffic-safety example of operant learning is the pairing of starting a vehicle's engine (the behavior) and the sounding of the safety belt reminder (in this case the punishment) and relief from the reminder that drivers experience when they buckle their safety belts (a negative reinforcer).

Four factors influence whether a behavior is learned through operant learning (e.g., Kalish 1981; Holmes and Robbins 1987; Skinner 1961). First, the effectiveness of the reinforcement or punishment to change behavior decreases with the amount of time between the behavior and the outcome. If the safety belt reminder sounds immediately when the vehicle's engine is started while the driver is unbuckled, it is more likely that the driver will learn to use the safety belt than if the outcome came later, such as in the issuance of a citation (punishment).

Second, the effectiveness of the reinforcement or punishment to change behavior increases with the magnitude of the outcome. Using the safety belt example, drivers are more likely to learn to use their safety belts if the reminder is more annoying, troublesome, or interferes with their comfort (stronger punishment), or if the cessation of the reminder is rewarding (negative punishment).

Third, a behavior does not have to result in the outcome every time it happens in order for behavior to change. The key factor is that the person remembers that a certain outcome is likely to result from the behavior. For example, if the reminder does not sound every time the driver starts a vehicle's engine, such as when driving different vehicles that have the reminder disabled, drivers will still learn the behavior so long as they sometimes drive a vehicle with an activated reminder system.

Finally, the learned behaviors are not necessarily permanent. If the reinforcement or punishment is removed, the learned behavior may discontinue over time. If the driver were able to permanently disable the safety belt reminder, the driver would eventually stop using a safety belt (assuming there were no other reinforcers or punishers to sustain the behavior). Hence, it is important that reminder systems be reliable and not easily disabled.

Observational learning involves people learning by observing what others do and the resulting consequences that others experience because of their behavior. Some have argued that an individual's culture strongly influences behavior in this way (McGraw-Hill 2005): that people learn by observing behaviors, consequences, emotional responses, and so forth, from the cultural setting that surrounds them. For example, a driver might learn to consistently exceed the speed limit by 10 mph and experience little risk of being issued a citation by observing that other drivers typically exceed the speed limit by this amount without being stopped by law enforcement.

As with the other learning processes, there are several factors that influence observational learning (Bandura 1977, 1986, 1989). First, a person must be paying reasonably close attention to the person or persons performing the behavior. Second, a person must remember the action and consequences at a later time. Third, a person must be able to reproduce the behavior. Fourth, a person must have some motivation for performing the behavior. Using the example of traveling 10 mph over the speed limit, if drivers are unaware of the specifics of other drivers' speeding behavior, such as the exceedance of the speed limit that is permissible, if they fail to remember the specifics of the behavior at a later time, or if their vehicle will not exceed the speed limit by that amount, or if they have no reason to drive faster, they will not learn to typically exceed the speed limit by 10 mph.

Motivation

Motivation is an important part of learning and of using learned behaviors. It has been defined as the set of influences that account for the initiation, direction, intensity, and persistence of behavior (Bernstein et al. 1991). In other words, motivation is the reason why people do what they do. An understanding of motivation is important for those who wish to change American traffic-safety culture because people must have a motivation to change their behavior. The set of potential motivations is quite varied and complex, ranging from hunger, to the need for achievement, to the need for excitement (e.g., Maslow 1971). An important part of changing the American traffic-safety culture will be identifying the motivations that are most compelling to American citizens, so that their desire to act in a manner consistent with a safety culture is heightened, and their willingness to learn is enhanced.

Socio-cultural elements of cultural change

Motor vehicle transportation has a large social component: people frequently drive to serve social needs, drivers interact in a social environment while in traffic or with passengers in the car, and people's thoughts and beliefs about social interactions influence how they drive. Thus, social factors are an important facet of traffic-safety culture. Here we discuss some of the more common social factors that may have important influences on the traffic-safety culture and that may be shaped through customized driver feedback.

Social norms: Culture is governed by a subtle set of rules that define appropriate and inappropriate behaviors, attitudes, and beliefs (Bernstein et al. 1991). The same is true for

American traffic-safety culture. These rules, or social norms, may be explicit, but are quite often implicit (such as the number of cars that can travel through an intersection once the light has turned red). Social norms are learned through interaction with society. Because many people have a strong desire to conform and belong to a group, social norms can have a powerful influence over behaviors. People who unknowingly break a social norm often receive clear negative feedback from others in the form of censure, exclusion, or disapproval. Social norms do not necessarily follow written law, nor are they universal or concrete.

People's perceptions of social norms are not always correct. Correcting people's perceptions of social norms has been used successfully to change people's behavior. For example, many people over-estimate the amount of alcohol that others drink, or that others think is appropriate to drink. When these norms are corrected, people often respond by moderating their own alcohol consumption. A similar approach could be used to promote a culture that values traffic safety, by providing people with accurate information about driving behavior and others' expectations. Customized driver feedback could have a great influence of traffic-safety culture if this feedback was successful in changing social norms toward safer driving behaviors, and one way this might occur is by providing accurate information on driving norms to drivers.

Attribution: People continually try to make sense of their social world, including attributing causes to the events they observe (Zimbardo 1985). For example, if a driver were to observe a vehicle drifting over the center-line of a roadway, that driver may assign the cause to the other driver being intoxicated or distracted. Research on attribution has identified several factors that affect how people make attributions (e.g., Augoustinos and Walker 1995; Jaspars, Hewstone, and Fincham 1983). First, people act as naïve scientists when making attributions, deducing causes using common sense. They, therefore, make naïve mistakes, such as assigning a single cause, rather than multiple causes, for an event. Second, people will consider two events as related causally if they occur close together in time. Finally, people tend to make attributions of other people's behavior as being caused by internal factors rather than external factors. Thus, a person is more likely to blame an elderly driver's poorly executed left turn to the driver's declining abilities rather than to he or she being temporarily distracted.

Customized driver-feedback technology

Customized driver feedback could take one of two general forms using current technology. The first is feedback issued to the driver through an adaptive feedback program that is integrated into the vehicle. The second is a system that issues feedback from information that is retrieved form the vehicle's systems, routed to an external agent where it is organized and assimilated for graphic and tabular presentation, and then relayed to the driver through a secondary process, such as through a fleet supervisor, vehicle rental agency, or a parent.

Integrated customized driver-feedback systems

Advances in computer technology have introduced the potential to monitor many elements of vehicle functioning and factors in the area surrounding the vehicle, and to transmit this information instantly to the driver of the vehicle. For example, using the On-Board Diagnostics (OBD) II protocols in the on-board computing systems of modern vehicles, information on the function of many aspects of the engine and vehicular systems can be obtained, including information on engine RPM, throttle position, steering wheel position, brake pedal motion, belt use, engine load, fuel pressure, fuel system status, short- and long-term-fuel trim, battery voltage, timing advance, coolant temperature, air-flow rate, intake air temperature, intake manifold pressure, oxygen-sensor voltage, as well as other functions. While much of this information is not pertinent to helping the driver learn safe driving practices and changing the traffic-safety culture, other sources of information are relevant.

Additional sensor systems come standard on motor vehicles that are designed to provide drivers with feedback relating to safety systems. One of these is the safety belt reminder. While these reminders have not yet been programmed to be interactive, they have the ability to be programmed to be interactive so that more invasive reminders are issued if the safety belt is not being used (e.g., increasing reminder intensity the further the car is driven without the safety belt being engaged, or feedback that adapts to the driver of the vehicle over time, with less intense reminders provided for drivers who consistently use their belts, and more intense reminders to drivers who do not).

Other additional sensors that are becoming available or may soon be available include headway sensors that can provide warning if the vehicle is approaching another vehicle too quickly or is following a lead vehicle too closely. Proximity warnings are another example of technological devices that can potentially increase driver safety by providing drivers with feedback on the location of other vehicles that are traveling nearby. These devices could be made to adapt to the roadway type or to the characteristics of the driver.

Smart cards are another technological device that could soon play a role in adaptive driver feedback by allowing the driver to be identified by the vehicle's on-board computer. Information provided by a smart card can be combined with data collected by the on-board computer to coordinate the various on-board safety and warning systems available in a particular vehicle and to tailor them to the characteristics of a given driver. This information could then be used by the on-board systems to select and provide feedback that is appropriate for the driver of the vehicle. For example, if the driver is identified as a teen driver, the threshold of headway warnings might be lowered so that a warning is given at a greater following distance than would be needed for an experienced driver. Another example is the selection of the safety belt warning procedure that is appropriate for a driver who is often reluctant to buckle up.

External customized driver-feedback systems

Advances in telecommunication, global positioning, on-board computing, and sensor technologies have led to the development of an assortment of systems that are capable of monitoring driver state and driving performance, and providing feedback to the driver through the driver's overseer (e.g., parent or fleet manager). While the majority of these systems have been designed for use with commercial motor vehicle (CMV) drivers, many have been adapted for use in private vehicles, and others have been designed with specific types of drivers in mind, such as young novice drivers or elderly drivers. Because of the large number of external customized feedback systems available, a complete review will not be attempted here. (For a more extensive review of available external customized driver feedback systems, see Finnegan and Sirota 2004 and Huang et al. 2005). However, common types of information provided by external customized driver feedback systems include any of the functions monitored by the OBD II protocol, following distance, speed, location, time that the vehicle is in motion, stop locations and duration, hard stops/starts, turning, audio of the interior of the vehicle, and/or video feedback of both the driver/passenger compartment and external surroundings of the vehicle. As with direct driver feedback systems, these systems could be designed to adapt to individual drivers, and with the addition of a key fob or smart card, could identify the driver and apply personalized feedback protocols.

Issues for effective customized driver feedback

For both the direct and external systems, four questions can be asked: (1) What behaviors are monitored? (2) How is the information acquired and analyzed? (3) How is the information formatted and delivered? and (4) How is the feedback going to be learned by the driver and influence the greater traffic-safety culture.

Monitoring driving behaviors

Driving is a complex activity requiring the coordinated proper performance of a variety of skills. Which of these skills are critical for safe driving? An expert panel for a recent study on the effects of health concerns of driving performance addressed this question (Eby, Molnar, and Blatt 2005). The results of this expert panel (Eby et al. 2005) were used to develop a set of "critical driving skills" and divide them into the following three categories of skills: strategic, tactical, and operational.

Strategic skills relate to pre-trip activities and preparation for driving. These activities vary depending on the purpose, type and length of the trip, the area that will be traversed during the trip, and the trip's destination. Strategic skills include general planning, selecting routes, coordinating travel demands with alcohol/drug use, care of one's own physical and emotional condition, safety belt and other safety restraint needs and use, start and stop times and restrictions on driving, and navigation/wayfinding.

Tactical skills relate to the management of driving demands and tasks that are limited in their duration, and all relate directly to vehicle handling and the execution of driving maneuvers. Tactical skills identified by the panel included, yielding right of way, intersection negotiation, left turns, right turns, maintaining proper speed, responding appropriately to traffic signs and signals, backing up, changing lanes, passing, maintaining lane position, following/gap acceptance/ judging distances, maintaining attention, observing surroundings, negotiating curves, signaling, and merging. These tactical skills vary in difficulty and, therefore, in the skill level required for safe execution. In addition, the levels of difficulty of these tasks vary by age and driving experience, with novice, younger, and older drivers experiencing greater demands and difficulty in performing these skills.

Operational skills are relevant to the immediate control of the vehicle, and are required over longer stretches of time. These include such basic skills as steering, accelerating, braking or stopping, speed control, signal use (indicators), and the use of headlights.

Collectively, these skills can be thought of as "driver behavior," and a driver's capabilities in performing these skills can be thought of as "driver performance." As these skills are degraded, crash risk increases. As they improve, crash risk decreases. Again, devices that monitor the driver behaviors and vehicle responses related to these skills could be designed to adapt to the driver, over time, by collecting information on the driver, as well as by linking the monitoring system to a smart card or other source of information that the system could use to identify the driver and apply the feedback protocol that is appropriate for that driver.

Information analysis, format, and delivery

As previously noted, critical driving skills can be monitored and information for feedback can be acquired through the use of a variety of technological mechanisms. In a few cases, data from these sensors can be used directly as feedback to the driver indicating the performance of a critical driving skill. One example is a simple safety belt monitor and feedback device. However, in the overwhelming majority of cases, the information taken directly from a given sensor or monitoring device must be analyzed, extraneous information removed, relevant information formatted, and the information delivered in an understandable manner to convey useful information to the driver regarding performance of critical driving skills and the resulting level of safety.

Gathering and processing data is a very complex task, even where simple driving tasks are concerned. For example, to obtain a measure of vehicle-following distance on a trip, return signals from forward-facing radars and information about the vehicle speed and acceleration need to be combined algorithmically over the trip to determine a function that indicates the proportion of time the driver is following too closely (see, e.g., Fancher and Bareket 1998). Because of natural surrounding-vehicle lane-changes and lead-vehicle breaking events, all drivers are too close to lead-vehicles for some proportion of a trip, even if they are driving safely. Where is the cut-off for safe versus unsafe following? A similar question can be asked for most of the critical driving skills and empirical answers are needed if customized driver feedback technology is going to positively influence traffic-safety culture.

Because of the complexity of information provided by monitoring systems, the analysis of incoming information is the first critical task. Analysis of these data is a daunting task for several reasons. First, most of the information from monitors and vehicle systems is not directly usable as feedback to the driver. Before feedback information can be identified, irrelevant information must be removed without eliminating information that is relevant to safety. Second, the information needed to provide driver feedback on even simple tasks, such as lane keeping, must be compiled from various sources and then combined in a manner that allows accurate coherent feedback information. The difficulty of this task is only amplified in the case of more complex driving behaviors, such as changing lanes on a busy freeway or making a left hand turn. Finally, safe driving is made up of many driver behaviors. The process of extracting feedback information from monitors and systems for each of these behaviors must happen first and must then be followed by assigning the information a priority score for delivery so that the driver is not overwhelmed by a large amount of feedback.

Once the analysis is complete, the feedback must be formatted so that it is easy for the driver to interpret and use. Hence, the information collected and combined from various systems and monitors must be reduced to a simple, intelligible, and easily utilizable message that can be given to the driver. Finally, the feedback must be delivered to the driver in a manner that does not decrease safety by distracting the driver or overburdening the driver with tasks required by various sources.

Running throughout the analysis, formatting, and delivery of the information is the need to adapt the feedback so that it is appropriate for a given driver who may be old or young, experienced or novice, and highly skilled or unskilled.

Driver learning and the traffic-safety culture

Assuming that critical driving skills can be accurately detected and monitored, this information needs to be transmitted to the driver in a way that will result in the driver learning to behave in a manner that enhances traffic safety. As pointed out in the initial section of this paper, the content and format of the feedback to the driver is critical in order for the driver to learn safe driving behavior. Feedback should employ the principles of learning (e.g., stimulus-response, reward and punishment), recognize the role of motivation in behavior change, utilize social factors to influence behavior change, and be informed by the factors and conditions that enhance the learning process. Very good guidelines for effective customized driver feedback have been developed by Huang et al. (2005) and are paraphrased and expanded upon here:

- The feedback must be perceived to be objective, accurate, and from a credible source.
- Terms must be used that describe specific, observable behaviors.
- Personality traits should not be targeted, as these cannot be easily changed.
- Only behaviors that the driver can change should be targeted.
- Clearly the criteria for safe driving should be provided and not just the identification of unsafe driving performance.
- Feedback should not be judgmental.
- Feedback should increase the motivation for behavior change.
- Performance feedback should be given as closely as possible to when the behavior occurs.
- Feedback that promotes emotional reactions should be avoided.
- Social norms governing behavior for a driver's particular group should be utilized in the feedback.
- Feedback should be specific for the audience (i.e., driver, parent, boss, etc.).

Can customized driver feedback devices positively influence traffic-safety culture?

It is important to draw upon all available resources in an effort to promote a traffic-safety culture that values and promotes safe driving practices and refuses to accept driving behavior that places others at risk. As previously mentioned, one potential resource is customized driver feedback and the technology that will make it possible. This said, as we look for technological approaches to enhance traffic safety, we must remain cognizant of several caveats.

First, while living in an era of rapid technological advance, the technology and software needed to interactively gather information, interpret it and reduce it to understandable feedback for the driver, and then adapt it to the specific driving habits of individual drivers has not yet been combined in a form that will provide a comprehensive assessment of driver performance. However, advances are continually moving us toward a time when systems will be available and linked in the manner needed to provide comprehensive customized driver feedback.

With the technology and external monitoring devices that are now available, the ability to discern good from bad driving behavior is, at best, difficult and limited. Many systems provide information that is too limited to be useful. For example, information on acceleration is available directly from the OBD II protocol; however, the information necessary to determine whether the observed rapid acceleration was a result of risk-taking, reckless driving, or proper evasive action taken to avoid a crash is not available. As another example, monitoring older drivers with a progressive disease could be useful for enhancing and extending their safe mobility. Older drivers experiencing early-stage dementia from Alzheimer's Disease could continue to drive longer if a device were available that would monitor their driving behavior for signs that the driver has become lost or confused, and yet this seemingly simple determination is difficult to program into a machine. For example, how would technology distinguish between a driver who is confused and one who is doubling back to run a forgotten errand, or is searching for an address in an unfamiliar neighborhood? Such small distinctions are difficult, and the simple installation of currently available after-market devices cannot address such a specialized issue. In sum, correct interpretation of driving behavior is one impediment to the development of effective customized driver feedback systems and should be the topic of further research.

Another issue that will need to be addressed as customized driver feedback systems are developed is that drivers may be overly reliant on the system, using it as a safety net rather than as a tool to enhance their safety. Some current technology has resulted in unanticipated outcomes that have negatively affected traffic safety. One example is anti-lock brakes, which were intended to increase traffic safety through the optimization of both vehicle control and stopping distance by disallowing the brakes to become locked. Instead of this intended outcome, it appeared that many people misunderstood the function of the anti-lock system or adversely changed their behavior as a reaction to the system, resulting in an overall increase in crash rates. There is a similar risk for any new device that is introduced. A misunderstanding of the purpose of the technology, or unrealistic confidence in the technology may increase risk. For example, drivers whose vehicles are equipped with a headway warning system may trust the system to keep them safe, and be less attentive to traffic ahead of them. These concerns relate back to the need for the feedback to be delivered in a manner that helps the driver learn safe driving habits, rather than removing or taking over driving functions.

Finally, it is obvious that the manner in which customized driver feedback will change the traffic-safety culture of the US will be by altering the behavior and attitudes of individual drivers. Hence, if customized driver feedback is to move the traffic-safety culture in the direction of greater traffic safety, it must possess a relatively high degree of uniformity in the safe driving behaviors that are promoted and in the way drivers learn these behaviors from the system. This uniformity must extend across vehicle manufacturers but also must apply equally well from one state to another. If there is too great of a disparity across vehicle makes and types in the learning process that the feedback system promotes, or if there is too little uniformity in laws and regulations promoting safe driving behavior across states, customized feedback will be less effective in shifting the traffic-safety culture in the desired direction because people will be learning behaviors and adopting attitudes that are discrepant and potentially incompatible. The result could range from increased confusion on the road as drivers try to drive according to disparate rules, to an increase in crash rates if differences in the systems are directly contradictory.

Conclusion

This brief examination of various issues related to customized driver feedback as a mechanism to promote change in the US traffic-safety culture toward greater valuation of traffic safety is far from comprehensive. Nevertheless, this paper raises several key points for consideration. The first is that the means by which customized driver feedback would impact the traffic-safety culture is through individual drivers (although many drivers will need to be receiving feedback for the culture to be influenced). The clear mechanism by which such change would occur is through learning; in order to change driver behavior and attitudes, drivers must learn new driving skills, behaviors and attitudes that promote safety. This is a key issue as the use of customized driver feedback is concerned because it suggests that feedback should not eliminate driver responsibility for safe driving practices, such as maintaining safe headway, but should instead leave this responsibility in the hands of the driver while providing feedback that increases the likelihood that the driver will learn safer driving behaviors and attitudes.

Second, this paper directed attention toward a critical impediment to devising feedback systems that promote the learning of safe driving behaviors and attitudes. Quite simply, this impediment is that while much of the sensor technology and software needed is available, it is limited and frequently not available in a form that lends itself directly to the development of comprehensive customized driver feedback systems. The first step needed is to devise a means by which the independent systems that generate customized driver feedback can be interconnected so that the can be efficiently consolidated. The next task will be to develop an analysis system that can sort through the large amount of data provided by the various systems and extract the information that is essential for providing feedback. Systems will also need to be developed that can take the raw information from the analysis and transform it into a coherent and deliverable message, organize it into a hierarchy with those that are most essential to safety being at the top, and monitor the activities of the drivers to determine their current workload and identify appropriate times to deliver the feedback. Finally, research examining modes of message delivery will need to identify the most appropriate mode of delivery so that the message is simultaneously easily understood, not distracting, and reliably conveys information that the driver interprets correctly.

This paper also touched on the difficulty of interpreting the information obtained from on-board systems. This will be another major hurdle in designing a system that promotes the learning of safe driving behavior. It will be essential that driving behaviors are followed by appropriate responses and reinforcers, or the intended behavior will not be learned. By simply providing feedback about the rate of acceleration, without knowing if it was done to increase safety or in a manner that decreases safety, will not have the intended result. Research should examine the effectiveness and feasibility of various rewards and punishments that can be utilized to facilitate driving. One current system, Progressive Insurance’s TripSensor™, awards what this system defines as safe driving through discounts on insurance premiums. It is unknown if this is type of reward changes behavior.

The day when drivers can be completely reliant on technology to help them drive safely is probably a long way off, and in fact, may never arrive. This means that we must focus efforts on the development and design of customized feedback systems that will increase traffic safety. This must be done planfully and with care to ensure that the systems have the intended effect on driving behavior and safety; that the systems are not just crutches to assist the driver, but that they effectively promote learning of safe driving behaviors and attitudes.

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