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7. Authors Ron Van Houten and Bryan Hilton,[a] Richard Schulman,[b] and Ian Reagan[c]		8. Performing Organization Report No. 211.5-1
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16. Abstract

This study pilot-tested a new application of a technology-based intervention to increase seat belt use. The technology was based on a contingency in which unbelted drivers experienced sustained haptic feedback to the gas pedal when they exceeded 25mph. Although drivers could continue to drive unbelted and exceed 25 mph by pressing on the pedal harder, they needed to exert constant mental and physical effort to do so. The feedback disappeared when drivers buckled. The feedback was sufficient to set up an establishing operation to reinforce seat belt buckling behavior. Participants were 7 commercial drivers who operated carpet-cleaning vans. During baseline, no contingency was in place for unbuckled trips. The yieldable haptic feedback technology was introduced on a multiple baseline across drivers design. Once the first set of drivers had responded to the contingency, it was introduced for the second set of drivers. During the first day of treatment the device was explained and demonstrated in vivo for all drivers of the vehicle. Driver's indicated they were impressed with the device and would not drive very long unbelted with the force in place. The introduction of the feedback system was associated with an immediate sustained increase in seat belt use to 100%. Occasionally drivers would initially forget to buckle during a trip and encounter the force. In all instances they buckled within less than 25 s of the force being applied. One advantage of this device relative to a gearshift interlock that requires buckling before moving a vehicle, is that drivers do not need to buckle while operating the vehicle in reverse, moving to a loading dock or switching parking spaces.

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Table of Contents

Executive Summary

This study evaluated a device that applied haptic feedback to encourage seat belt use. The feedback was a yieldable but sustained increase in accelerator pedal back force whenever unbuckled drivers exceeded a preset speed criterion without buckling their seat belts. Once the seat belt was fastened, this counterforce was removed. Participants were six commercial drivers who operated carpet-cleaning vans. During baseline data collection no contingency was in place for unbuckled trips. The yieldable pedal feedback was introduced on a multiple baseline across drivers design. Once the first set of drivers had responded to the contingency, feedback, it was introduced for the second set of drivers. During the first day of treatment the device was explained and demonstrated in person for all drivers of the vehicles. Drivers indicated they were impressed with the device and would not drive very long unbelted with the pedal feedback force in place.

The introduction of the treatment resulted in an immediate sustained increase in seat belt use to 100%. Occasionally drivers would forget initially to buckle during a trip and encounter the force. In all instances they would buckle within less than 25 s of the force being applied. Drivers who buckled upon reaching the target speed were recorded as buckled in all phases of the study. One advantage of this device compared to a gearshift interlock system that would require buckling to move a vehicle, is that drivers do not need to buckle to complete vehicle operations such as reversing to a loading dock or moving a short distance in a parking lot. At the end of the study, participants provided insight about their experience with the system. The drivers indicated that the system was an effective and acceptable safety feature.

Introduction

Seat belt use has been demonstrated to decrease serious injury in crashes (Tison et al., 2008). The legacy of research on increasing seat belt use has focused on enactment of primary laws, public education, high-visibility police enforcement, and seat belt reminder systems. Although these measures have proven to be effective, they have not increased U.S. seat belt use to 100% (Pickrell & Ye, 2009, August).

Behavioral programs have produced large sustained increases in seat belt use, and several of these techniques have been employed on a national, State, and communitywide basis to increase belt use. For example, highly publicized enforcement techniques such as *Click It or Ticket* influence behavior via a direct punishment contingency. The message is clear, “If I don’t wear my seat belt, I may get stopped by the police, get a ticket, and get points.” The national seat belt use rate reached 83% across the United States in 2008 (NHTSA, 2009). Innovative technologies may have the potential to elevate this rate further, possibly to 100%.

One innovative technology that has shown promise is the application of a gearshift delay when the driver is unbuckled (Van Houten, Malenfant, Austin, & Lebbon, 2005 ; Van Houten, Malenfant, Reagan, Sifrit, & Compton; 2009). The system tested by Van Houten and colleagues prevented drivers from placing their vehicles into gear for several seconds if they were unbuckled. This technology led to increased seat belt use of drivers of fleet vehicles with low seat belt use, although it did not consistently lead to 100% use. Many drivers reported that system acceptability would be significantly improved if it did not force drivers to buckle when backing and moving vehicles at a slow speed for a short distance.

A different concept uses technology to provide haptic feedback to drivers who are unbuckled. This system imposes an increased resistance of the accelerator pedal when the unbuckled driver exceeds a pre-determined speed. Although drivers can easily override this system when motivated to do so, such as to avoid a crash, they find it effortful to do so for sustained periods of time. This concept offers several potential advantages over other technologies. First, the system would not affect drivers who buckle but do so after putting the vehicle in motion nor would it affect drivers who do not buckle brief periods such as when backing a vehicle to a loading dock. Second, because driving at a chosen speed in a comfortable manner should be a powerful reinforce to a driver, the device should produce a rapid and sustained increase in seat belt use to 100%. Third, this system remains in effect until drivers fasten their seat belts. Finally, the system is consistently applied by the vehicle and does not require action from anyone other than the driver, such as a law enforcement officer. Previous research indicates that imposed pedal resistance technology can be successfully used to reduce speeding (Schulman, 2005). The purpose of this study is to evaluate the effect of this haptic feedback device on seat belt use and driver acceptance of the device. The hypotheses tested were that the device activation would lead to significantly increased belt use on trips longer than 1 minute relative to a baseline period and that drivers would find the system to be acceptable.

Method

Participants

The efficiency of the haptic feedback system was field tested on seven drivers of a carpet-cleaning fleet. Drivers from this sample were males ranging in age from 24 to 35 who averaged about 9 trips above the criterion speed per day.

The researchers assured the drivers and the participating agency, a carpet-cleaning business in Plainwell, Michigan, with a fleet of 48 vehicles, that individual seat belt use data would be kept anonymous, confidential, and would not be divulged to their supervisors or anyone else. The employer fully agreed and supported this commitment.

Apparatus

The apparatus included a microprocessor installed under the driver's seat and connected to six functions of the vehicles via a specially designed harness, as well as two weight sensors located under the driver's seat. The microprocessor recorded all data. These data included time, date, vehicle speed, presence of weight on the driver seat, ignition on or off, brake on or off, seat belt closure switch on or off, pedal force stepper motor on or off, start of trip, end of trip, and trip history in baseline as well as the experimental condition. In addition, the microprocessor was capable of analyzing the recorded data and downloading data into a spreadsheet. The researchers downloaded data using a modem that allowed wireless access to the microprocessor.

A separate circuit activated a stepper motor that applied the pedal contingency to manipulate the accelerator pedal. A potentiometer measured the motor's piston position. The motor was bracketed under the dashboard in such a manner that the motor's piston head was capable of contact with a flat metal disk that was affixed to the linkage arm that had the pedal attached. The piston could remain in contact with the affixed disk across the full travel of the accelerator pedal, from fully up to fully depressed. The device could not be seen without looking under the dashboard. The system operated in two modes, a position control mode and a force control mode. The device complied with FMVSS "make inoperative" requirements for No. 124 accelerator control systems. The device was not directly linked to the accelerator pedal arm and could not offer any resistance to the control springs.

The Position Control Mode. The position control mode is critical to maintaining a preset speed in that it sustains smooth, comfortable, and accurate speed regulation. This system operates across a 2 MPH speed range, from 1 mph below the preset speed to 1 mph above the preset speed, and is designed to provide the driver with a comfortable foot rest, via the pedal, when traveling at the preset speed. If the device is set for a 40 kph (25 mph) speed limit, the device's piston begins to rise as speed exceeds 24 mph. The piston stops upward travel when the accelerator pedal (due to driver depression of the pedal member) is in contact with the piston and the vehicle is traveling at 25 mph. At this point, the system is quite comfortable to the driver. The driver can simply rest the foot on the pedal. As long as the driver is depressing the pedal far enough to contact the piston, travel will always be at the preset speed. As the driver encounters a downhill gradient, the vehicle will pick up speed. The piston will then gently move upwards, along with the accelerator pedal and driver's foot, to exactly the position required to bring speed back to the preset speed. If the driver encounters an uphill gradient, and speed begins to fall below the preset speed, the piston will slowly and smoothly retract to allow the driver's natural foot weight to depress the pedal to the exact position required to bring the vehicle back to the preset speed. To enforce pedal position, the system uses a yieldable constant 18-pound back force. This force provides no punishment or aversive stimulation unless the driver attempts to override it. Rather, when complying with the automated pedal movement provided by the piston's position control system, in tandem with the motorist's degree of accelerator pedal depression, the pedal literally morphs from a piece of rubber to an aid regarding comfortable speed regulation. In summary, the device's position control system is designed to control vehicle speed and operates across a 2 mph speed range regarding the maintenance of the preset speed. Another version of this position control technology is used in traditional cruise control.

The Force Control Mode. As already noted, the system's pedal position control makes use of 18 pounds of backforce to enforce the position of the pedal. This particular pedal position back force was chosen so that even the heaviest foot would not unintentionally override the system during travel at the preset speed. However, this 18-pound position control back force is easy to override given the strength of the most drivers. Once the 18-pound position control system is overridden, the vehicle will increase in speed. At this juncture, pedal resistance increases up to 38 pounds. It is important to note that this high resistance value is present regardless of pedal position. In other words, throughout the full travel of the accelerator pedal, a higher force than the force used to control pedal position is imposed. Once speed begins to drop 1 mph above the preset speed the pedal position system is once again activated. It is important to note that 38 pounds of accelerator pedal resistance can be easily overridden by a normal driver. In fact, it is probably the case that in a life-threatening passing situation, almost all drivers press on the accelerator pedal with considerably more force than that imposed by the force mode system. If the driver reduces the degree of pedal depression or stops depressing the accelerator pedal altogether during any part of the system's operation, the pedal will act in a normal manner. It will pop upwards and the vehicle will slow down in the typical manner.

In the present experiment, the position control system became active as unbuckled drivers approached 40 kph (25 mph). The driver could remain unbuckled and drive quite comfortably in this mode. In terms of what the driver physically experiences, travel in the position control mode is akin to sitting in a chair and simply resting the natural weight of the right foot on a bathroom scale. However, if the driver overrides the force maintaining pedal position control, and vehicle speed begins to increase beyond 40 kph, the force control system becomes activated and pedal resistance increases to 38 pounds and is sustained regardless of pedal position, from fully extended to fully depressed . Driving in the force control mode is akin to sitting in a chair and pressing one's right foot on a bathroom scale with at least 38 pounds of force. The driver must buckle the seat belt to escape the system. Once the driver buckles, accelerator pedal resistance dissipates gradually over a 4-second interval.

The 40-kph speed criterion was selected for two reasons. First, this speed criterion would make the pedal contingency transparent to those who normally buckle their seat belts after starting trips. Second, drivers in previous studies with the seat belt shift interlock found it aversive to buckle their seat belts when moving vehicles short distances or backing up to loading docks. Fleet drivers often move vehicles around at speeds in excess of 24 kph (15 mph) and fleet drivers suggested we use 40 kph in previous studies. Once drivers exceeded this speed, it was assumed they would now be traveling on an actual trip, rather than moving around loading docks. To prevent drivers from bypassing the device by buckling the seat belt behind them, the system was designed to apply force when it detected that the seat belt was fastened before the participant sat in the driver's seat. The microprocessor detected zero attempts by drivers to fasten their seat belts behind them.

Safety Features. When the force mode was activated, the force gradually increased to 18kg (40 pounds) over a 3-second interval to ensure the driver had time to respond to the increased force to maintain or increase speed. The force also gradually deceased over a 4-second interval once the driver buckled the seat belt. This measure was taken so that the driver had time to adjust to the change in the force required to operate the pedal. Without such a measure, a driver might over-depress the pedal due to a sudden decrement in the force required for its operation. This could lead to a sudden and unintended increase in the rate of acceleration. If the force was activated and the drivers did not buckle their seat belts, the force was removed as they decelerated below 40 kph for any reason, such as approaching a red light, a stop sign, or a slower vehicle that pulled in front of them. Hence the force was never in place when drivers were operating below 40 kph. All of these features were demonstrated to drivers prior to introducing the treatment phase.

Measures

The microprocessor sampled the following events at a rate of 1Hz: vehicle ignition, vehicle speed, person seated in driver's seat, seat belt closure, brake use, vehicle motion, start and end of trip, and implementation of increased accelerator pedal force. The data logging component of the microprocessor recorded each of these events with a date and time stamp (year, month, day, hour, minute, and second), with events recorded when a variable changed status. The program also calculated the percentage of trips the seat belt was fastened and the times when the seat belt was unbuckled while the vehicle was moving. If the driver was unbuckled during vehicle motion for more than 30 s and the driver was traveling over 40 kph, the trip was scored as unbuckled. The dependent variables were percentage of trips the seat belt was fastened; percentage of trips the driver's seat belt was removed; percentage of trips that the driver buckled in response to increased pedal resistance; mean number of trips; and mean trip duration. Seat belt use was measured only for trips that attained a speed of 40 kph or more. Drivers were scored as wearing their seat belts on a trip during baseline and treatment if they buckled their seat belts within 30 s of attaining a speed of 40 kph. The 30 s grace period was added to allow the driver time to buckle their seat belts to escape the force. It was judged that 30 s would afford the driver adequate time to buckle in response to the increased pedal force at a time when the driving workload was not too high. This criterion was also employed during baseline for comparability.

Experimental Design

A multiple baseline design across two groups of participants was employed in this study. The treatment was first introduced for the first group of two drivers and later introduced for the second group of five drivers. One driver in Group 1 drove the vehicle 3 days during baseline and 7 days during the treatment condition while the other driver drove the vehicle 2 days during baseline and 6 days during the treatment condition. In Group 2, four drivers drove the vehicle 2 days during baseline and 2 days during the treatment condition. The remaining driver drove the vehicle 1 day during baseline and 1 day during treatment. Dispatchers determined the order in which participants drove the vehicles. Only one driver drove the vehicle on any day.

Procedure

Baseline. Prior to installing the equipment and recording data, meetings were held with the drivers to explain the baseline data collection phase of the study. Drivers were informed that a data logger had been placed in their vehicles as part of a study for NHTSA, but drivers were not told that the target behavior was seat belt use. After the microprocessors were installed and baseline began, the data loggers recorded the dependent measures, but drivers did not experience the increased accelerator force contingency until the intervention phase.

Intervention phase. After obtaining baseline data, the force contingency was activated for the first group of drivers and later introduced for the second group of drivers. Drivers in the first group were instructed not to talk to other drivers about the force feedback device. At the start of this condition each of the drivers for a particular vehicle received an explanation of the pedal force contingency. Because this device affected the accelerator pedal, each driver test drove the vehicle with a researcher to experience the force feedback contingency. The drivers indicated to the research assistant that they were impressed with the device and that they would not want to drive any distance with the force schedule in place.

Driver Acceptance

The study ended with discussions with the drivers to obtain feedback about the contingent pedal resistance system. Topics of interest included perceived effectiveness on seat belt use, ability to bypass the system, usefulness for teenage drivers, annoyance, acceptance, any rules formed as a result of the demonstration, their reaction if the devices were placed in all of their fleet vehicles, their reaction if they were placed in all vehicles sold provided it was paired with reduced insurance rates, and aspects of the device they liked best.

Results

Trips per Day

Drivers in each group made a similar number of trips during their respective baseline and treatment periods. Drivers in Group 1 average 8.6 trips per day during baseline and 8.5 trips per day during the treatment condition. Drivers in Group 2 averaged 8.9 trips during baseline and 9.7 trips per day during the treatment condition. Trips per day were scheduled by dispatchers who were not aware of the purpose of the study.

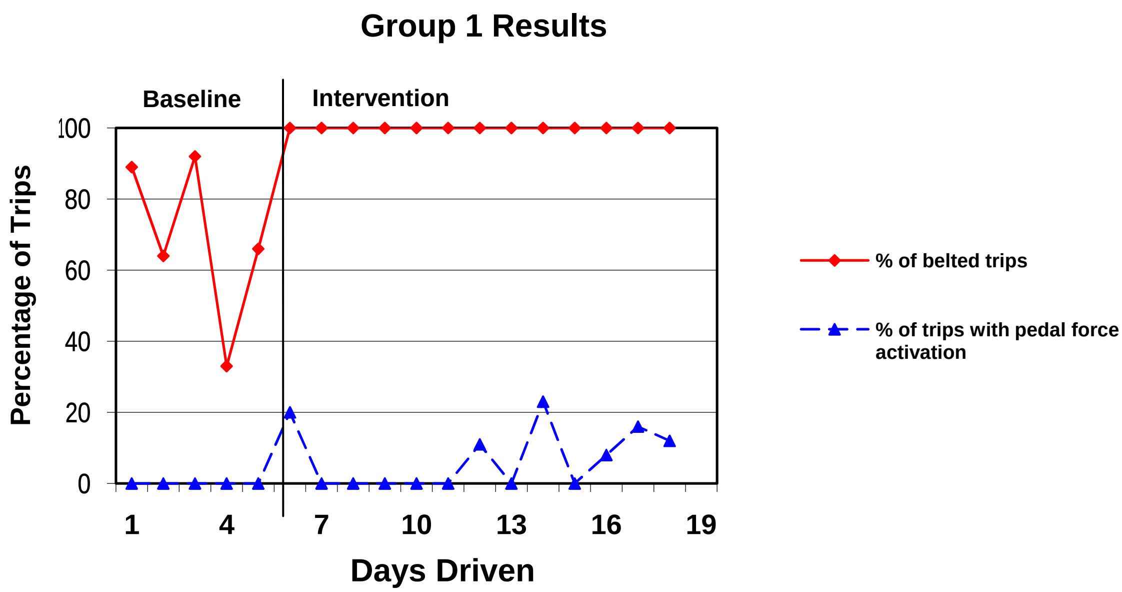
Seat Belt Use

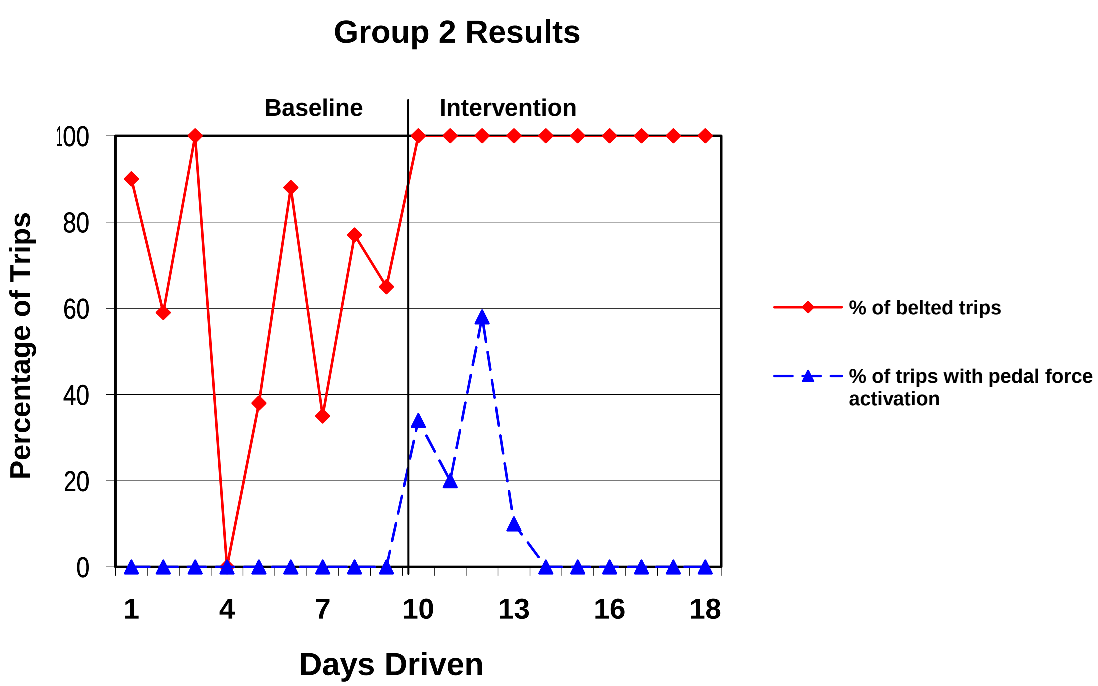
Baseline Period Results. Trips were counted as belted if the driver buckled within 30 seconds of attaining a speed of 40 kph. During baseline, the first group of two drivers buckled their seat belts an average of 69% of the time. There were two instances of buckling the seat belt after motion during baseline in the first group of drivers with the drivers buckling 2 s and 17 s after motion. These two instances were counted as buckled trips.

The second group of drivers buckled their seat belts 61% of the time during baseline. A driver in Group 2 removed and then refastened his belt during motion for less than a minute. This trip was counted as buckled. During Group 2's baseline there were three instances of buckling after motion, with the drivers buckling 3 s, 7 s, and 29 s after motion. These three instances were also scored as buckled trips.

Treatment Period Results. Activating the pedal force contingency was associated with100% seat belt use for both groups of drivers. Drivers in Group 1 buckled their seat belts 7% of the time in response to increased the haptic feedback, while drivers in Group 2 buckled their seat belts 13% of the time in response to increased pedal resistance. In each case the drivers buckled within 25s of the force being applied with an average latency of 12 s. Figure 1shows the percentage of buckled trips each day during baseline and intervention.

Figure 1. Belt use during baseline and intervention and pedal force activation during intervention.





Driver Acceptance

After completing the intervention, drivers gave feedback about the perceived effectiveness, reliability, usefulness, acceptance, and annoyance of the system. The participants' comments were overwhelmingly positive. See Table 1 for sample responses to the discussion questions. In general, the drivers indicated that the system was very reliable. It activated when they went over 40 kph and were unbuckled. Drivers stated that the pedal force got them to buckle up. All participants felt that novice drivers would benefit from the system, and many drivers said they would accept it if it were available for all vehicles, particularly if it were accompanied with insurance discounts. Negative comments about the device were limited. Two drivers commented that the device was somewhat noisy. No driver could think of a way to bypass the system other than intentionally breaking it.

Table 1

Sample Responses from Focus Group Testing

Question	Responses
How effective was the system?	“Every time I didn’t wear my seat belt it let me know”; “Pretty well effective”; “I started wearing my seat belt more”; “Very effective”; “I would wear my seat belt every time.”
Could you ‘beat’ the system, and, if so, how?	“Not without breaking it.”; “Cut wires”
How would teen drivers react to the system?	“They would get tired very fast of pushing a rock hard pedal and would put their seat belt on.” “Lights and tones can be ignored but not the pedal”; “Great thing to have because many teens don’t think of buckling, they just forget”; “Excellent for teen drivers”; “Not cool for teens to wear their seat belt”; “Would benefit teen drivers; they would avoid tickets.”
Did you form any rules about belt use? your	“No seat belt and it is a pain to drive.”; “If you don’t wear seat belt it is hard to press.”
How would you react if it were in all vehicles?	“Would be great”; “It’s a cool feature.”; “Great if it lowered insurance”; and “Anything to save money.” “It would not bother me.”
What aspect did you like best?	“It made me put my seat belt on for every trip. Never saw a feature like that.” “(The force) eases out when you buckle your seat belt so that pedal does not go to the floor.” “Seems safe, does not affect the way the vehicle drives”; “Felt safer because something was there to remind me to buckle”; “Did not take long to remind you that you were not wearing your seat belt”; “It worked”; “Good idea”; and “Don’t know it’s there unless you are on a trip.”

Discussion

The results of this study support the effectiveness of the haptic feedback contingency in producing high levels of seat belt use. It is interesting to note that all drivers indicated that they would always wear their seat belt to avoid the force during the initial demonstration. However, drivers occasionally failed to wear their seat belt until the force was applied during the treatment condition. It was necessary to both explain and demonstrate the contingency at the start of the treatment because it affected the feel of the accelerator pedal. Participants indicated that the demonstration was an important factor in its acceptance. In particular, the drivers appreciated knowing how the pedal force could be overcome in an emergency by exerting greater down pressure on the pedal, how it felt when the force initiated, and how the force gradually reduced when the buckle was in place. Given the suddenness of the change in seat belt use, it is apparent that the demonstration of the contingency had an immediate effect on seat belt use. It is likely that this effect was mediated by the formation of rule-governed behavior of the general form, "If I don't buckle up, the accelerator pedal will be harder to press when I go over 40 kph."

This device has several advantages over ignition or gearshift interlock systems that prevent starting or moving vehicles if the driver is unbuckled. First, it does not require the driver to wear the seat belt to start the vehicle before scraping the windshield or preheating it in winter or cooling it in summer. This represents a significant advantage over an ignition interlock system. Second, it does not require the driver to fasten the seat belt to move the vehicle (operators in vehicle fleets often need to move their vehicles short distances at very low speeds). Instead, this system only requires the operator to fasten the seat belt when they exceed a predetermined speed criterion that defines an actual trip. This is an advantage of an accelerator pedal resistance system. Third, this system can be installed in vehicles with both standard and automatic transmissions, unlike limitations of seat belt gearshift interlock systems.

The use of haptic feedback to the accelerator pedal has also effectively reduced speeding behavior (Schulman, 2005), and Nissan recently introduced force feedback to accelerators in efforts to increase fuel economy by alerting drivers with moderate pedal resistance when they accelerate too abruptly (World First Eco, 2008). Given the heavy visual processing demand associated with driving and the number of auditory alerting and reminder systems currently in use, haptic feedback may have several beneficial applications. For the current application, the system can be overridden if a driver needs to increase speed in an emergency situation, which is not the case with governors or interlocks. However, research would be necessary to ensure that negative consequences did not occur from a particular application or from the use of the same sensory mode for multiple applications.

In summary, this field study showed that the haptic feedback contingency could increase seat belt use to 100% among a small group of adult drivers. The upcoming phase of the study will test the system using a larger sample of drivers and will track seat belt use over a longer period of time to further increase the generality of this finding.

References

Pickrell, T. M., and Ye, T. J. (2009, August). Seat Belt Use in 2008—Demographic Results. Traffic Safety Facts Research Note. (DOT HS 811 183). Washington, DC: National Highway Traffic Safety Administration. Available at www-nrd.nhtsa.dot.gov/Pubs/811183.PDF.

World [sic] First Eco Pedal Helps Reduce Fuel Consumption. (2008, August 4). Nissan. Retrieved from www.nissan-global.com/EN/NEWS/2008/_STORY/080804-02-e.html.

Schulman, R. (2005). The Deaccelerator: A behavioral solution to highway speeding. *Behavioral Technology Today*: Cambridge Center for Behavioral Studies, 4, 2-24. Available at http://www.behavior.org/resource.php?id=189.

Tison, J., Solomon, M. G., Nichols, J., Gilbert, S. H., Siegler, J. N., & Cosgrove, L. A. (2008, June). *May 2006* Click It or Ticket *seat belt mobilization evaluation: Final report*. (DOT HS 810 979). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/810979.pdf

Van Houten, R., Malenfant, J. E. L., Austin, J., & Lebbon, A. (2005). The effects of a seatbelt-gearshift delay prompt on the seatbelt use of motorists who do not regularly wear their seatbelt. *Journal of Applied Behavior Analysis, 38*, 195-203.

Van Houten, R., Malenfant, J. E. L., Reagan, I., Sifrit, K., & Compton, R. (2009, December). Pilot tests of a seat belt gearshift delay on the belt use of commercial fleet drivers. (DOT HS 811 230). Washington, DC: National Highway Traffic Safety Administration and Ottawa, Canada: Transport Canada. Available at www.nhtsa.gov/staticfiles/nti/pdf/811230.pdf.

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