In-Vehicle Safety Feedback

Driver perspectives suggest technology has promise for improving safe driving behaviors

By Yueng-Hsiang Huang, Matthias Roetting, Jamie R. McDevitt, David Melton and Theodore K. Courtney

DRIVING IS ONE OF THE MOST DANGEROUS work-related activities. Truck drivers are particularly at risk in their "lone worker" environment. In-vehicle technologies are proliferating in more modern fleets. Prior research on the use of feedback in work settings has shown that it consistently improves safety performance. Would it be possible to use data gathered by new in-vehicle technology to provide real-time and post-shift feedback to drivers about their safe driving behavior?

This article discusses performance feedback systems and assesses the likelihood of driver acceptance of such an approach. The researchers examined truck drivers' attitudes and opinions about receiving feedback through in-vehicle technology via focus groups with drivers and other transportation industry experts (n = 66) and questionnaire responses from an additional sample of 198 long-haul truck drivers. Drivers saw the main benefit of in-vehicle technology as providing better information about their behavior in traffic mishaps. Nearly half indicated that feedback by technology would make them safer drivers. In addition, most drivers did not feel the technology would be too complicated to use, be a distraction or "de-skill" the profession. The greatest concerns centered around privacy issues, such as data getting into the wrong hands or being used against drivers. Drivers also had varied preferences regarding the mode, manner and timing of feedback by technology, which indicates the need for flexibility and/or adjustability in such systems. Together, focus group and questionnaire results confirmed that drivers would like to receive more feedback and that feedback by in-vehicle technology would be acceptable if properly designed and implemented.

Yueng-Hsiang Huang, Ph.D., *is a research scientist at Liberty Mutual Research Institute for Safety in Hopkinton, MA. She received her Ph.D. from Portland (OR) State University. Huang's primary research interests are in occupational injury and accident prevention, return-to-work issues, work/life balance, employee selection, training and performance evaluation. She is a member of the Society for Industrial and Organizational Psychology, American Psychological Assn. and the ASSE Foundation Research Committee.*

Matthias Roetting, Ph.D., *is a research scientist at the Liberty Mutual Research Institute for Safety. His primary research interests focus on new in-car technologies and their affect on distracted and drowsy drivers. Roetting received his Ph.D. from the Faculty of Mechanical Engineering, Aachen University of Technology and matriculated from the mechanical engineering program at Hannover University, Germany.*

Jamie R. McDevitt, M.S., *is a loss prevention consultant at Liberty Mutual Insurance Group. She holds a B.S. in Computer Science from Central Washington University and an M.S. in Psychology from the University of Idaho. Prior to joining Liberty Mutual, she was an adjunct faculty member in computer science at Columbia Basin College and a graduate fellow at Pacific Northwest National Laboratory. McDevitt is a member of the Human Factors and Ergonomics Society.*

David Melton *is a product director at Liberty Mutual Insurance Group and is responsible at the corporate level for developing and supporting transportation-related safety and health consulting services. He is a member of the permanent committee on truck and bus safety, Transportation Research Board, a member of the ANSI Z-15 Committee on fleet safety, and a member of the Advisory Council for the Center for Transportation Safety, Texas Transportation Institute, Texas A&M University. Melton holds a B.A. and is a Canadian Registered Safety Professional.*

Theodore K. Courtney, M.S., CSP, *is director of the Quantitative Analysis Unit at the Liberty Mutual Research Institute for Safety, and instructor on injury, safety and ergonomics at the Harvard School of Public Health, Boston. A recipient of the Ergonomics Society's William Floyd Medal for his work in injury prevention, he holds a B.S. in Human Factors from Georgia Tech and an M.S. in Industrial and Operations Engineering from the University of Michigan. Courtney is a member of the ASSE Foundation Research Committee, the editorial board of the* Journal of Environmental and Occupational Hygiene *and ASSE's Greater Boston Chapter.*

The Work Environment

Data from the federal Census of Fatal Occupational Injuries show that highway incidents, including collisions and rollovers and other traffic mishaps, remained the leading cause of work-related deaths in 2002, accounting for 25 percent of the nation's occupational fatalities. In fact, while occupational fatalities due to homicide have dropped considerably over the last decade, the number of fatalities due to highway incidents has slightly increased. In addition, truck driving remains one of the most dangerous jobs in America, with 69 percent of those driver fatalities arising from a highway incident (BLS 1).

The Scenario

John has been a long-haul truck driver for eight years. He has never been involved in a crash but has been in several situations where his or other drivers'

actions have led to close calls. So he volunteered when his company started a program to provide its drivers with feedback about the safety of their driving performance. John and his coworkers met several times to discuss safe driving behaviors, eventually targeting five for improvement.

Maintaining a safer following distance behind vehicles was one of the target behaviors. As part of the project, a small computer was installed in the cab of John's truck. It uses sensor data from systems already available in the truck to measure parameters of safe driving behavior. For example, sensor data from the collision avoidance system are used to monitor the distance to vehicles in front of John's truck. At the end of each shift, John receives a readout of how he performed on this factor and the four other targeted safe driving behaviors. The driver group reliably maintained the safe behavior thresholds they established and will next target additional safe driving behaviors.

Brave new world? Is this scenario feasible? Would truck drivers actually want to receive feedback from a machine? This article discusses the general definition and attributes of performance feedback systems, and describes the first phase of a research project that explores in-vehicle technology as a feedback mechanism.

Guidelines for an Effective Feedback Procedure

- Use feedback terms that describe specific, observable behavior rather than general or global terms.
- Avoid mention of individual personality traits; it may be possible to control behavior, but not to change traits.
- Limit the discussion to actions that pertain to the receiver's responsibilities; fall within his/her control; and will enable the individual to improve or plan alternative actions.
- Present feedback not in judgmental terms such as "good" or "bad," but in terms related to established criteria, probable outcomes or possible improvement.
- Provide performance feedback that follows as closely as possible on the action. Day-to-day feedback is highly preferred to yearly evaluation.
- Clearly present perceptions, reactions or opinions as such, not as facts.
- Avoid loaded terms that produce emotional reactions and raise defenses. If the receiver becomes defensive or emotional, deal with the reactions, rather than trying to convince, reason or supply additional information.
- Present the feedback in a manner that communicates acceptance of the receiver as a worthwhile person and of that person's right to be different.
- Remember that feedback (even when unfavorable) tends to be well accepted to the extent that the receiver perceives the source as expert, attractive, credible and controlling important sanctions and rewards; and to the extent that the feedback is consistent with previously received feedback.
- Feedback tends to be poorly received when it is inconsistent either with previous feedback or with other feedback simultaneously received. (Note: Inconsistent simultaneous feedback may occur as a result of different work samples or because of conflicting criteria.)

Adapted from Center for Creative Leadership; and Kerr and Slocum (116).

What Is Feedback?

Feedback is "information about a person's performance or behavior, or the impact of performance or behavior, that is intentionally delivered to that person in order to facilitate change or improvement" (Velsor, et al 36). Several social psychological theories have shown that individuals want and seek feedback on their performance (e.g., Festinger 117), since it helps them learn about themselves.

Feedback about the effectiveness of an individual's behavior has long been recognized as essential for learning and for motivation (Ilgen, et al 349). Prior research on the use of feedback in work settings has shown that feedback consistently improves performance (e.g., Guzzo, et al 275; Kluger and DeNisi 254; Pritchard, et al 337), although the effects vary widely. Feedback systems also have been shown to improve safety performance (e.g., Zohar 156). One study which employed passenger/observer feedback to help drivers improve their safety behavior showed that individual feedback is an effective tool for positive behavior modification (Hutton, et al 257).

Another study suggests that the introduction of vehicle data recorders alone, without giving feedback to drivers, might increase safety in transport operations and reduce traffic accidents (Wouters and Bos 643). The authors hypothesize that people "who are aware of being observed tend to modify their behavior" and expect an even greater effect in encouraging "individuals to behave more safely when driving if there were means of providing feedback to the drivers about their behavior on the road" (Wouters and Bos 643).

For feedback to be effective in changing behavior, workers must believe that it accurately describes their performance. In addition, they must have an intention to respond and some understanding of how to respond; they must also be able to implement the intended response (Mohrman, et al 19). In general, feedback is more likely to be accepted if the source is perceived as credible. Trustworthiness of the source, as well as the extent to which the recipient trusts the source's motives, dramatically affects the degree to which s/he accepts the feedback.

Feedback can result in development only when it is delivered in a way that allows a recipient to know how to adjust his/her behavior. In other words, it must be actionable—the recipient must be able to act on the feedback received in order to modify performance. Ideally, the appraiser continuously and immediately shares information about the performance of the appraised throughout the work process so that a separate feedback stage is not needed. If this is not possible, feedback should be delivered immediately after assessment. If this process is implemented well, feedback is both immediate and continuous. The sidebar above presents guidelines for feedback procedures taken from the traditional setting of a supervisor giving feedback to a worker (Center for Creative Leadership 1; Kerr and Slocum 116).

Feedback & the Lone Worker

Feedback systems are less straightforward in lone-worker situations. Typically, self-observation is relied on as the basis for feedback information. Some studies have found positive effects using self-observation (e.g., Olson and Austin 5). One study gave examples

Table 1

In-Vehicle Technologies: Data Sources for Safety Aspects of Driving Behaviors

In-Vehicle Technology	Description
Collision Avoidance/Warning System	Sensors installed at the front of a vehicle constantly scan the road ahead for vehicles or obstacles. When an obstacle is detected, the system determines whether the vehicle is in immediate danger of crashing. If so, the driver is warned (for example, by a tone, a warning light or a head-up display).
Adaptive (Intelligent, Smart) Cruise Control	A combination of collision warning technology and existing cruise control. The system will maintain separation distance behind a followed vehicle using an adjustable range control feature.
Rollover Detection and Prevention System	Using either in-vehicle sensors or highway-mounted sensors, the system alerts the driver to the fact that s/he may be exceeding the speed at which a rollover or load shift may occur.
Lane Tracking or Lane Departure Warning	If a vehicle moves to the edge of the roadway, an audible alarm in the vehicle is sounded to alert the driver. Some systems track the highway lane markers and give an alarm if the driver crosses a lane marking without the appropriate turn signal. These systems can also be used to sense the driver's level of alertness by detecting erratic steering or weaving.
Side Sensing (Proximity) Devices	Using technology similar to collision avoidance systems, these systems monitor the close proximity (sides) of the vehicle. The system gives an alarm to assist in preventing sideswipe crashes if it senses an object.
Vehicle and Cargo Tracking Systems	These systems use a satellite-based global positioning system to track the vehicle and broadcast its position to the transportation company, thus enabling the company to track the progress of the vehicle and the driver's performance.
Driver Alertness Monitors	Using eyelid movement blink rate, head movements or steering wheel movement (or some combination), these systems monitor driver alertness and warn the driver if s/he is outside preestablished personal benchmarks.
In-Vehicle Event Data Recorder (EDR) or "Black Box"	EDRs are devices that constantly record information related to vehicle performance. Recorded data might include information such as the driver and passenger belt usage, the driver's steering and brake input, airbag and seatbelt tensioners' data, information from the ABS, the speed and deceleration information of the vehicle, and the location of the vehicle. In addition, the system might also trigger an automatic collision notification.
In-Vehicle Cameras	Cameras record but do not save video and audio images of the driving scene. When a preset g-force is exceeded, the camera saves audio and video of the event for future review by management. This record of driving events can be used to counsel drivers and improve their behavior. Drivers with no recorded events can be praised for good performance.

Adapted from Roetting, et al (277).

of self-observation for loggers (Pinney 14). In this case, self-observation was triggered by a random event, a plane flying over the worksite. Loggers would then check their behaviors—for example, were their boots in good condition, had they checked for overhead hazards or had they laid out an escape route? They would mark these observations on a scorecard and the results would later be combined with the results of others working in similar situations.

Other ways of providing feedback might be beneficial in lone-worker situations as well. In truck driving, technology can provide feedback to drivers about their safe driving performance. Table 1 presents a selection of in-vehicle technologies that can provide data on safety-relevant aspects of driving behavior. As more in-vehicle technologies are introduced, it may be possible to implement a system such as that outlined in the introductory scenario.

Truck Drivers' Attitudes Toward Feedback: A Study

Issues such as the best way to provide feedback to truck drivers (e.g., positive vs. negative, immediate vs. time delayed; or frequency of feedback) have not been well researched. Driver concerns regarding in-vehicle technology and who may have access to the data sampled by these systems need further exploration. This study investigated truck drivers' attitudes toward receiving feedback, and whether feedback by technology could be used to improve safe driving performance. The study employed a combined qualitative (focus group) and quantitative (survey) approach.

Participants

Sixty-six subject-matter experts, including 48 truck drivers, 12 supervisors/managers and six fleet insurance industry safety professionals, participated in nine focus groups to collect qualitative data on attitudes toward technology and feedback. Results were used to develop a questionnaire. Questionnaires were then collected from 198 long-haul truck drivers to provide additional quantitative information.

Table 2

Driver Questionnaire Responses: Part 1

Topic Area	Response: Strongly disagree or somewhat disagree (%)	Neither agree nor disagree (%)	Strongly agree or somewhat agree (%)
Would truck drivers like to receive more feedback about their driving performance?			
I receive enough feedback about how I drive.	23.7	34.0	42.3
I would like to receive more feedback about how I drive.	19.5	35.9	44.6
When I receive feedback about how I drive, it is mostly positive feedback.	14.8	30.6	54.5
When I receive feedback about how I drive, it is mostly negative feedback.	48.0	18.9	33.2
Positive feedback about how I drive is more helpful to me than negative feedback.	12.1	28.8	59.1
What are the perceived benefits of receiving feedback on safe driving performance by technology?			
Data from technology will likely be used to defend me if I am involved in an incident.	27.7	15.9	56.4
In-vehicle technology giving feedback about how I drive will make me a safer driver.	32.2	21.9	45.9
In-vehicle technology giving feedback about how I drive will reduce the stress of driving a truck.	46.1	22.3	31.6
What are the perceived drawbacks and concerns of receiving feedback on safe driving performance by technology?			
I want technology to create a record of how I drive.	35.3	30.1	34.7
I am concerned that the data collected by in-vehicle technology will get into the wrong hands.	18.4	16.3	65.3
I am concerned that the technology will be too complex for me to use.	47.4	33.2	19.4
Too many people will be able to drive trucks because these technologies will make the job too easy.	62.3	14.8	22.9
Drivers who depend too much on technology will lose the skills they need to be a safe driver.	36.0	11.9	52.1
Receiving feedback from technology may be a distraction.	27.9	23.7	48.5
I am concerned that technology may not be very reliable.	25.0	32.7	42.3

Focus Group Results

Consistent with the guidelines noted in the sidebar, focus group participants noted that certain issues should be avoided when delivering feedback. One was "beating a dead horse"—discussing the same event repeatedly. Negative feedback in public, referred to as public beating, was similarly perceived as not helpful. Receiving negative feedback for doing something wrong without being told how to do it correctly was cited as another unhelpful approach.

Different feedback modalities were discussed. Participants agreed that the type of feedback generally dictates the mode in which it should be delivered. For example, warnings (requiring immediate attention) need to be given with an auditory or visual alarm, whereas a review of driving behavior could be delivered in other ways. Participants expressed various preferences in this regard. Some prefer an artificial voice, others a message on a computer screen or a printout; others suggested that an e-mail message be sent to the driver. These findings suggest that drivers would feel more comfortable if they were able to choose how feedback is presented to them.

Timing of feedback was another issue that produced many opinions. Although drivers consistently declared that warnings (e.g., collision or rollover warnings) should be given immediately, opinions about the right time and frequency for driving per-

Table 3

Driver Questionnaire Responses: Part 2

Topic Area	Response: Strongly disagree or Somewhat disagree (%)	Neither agree nor disagree (%)	Strongly agree or Somewhat agree (%)
What is the preferred form of feedback on safe driving performance by technology?			
I would like to receive feedback from technology about how I drive by a display on the dashboard.	33.7	19.4	46.9
I would like to receive feedback from technology about how I drive by a computer printout at the end of a shift.	43.1	20.3	36.6
I would like to receive feedback from technology about how I drive by a computerized voice.	56.7	23.5	19.9
I would prefer to receive feedback from technology when I request it rather than technology delivering feedback automatically.	15.7	33.8	50.5
I would like to receive feedback from technology at regularly scheduled intervals.	22.2	35.4	42.5
I would like to receive feedback about how I drive:			
•immediately after the event.	20.5	23.1	56.5
•once a day.	34.3	31.4	34.3
•once a week.	25.0	31.4	43.6
•once a month.	25.5	27.8	46.6
•once every three months.	32.4	29.5	38.2
•once a year.	35.1	28.0	36.9
From whom would truck drivers like to receive feedback on safe driving performance?			
Receiving feedback about how I drive from technology is as helpful as feedback from a real person.	36.9	26.3	36.9
I would like feedback about how I drive:			
•from the safety director of my company.	17.2	15.2	67.5
•from my direct supervisor, dispatcher or driver manager.	21.2	18.3	60.5
•from a senior manager in my company.	20.9	22.5	56.7
•from a team driving partner.	22.6	23.9	53.5
•from other truck drivers.	28.2	22.0	49.7
•from a customer.	30.1	25.4	44.4
•from a 1-800 "How's my driving" service.	46.2	24.5	29.2
•from "four-wheelers."	58.9	18.9	22.1

formance reviews varied. Some participants wanted feedback to be delivered upon request, while others preferred that information be delivered at the end of the trip, shift or day. Others preferred a weekly or monthly review schedule. Similarly, opinions varied regarding feedback frequency and timing (random or regular). This lack of consensus suggests that a feedback system should be adaptable to individual preferences as well as organizational needs.

Most participants seemed to accept that it is necessary at times to receive negative feedback (drivers considered warnings, such as a collision warning, to be negative feedback). But in their opinion, negative feedback should be limited, delivered in a constructive manner and paired with positive feedback. This finding is consistent with recent thinking in behavioral safety and other fields, where participants advocate a high ratio (4:1 or greater) of positive to negative feedback occurrences (e.g., Wysocki and Kepner).

Perceived Benefits of Receiving Feedback by Technology

When discussing the perceived benefits of receiving feedback by technology, focus group participants

expected improvements in driving performance and driving efficiency. Other benefits cited included lower driver stress. Some also anticipated a decrease in operating costs due to fewer crashes and lower insurance rates.

Some drivers reported that they felt mistrusted by their companies and by safety inspectors from the state departments of transportation. In such situations, some participants saw potential for the data created by technology to aid them. However, an even more important aspect in the discussions was the potential use of data to vindicate drivers in the event of an incident or crash.

Perceived Drawbacks & Concerns of Receiving Feedback by Technology

One concern voiced consistently by the focus groups was privacy. Participants would not feel comfortable with being watched by technology and were concerned how the data would be used. Some participants saw the introduction of technology as a threat to the profession, as only technology-literate drivers would be able to work with such systems. Others felt technology that makes the driving task easier would de-skill the profession, allowing the entry of unqualified drivers. Some were also concerned that some drivers would over-rely on technology and no longer engage in safe driving habits on their own. Related to this were reliability issues regarding the technology. In addition, some participants were concerned that the initial cost of the technology would be too high.

Finally, participants provided several suggestions for developing and implementing programs that use in-cab technology to provide feedback on safe driving performance. For example, they noted that all levels in commercial fleets need to be involved—from drivers to management, dispatchers and trainers. They also noted that the organizational culture must be supportive of such a system.

The groups agreed that drivers should be involved at all levels of development and implementation. It was suggested that drivers should participate in pilot-testing new in-cab technology. It was also suggested that the technology should not interfere with the driving task and should not be distracting, and that it should be reliable and cost-effective (i.e., affordable and provide measurable benefits). Appropriate and thorough training on new technologies and procedures would also be needed. Finally, focus group participants cautioned that drivers should be given full disclosure regarding use of data obtained from the system and that using the data in a way other than described in the disclosure would be a grave mistake.

Survey Results

As noted, focus group results were used to develop a questionnaire that explored six topics:

1) Would truck drivers like to receive more feedback about their driving performance? In addition, should the feedback have a more positive or negative connotation?

2) What are the perceived benefits of receiving feedback on safe driving performance by technology?

3) What are the perceived drawbacks and concerns of receiving feedback on safe driving performance by technology?

4) What is the preferred form of feedback on safe driving performance by technology? In terms of modalities, how should feedback be given, and how often do truck drivers like to receive feedback?

5) From whom would truck drivers like to receive feedback on safe driving performance?

6) What are the most important safe driving behaviors?

The questionnaire presented 27 fundamental statements assessing the six topics. Drivers were asked whether they strongly agreed, somewhat agreed, neither agreed nor disagreed, somewhat disagreed or strongly disagreed with the statements. Selected aspects of responses to each topic presented in Tables 2, 3 and 4 are the focus of the following discussion.

Would Truck Drivers Like to Receive More Feedback about Their Driving Performance?

Surveyed drivers were generally receptive to receiving feedback on their driving performance. Forty-two percent of the drivers agreed with the statement, "I receive enough feedback about how I drive" and 45 percent agreed with the statement, "I would like to receive more feedback about how I drive." Positive feedback was reported as more prevalent than negative feedback in the work environment: 55 percent said that when they received feedback about how they drive, it was mostly positive, whereas 33 percent reported that it was mostly

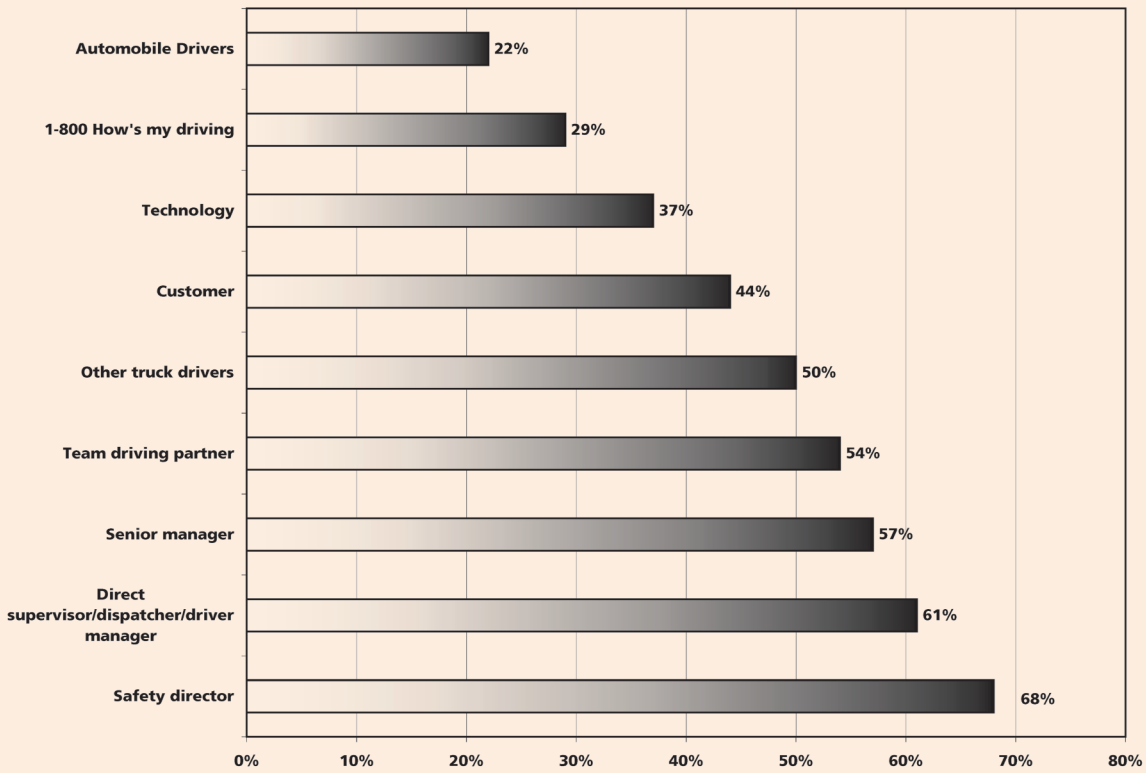
Table 4

Driver Questionnaire Responses: Part 3

Topic Area	Response (%)
What are the most important safe driving behaviors?	
1) Looking well ahead of my vehicle to adjust to what is happening in front of me.	74.4
2) Expecting other drivers to make driving mistakes and being ready to avoid them—expect the unexpected.	55.4
3) Using turn signals to give other drivers plenty of warning when changing lanes or making turns.	48.7
4) Adjusting my mirrors to prevent blind spots.	29.2
5) Not driving drowsy.	28.2
6) Not driving faster than the posted speed limit.	17.4
7) Wearing my seat and shoulder belt.	16.4
8) Keeping at least two seconds following distance between my rig and vehicles in front.	13.3
9) Not driving distracted.	8.7
10) Being courteous to other drivers.	8.7

Figure 1

Truck Driver Preferences for Receiving Feedback from Different Sources* (n = 198)



**Findings reflect the percentage of survey participants who "agreed" or "somewhat agreed" with the question, "I would like feedback about how I drive from _____." In the case of technology, the number reflects agreement with the statement, "Receiving feedback about how I drive from technology is as helpful as feedback from a real person."*

negative. A majority (59 percent) agreed that positive feedback was more helpful than negative feedback.

What Are the Perceived Benefits of Receiving Feedback on Safe Driving Performance by Technology?

The greatest perceived benefit of in-vehicle technology to provide feedback was the use of the recorded data in defending the driver if s/he were involved in an incident (56 percent of the drivers agreed). More drivers (46 percent) agreed than disagreed (32 percent) with the statement that in-vehicle technology giving feedback would make them a safer driver. However, only 32 percent agreed that such technology would reduce their driving stress, while 46 percent disagreed.

What Are the Perceived Drawbacks & Concerns of Receiving Feedback on Safe Driving Performance by Technology?

The greatest concerns regarding technology feedback involved privacy issues. The surveyed drivers were undecided on the item "I want technology to create a record of how I drive," with equal numbers agreeing (35 percent) and disagreeing (35 percent). Many drivers (65 percent) were concerned that "the data collected by in-vehicle technology will get into the wrong hands."

Most drivers were not worried about the complexity of the technology—only 19 percent agreed to the question, "I am concerned that the technology will be too complex for me to use." Sixty-two percent did not agree that "Too many people will be able to drive trucks because these technologies will make the job too easy." About half (52 percent) agreed that "Drivers who depend too much on technology will lose the skills they need to be a safe driver." Forty-nine percent of the drivers agreed that "Receiving feedback from technology may be a distraction," and 42 percent were "concerned that technology may not be very reliable."

What Is the Preferred Form of Feedback on Safe Driving Performance by Technology?

The statements exploring drivers' preferences in terms of the modality, frequency and timing of feedback by technology failed to provide conclusive answers. Regarding the modality of the feedback, results showed that 47 percent preferred to receive feedback by a display on the dashboard; 37 percent preferred to receive feedback by a computer printout at the end of the shift; and 20 percent preferred to receive feedback by a computerized voice.

Regarding the timing of the feedback, 51 percent expressed that they would prefer feedback being delivered when they request it, and 43 percent agreed with receiving feedback from technology at regular intervals. More than half (57 percent) agreed that they would like to receive feedback immediately after the event. In addition, drivers were asked how often they would like to receive feedback—ranging from once a day to once a year. No clear preference emerged, with agreement rates ranging from 34 percent to 47 percent.

From Whom Would Truck Drivers Like to Receive Feedback on Safe Driving Performance?

Survey results showed that 68 percent of truck drivers would like to receive feedback from their safety directors; 61 percent from their supervisors; 54 percent from a team driving partner; and 50 percent from other truck drivers. This implies that truck drivers would like to receive feedback from multiple sources. Figure 1 provides detailed information.

The results indicated that in general, commercial vehicle drivers would like to receive more feedback. Drivers want feedback that is specific, constructive, respectful and individualized. Feedback is especially welcome if it is positive and accompanied by signs of recognition, such as a bonus or an award. Drivers expressed the importance of receiving feedback from persons they respect and perceive as knowledgeable about their job. Feedback was viewed as less desirable if delivered by persons the driver does not respect.

What Are the Most Important Safe Driving Behaviors?

Drivers were presented with 10 safe driving behaviors developed from focus group results and were asked to select the three they believed to be most important. Seventy-four percent selected "Looking well ahead of my vehicle to adjust to what is happening in front of me." "Expecting other drivers to make driving mistakes and being ready to avoid them—expect the unexpected" was selected by 55 percent, while 49 percent selected "Using turn signals to give other drivers plenty of warning when changing lanes or making turns," making it the third-most-important safe driving behavior.

Discussion

The survey data were generally consistent with the focus group data. Based on the results of this study, the authors believe that feedback by technology would be acceptable to truck drivers and is a promising area for further research. In-vehicle technology could provide a feedback method in the driving environment when no peers are nearby to offer feedback, meaning drivers would receive more feedback than they currently do. Since feedback from supervisors or managers is preferred to feedback from technology alone, such a program should be supplemented by human feedback. In turn, information from technology can help managers/supervisors provide concrete feedback to truck drivers.

Real-time feedback (i.e., warnings) via in-vehicle technology may allow the driver to interrupt the sequence of events leading to an injury or crash. However, the same data could also potentially be used to provide drivers with information that can change their safe driving behavior. Drivers who drive defensively might exhibit fewer hard-braking events or abrupt driving maneuvers. The occurrence of such events could be registered by technology and fed back to the driver.

The results of the focus groups pointed to the importance of involving all relevant entities within the organization. Drivers should be involved early on in the design of the technology and the implementation of the program. Results showed that nearly half of the drivers surveyed would be willing to become involved in the evaluation and implementation process. This study provides a platform for future research on the impact of in-vehicle technology in a lone-worker driving environment. ■

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