12-2012

The Effect of Innovative Technology on Seatbelt Use

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THE EFFECT OF INNOVATIVE TECHNOLOGY ON SEATBELT USE

Bryan W. Hilton, M.A.
Western Michigan University, 2012

A previous pilot study documented that providing sustained haptic feedback to the gas pedal when a driver exceeded 25mph with his seatbelt unbuckled and removing the feedback contingent on seatbelt use increased seatbelt use in 7 commercial drivers. This study replicated this effect with 20 young drivers who did not consistently wear their seatbelt.

In the current study unbuckled drivers received increased accelerator pedal resistance when they exceeded 20 mph. A non-concurrent multiple baseline design was employed for this study. The dependent variable was percentage of trips driven without seatbelt use. The independent variable was an increase accelerator pedal resistance (force feedback). The force feedback disappeared when the drivers buckled their seatbelt. All drivers drove the vehicle for one week without haptic feedback during the baseline phase. During the treatment condition the haptic feedback system was activated.

All drivers responded to the system by increasing their seatbelt use to 100%. Drivers often encountered the force and buckled within 40 seconds to terminate the force.
THE EFFECT OF INNOVATIVE TECHNOLOGY ON SEATBELT USE

by

Bryan W. Hilton

A Thesis
Submitted to the
Faculty of the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Arts
Department of Psychology
Advisor: Ron Van Houten, Ph.D.

Western Michigan University
Kalamazoo, Michigan.
December 2012
ACKNOWLEDGMENTS

I would like to start, first, by thanking my thesis committee for guidance, and especially Dr. Ron VanHouten. Without them and him I would not have had the ability to participate in the activities which generated this thesis.

Secondly, I would like to give thanks to all the people who supported the technology in creation and implementation. The short list includes Dr. Richard Schulman, Dr. Jeff Tenenbaum, Maurice Fauchstich, and Lewis Tann.

I would also like to thank Hana Manal for her assistance on the statistical analysis and Dr. Sarah Casella for assisting with data collection.

I would like to acknowledge the funding agency, The United States Department of Transportation (USDOT)/ National Highway Transportation Safety Administration (NHTSA) and specifically Dr. Ian Reagan and Richard Compton.

Finally, I would like to extend my gratitude to my family and friends for their support during this process. Thank you for your help and patience. And a very special thank you to my wife, Laura, who now knows more about mechanical and electrical engineering than she ever wanted to and took it all in stride.

Bryan W. Hilton
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CHAPTER I
INTRODUCTION

Early attempts to use technology to increase seat belt usage were not met with positive public acceptance. For example, in the early 1970s seatbelt ignition interlocks that prevented drivers from starting their vehicles without first buckling their seatbelts met with considerable resistance and were subsequently eliminated by an act of Congress (Kratzke, 1995). Subsequent efforts have focused primarily on public education, police enforcement, and enhanced seat belt reminder systems.

Several behavioral programs applied on a community wide basis have produced large sustained increases in seatbelt use. For example, publicized enforcement techniques, such as Click It or Ticket, that influence behavior via a direct punishment contingency and rule governed behavior (e.g. If I don’t wear my seatbelt, I may get stopped by the police, get a ticket and lose points) have produced increased levels of seatbelt use to an estimated 85% across the US (NHTSA, 2010). Results obtained from countries with the highest level of seatbelt use demonstrate that public education and police enforcement have produced marked improvements in seat belt use; however, none have produced consistent seat belt use patterns much above 90%. Although this level represents a high percentage of seatbelt usage, there are still a significant number of individuals who are riding unbuckled. Innovative technologies may add to the success realized by the high visibility enforcement model and elevate this rate
further. Another way to increase seatbelt use is to prompt drivers with an audible or visible cue. The United States, which initiated vehicle-based reminder requirement relied on these systems for decades without substantial success. These reminder systems did not take into account variables during trip initiation that may be important in increasing seatbelt use. These variables include the sequencing, timing and saliency of stimuli involving the interactions between the vehicle and driver during trip initiation.

Changes in sequencing, timing and saliency of events may produce increases in seatbelt use by drivers most reluctant to buckle their seatbelts. Malenfant and Van Houten (2008) reported on the buckling sequence and relevant latencies of 1600 drivers in two urban areas in the United States and Canada. The distribution of the combined data for drivers who fastened their seat belts before ignition, after ignition and after placing their vehicle in gear was 31.1%, 42.2% and 23.5%. These data indicate that more than 65% of drivers buckle up after ignition and almost 25% after placing their vehicle in gear. There was little difference in gear-seat belt latency across driver gender and age grouping.

These data indicate that seat belt reminders required by the US regulation FM VSS-208 and CMV99 do not allow audible and visible prompts to reach maximum effectiveness. That is because the seatbelt prompt regulation compromises both the saliency and novelty of the prompt by presenting the reminder among other start-up prompts and by timing the presentation without
regard to the preferred behavioral sequence of most drivers. The data from the Malenfant and Van Houten (2008) study suggest that the prompt should be presented approximately 30 seconds after placing the vehicle in gear. However, a better way of assessing trip type in drivers of fleet vehicles, who frequently operate vehicles for longer duration when moving vehicles may be vehicle speed rather than time driven. In fact the best time to implement a second reminder may be after the vehicle has attained a speed that that is highly correlated with the onset of a trip. In recent years auto manufactures have implemented repeat reminders during the trip. However, even these systems have typically only produced modest increases in seatbelt use (Williams, Wells, and Farmer, 2002).

An alternative method that has been rejected is the use of an interlock system. There are three types of seatbelt interlock systems and all systems are fraught with problems. For example the ill-fated ignition interlock had several serious drawbacks. First, the system required drivers to buckle their seatbelt in order to start the car to heat it and defrost the windshield in the winter, or to cool it in the summer. If the driver then leaves the vehicle while it is warming or cooling and would need re-buckle when she reentered the vehicle because the motor is already running. This would deprive the occupant of the intended benefit of the interlock device. Second, key “fobs” used to remotely start vehicles would be rendered useless. These devices are valued because they can be used warm or cool down vehicles before entering them. Third, this system would force the majority of drivers that already wear their seatbelt, but only
buckle after ignition, to learn a new buckling pattern. This includes drivers who currently only buckle their seatbelt after backing out of a parking space because they find it uncomfortable to check behind them when their seatbelt is buckled. All of these problems contribute to very poor consumer acceptance of the ignition interlock device and it is unlikely that fleet owners would purchase such an option because of its negative aspects.

The second type of interlock is one that requires the seatbelt to be buckled in order to gain access to the vehicle entertainment system. This type of interlock also has a number of serious drawbacks. First, many drivers install after-market entertainment systems that involve digital music such as an I-Pod that could easily override an entertainment system interlock. Second, not all drivers use their entertainment system every time they drive, greatly weakening the impact of such systems.

The least problematic type of interlock system is a seatbelt shift interlock. This system allows the driver to use their key fob to warm the vehicle during winter, or cool it in summer but does not allow him shift out of parking gear in order to start a trip until his seatbelt is buckled. This system is also in effect on all journeys unlike the less compelling entertainment system interlock. However, even this system has several significant drawbacks. First, drivers that currently buckle their seatbelt after placing their vehicle in gear would need to modify their buckling habit. Second, drivers operating in reverse would need to
buckle their seatbelt first before backing up. Third, it does not prevent drivers from removing their seatbelt during trips.

One alternative to a seatbelt shift interlock is a timed limited interval lockout associated with a reminder to buckle the seatbelt. Van Houten, Malenfant, Austin and Lebbon (2005) found that a brief programming delay of between 5 and 20 seconds for fleet drivers not wearing their seatbelt was effective in increasing the seatbelt use of a small sample of drivers (six) that rarely fastened their seatbelts. Two of the six drivers only required the minimum delay of 5 seconds to change their behavior. Follow-up feedback from the six drivers underscored the importance of making four important changes to the device. All drivers stated that they found the 20-second delays frustrating and that the level of frustration was heightened when they were required to buckle simply to move their vehicle, a trip that required no more than a few minutes. The drivers also suggested that shorter delays and a modification of the data logger to allow regularly buckled drivers to avoid the gear-shift delay for short trips would make the device more acceptable to future drivers of work vehicles who make frequent low speed short trips. Finally, two of the drivers indicated that they typically buckled their seatbelt after placing their vehicle in motion. They suggested that drivers with this pattern of buckling would not require drastic changes if the device could count trips when the driver buckled shortly after motion as a buckled trip.
In a second study, Van Houten, Malenfant, Reagan, Sifrit, and Compton (2010) examined a seatbelt-gearshift timed interlock designed so drivers, who showed a pattern of buckling within 30 seconds of placing their car in gear, would be permitted to continue buckling in this manner without the prompt. The system incorporated four improvements to the interlock device. First, the duration of the delay was limited to 8 seconds. Such a system provided a seatbelt reminder that could not be ignored because it was impossible to place the vehicle in gear while the seatbelt-gearshift delay was presented, thus compelling the driver to notice the reminder chime that accompanied the delay.

Second, in order to accommodate drivers who suggested that they should not be required to buckle to simply move their vehicle, the modified system was programmed to discard trips of less than 30 seconds in calculating percentage seatbelt use. Consequently these trips were not included in computing the percentage of buckled trips. The microprocessor controlling the system was programmed so drivers would only receive the delay when belt use as defined above dropped below 80%. This was accomplished by scoring trips when the driver buckled their seatbelt within 30 seconds of initiating motion as buckled trips that counted toward the 80% seatbelt use criterion. Third, the data-logging device was programmed to allow the researchers to automatically have the device become inactive when buckling surpassed the 80 percent criterion.

The results of this study showed that an 8 second seatbelt shift delay produced a large and substantial increase in the seatbelt use of drivers who
made many short trips each day. This study found that: 1) Most drivers showed an improvement in seatbelt use after the device was turned on; 2) The improvement was sustained for many months in half the drivers when the device was turned off; 3) Although it produced a marked increase in seatbelt use, it did not produce perfect seatbelt use. Focus group comments of drivers in both conditions show that these drivers have difficulty wearing their seatbelt on short trips and many drivers said they had difficulty getting off the delay once they were on it because many short trips at low speed exceeded 30 seconds. The use of a speed criterion rather than a time criterion could make it easier for drivers to accurately discriminate in advance when a trip is short or long thereby enabling them to more easily work their way off the delay.

A more promising approach is to increase response effort when operators are driving without a seatbelt over a criterion speed. Van Houten, Hilton, Schulman and Reagan (2011) evaluated a device that applied a yieldable but sustained increase in accelerator pedal back force whenever unbuckled drivers exceeded a 25 mph speed criterion without buckling their seatbelt. This force was removed once the seatbelt was fastened. The increased force was sufficient to set up a motivating operation to reinforce seatbelt use. Participants were 6 commercial drivers that operated carpet-cleaning vans. During baseline no contingency was in place for unbuckled trips. The yieldable pedal resistance was introduced employing 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 treatment was associated with an immediate sustained increase in seatbelt use to 100%. Occasionally drivers would initially forget to buckle during a trip and encounter the force. In all instances they would buckle within 25 s of the force being applied. Drivers who buckled within 30 seconds of reaching the target speed were recorded as buckled in all phases of the study including baseline. One advantage of this device is that the drivers did not need to buckle while operating the vehicle in reverse, moving to a loading dock or moving vehicle. Another advantage was that the force seatbelt contingency could be reapplied any time drivers unfastened their seatbelt during a trip.

The primary purpose of the current study was to replicate the Van Houten, Hilton, Schulman and Reagan (2011) study with 20 young drivers who would receive increased accelerator pedal resistance whenever they drove the test vehicle over 20 mph with their seatbelt unfastened. A secondary purpose was to assess trust and acceptance of the device.
CHAPTER II

METHOD

Participants

The efficiency of the haptic feedback system was field tested on 20 young male and female drivers. Potential participants were recruited by presenting a survey (Appendix A) to the students of WMU Psychology 1000 courses (Introduction to Psychology). To keep the potential participants naïve with regard to the experimental intent, only one question in the survey addressed seatbelt use. Participants were distracted from focusing on this question by the addition of many questions regarding safe and unsafe driving behavior(s). If the respondent answered the seatbelt question (“How often do you wear your seat belt.”) with any response but 100%, they would move forward to be checked for participation requirements.

Drivers were university students that ranged in age from 18 to 21. Each potential participant was required to meet the following criteria: current valid drivers license, no license suspensions within the past five years, no impaired driving convictions, no reckless driving convictions, no more than three moving violations in the 12 months prior to participation, and drive at least 15 miles per day with at least half of these miles on roads with speed limits of 30 mph or greater. Participants had to agree to sign a statement that said they would not let anyone else drive the vehicle. They were permitted to take passengers in the
vehicle provided they did not let them drive. They were also informed they could not take the vehicle beyond a 50-mile radius of the University.

Participants were informed that they were to drive the test vehicle instead of their own vehicle for a 2-week period and that the test vehicle would be supplied with a full tank of gas at the start of the study. All drivers were assured that all data that related to their individual driving behavior would be kept confidential.

Apparatus

The vehicle selected for the installation of the apparatus was a 2000, six-cylinder, automatic transmission, Ford Taurus. The vehicle was in excellent working condition and was provided by the USDOT. The experimental apparatus included a microprocessor installed under the driver’s seat and connected to six functions of the vehicle 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, 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. The microprocessor also recorded time and date, start of trips and end of trips (determined by logical function- trips begin with speed at
or over 20 mph sustained for over 20 seconds, trip end – ignition off for 30 seconds or no weight on the seat for 30 seconds), complete trip history, and motor/gear reduction cable drive on/off. All sensors throughout the vehicle, were either OEM equipment or researcher-installed, and were connected to the microprocessor using a custom built electrical wiring harness. The apparatus that provided the force feedback was designed for this study and included a microprocessor installed under the driver’s seat and a motor/gear reduction cable drive which was centrally located between the driver and passenger seat. The device has many safety features built into it. First, and most important the pedal resistance was not directly applied to the pedal but was applied through the action of a rotary spring. This spring could only provide a resistance force and only up to the specified force of the selected spring, hence, the driver could always override it. The device complied with FMVSS "make inoperative" requirements for No. 124 accelerator control systems. The device could not depress the pedal and could not offer any resistance to the OEM control springs.

The pedal force contingencies were also controlled by the microprocessor. In the first contingency the motor/gear reduction cable drive engaged when a logical series of conditions were met. For instance, the system engaged and provided pedal force if participants drove the vehicle for 20 seconds, above 20 MPH (start of trip), and the seatbelt was sensed as “off.” A secondary contingency that also engaged the system would be if participants were to buckle the seatbelt before sitting in the seat (sitting on their seatbelt) and also met the criterion to start of trip. If the first contingency was met and
activated the system, pedal force would terminate immediately when the seatbelt was buckled. In the second contingency the pedal force would only terminate by ending the trip, leaving the vehicle and unbuckling the seatbelt.

The system operated by when it received a signal from the microprocessor. That signal activated the 12-volt DC motor. The motor rotated a shaft that engaged a set of gears and reduced high speed, low force revolutions to low speed, high force revolutions. The low speed, high force revolution engaged a circular plate- radial spring-circular plate assembly in which the first plate was directly connected to the end of the clockworks on the side with low speed, high force. That plate had a metal pin protruding perpendicular on the outmost radial path. The placement of the pin directly corresponded to one arm of the radial spring. When the system was off, the first plate pin could not come into contact with the arm of the radial spring. When the system engaged the first plate pin rotated in a curvilinear motion until the pin came into contact with the spring arm. The spring then begin to rotate in turn with the pin until the other arm of the spring came into contact with a pin of the second circular plate. The second circular plate was directly connected to a lubricated, sheathed, steel strand cable (much like a brake or clutch cable on a motorcycle). When the spring rotated to contact the pin of the second plate the spring would go into tension and the cable pulled around the second plate. The other end the of cable which was connected to the upper arm then came into tension and pulled the upper arm of the pedal down forcing the lower arm of the pedal up. The cable was affixed in such a manor that when the cable was pulled (spring in tension)
the knock at the end of the cable would come into contact with the upper pedal arm pulling down, and by proxy, forcing the lower arm of the pedal assembly (accelerator pedal) up. When the spring and cable come into tension the clockwork assembly rotated until the spring was at the point of 38 lbs or 169.02 Newtons of tension. Therefore, to press the lower part of the accelerator pedal down (increase gasoline flow to engine) 38 lbs of force would need to be applied to the pedal to overcome the spring tension before the pedal would move sufficiently to increase gasoline flow to the engine. The cable was connected to the pedal in such a way that if the system were not engaged the pedal would float freely and react as an unmodified (normal) gas pedal. This offered an extra level of safety for the driver. The cable could only move the pedal to reduce gasoline flow, it could not effect the pedal to increase gas flow. The specific level of force to press the pedal at full engagement was not measured by a constant measure of force, such as potentiometer, but by calculating the amount of curvilinear motion required to place the spring into a tension level equal to 38lbs. That curvilinear distance would then be applied to the first circular plate and a micro-switch was installed on that plate that would send a signal to the microprocessor to terminate motor rotation once the plate had rotated the pre-determined amount.

When the system was engaged, the force would increase linearly over time in relation to the technical design of the radial spring. The system would come in to full force over 10 seconds and would return to a no-force or at rest condition over 10 seconds. For instance, if the driver met the trip criteria
without a seatbelt on the motor began rotating and winding the spring to put tension on the cable. At one second after initiation of the system, 3.8 lbs of additional force would be required to press the gas pedal to the same location as before the system had engaged. At 2 seconds after initialization it would take 7.6 lbs of additional force to maintain the pedal position at the same point as pre-system engagement. This would continue for ten seconds at which time the force would be at the full 38 lbs. If drivers buckled their belt, the system disengaged linearly at the same rate at which it engaged. For example, if drivers buckled their seatbelt 5 seconds after the system engaged, the force would be at 19 lbs and would disengage completely over 5 seconds.

Measures

The microprocessor sampled events sensed at a rate of 1 Hz. The sampled events included, vehicle speed/motion, seatbelt on/off, weight in driver seat yes/no, ignition on/off, brake on/off, pedal force system on/off and trip begin and trip end. All of these variables were sampled, and if one or more variables differed from the previous sample, a data event line was created by the microprocessor. If there were no changes in samples over a period of 10 seconds the microprocessor created a data event line regardless of the absence of variable change. All recorded variables were processed by the microprocessor and inputted into a Microsoft Excel file when they were downloaded. The microprocessor also had the ability to analyze raw data
event lines and reduce the data to a summary file which would automatically go into a second excel file. The analysis function reduced all data events to a summary broken down into averages and totals of each variable by day and last line of the summary file would be averages and totals of all the daily summary lines. For instance total number of trips per day, total number over belted trips per day, average number of belted trips per day, average trip duration, average duration of driving at certain speeds throughout the day, number of times the driver buckled in response to the system engaging.

The dependent variables were the percentage of trips the seat belt was used, the percentage of trips the driver’s seatbelt was removed, and the percentage of trips that the driver buckled in response to increased pedal resistance within 40 seconds of the start of trip. Seatbelt use was assessed only for trips that attained a speed of 20 MPH or higher. Drivers were scored as wearing the seatbelt on a trip during baseline and treatment if they buckled their seatbelt within 40 s of attaining a speed of 20 MPH (drivers that buckled in response to increased pedal resistance). The 40-s grace period was added to allow the drivers time to buckle their seatbelts to escape the force. It was judged that 40 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 same grace criterion was applied to baseline for comparability.
System Reliability

Because the system included automated recording and treatment implementation, extensive testing was done using a multi-tiered approach. The first level included full testing of all aspects of the system by researchers. The second level included full testing of all aspects of the system by partially naïve members of the Behavior Analysis Lab at Western Michigan University. The final level included testing of all aspects of the system by 15, partially naïve, randomly selected students who had volunteered to participate in a research study previously.

During all levels of reliability testing the system was placed in conditions above and beyond any normal operating conditions. Drivers would be instructed to engage in the following tasks two separate times with one of the researchers in the vehicle. All with system fully on, accelerate from 0 MPH to 25 MPH, accelerate from 25MPH to 35 MPH, maintain 35 MPH for extended period of time, increase speed from 35 to 45 MPH, change lanes, change lanes while accelerating, and simulate buckling seatbelt (system disengagement) while driving. Each time a task was completed the participant would certify that they could complete the task while maintaining complete control of the vehicle. Second to participant certification, the researcher also observed each task and certified completion of the task and maintenance of vehicle control (Appendix D). Extensive demographic data was not collected.
at this point, but the range of driver size, which included male and female participants, was 5’1” tall and 97 lbs to 6’3” tall and 265 lbs.

When the study ended for each participant that participant also completed a “Trust and Acceptance” rating scale (Appendix C). The participant was advised to read each statement and rate the statement in the range of 1-10 with 1 being “completely disagree” and 10 being “completely agree.” Every statement began with “The system was” and ended with either “reliable”, “predictable”, “trustworthy”, “acceptable”, “pleasing”, “annoying”, “accurate”, or “agreeable”.

Experimental Design

A non-concurrent multiple baseline design was employed in this study. Each participant drove the vehicle for one week with the system off (excluding participant 5 – two days baseline), followed by one week with the system on (excluding participant 5 – 12 days intervention). At the end of the study all participants evaluated the device by filling in a Trust and Acceptance evaluation.

Procedure

Baseline

Before drivers took possession the vehicle all aspects of the vehicle were described and explained to the participant. These explanations included
safety features of the vehicle as well as demonstration and explanation of all vehicle functions i.e. use of automatic transmission, light location, windshield wiper location, climate controls, radio controls, mirrors, and seat adjustment.

Participants were told that many aspects of the vehicle would be monitored and recorded. No driver was told that the primary variable of interest was seatbelt use. Drivers were informed that this study was funded under contract from the NHTSA and that the car was equipped with multiple sensors and a microprocessor that could monitor driving behaviors. All drivers signed a “non disclosure” contract that indicated they could not communicate any aspect of the research to anyone until they had received the final debriefing notification. Driver behavior was monitored during baseline, but treatment was not described until the beginning of the intervention phase.

Intervention

After the set baseline period expired, the drivers brought the car in to the researcher at the University. The specific contingencies of the pedal force system were explained to each driver. Then the researcher engaged the system and had the participant take a test drive with the system on and the researcher and the participant performed the same task list that had been preformed during the reliability-testing phase. If the driver completed all tasks and certified they did so while maintaining control and the researcher concurred, then the researcher would remind the driver that they had the right to
withdrawal and would ask whether the participant would like to continue. If
the driver indicated they would like to continue, the participant would then
sign off on a consent form (Appendix D) that indicated all functions and
contingencies of the system had been demonstrated and that they would like to
proceed. All participants that made it to the intervention phase passed and
certified on the task list and agreed to continue on to the intervention phase.

Trust and Acceptance

At the end of the study participants were asked to complete a short
evaluation of the experimental device and were given the Trust and
Acceptance Evaluation (Appendix C).
CHAPTER III

RESULTS

The overall results for all measures are presented in Table 1. The mean percentage of seatbelt use increased from 54.7 in the baseline condition to 99.7 in the treatment conditions. The few instances where the seatbelt was not buckled during the treatment condition were on trips of 2 minutes or less. Overall, participants buckled without receiving the force 84.7% of the time. On occasions when participants were initially unbuckled and received the haptic force feedback, all but three participants (P 1, 2, and 10) always buckled within 40 seconds of receiving the force. The remaining three participants did not buckle on only one trip each and this was always a short trip of less than a 2 minute duration. Figure 3 shows sets of graphs for all participants. The left graph shows the seatbelt use for each participant. The right graph shows the percentage of trips that participants buckled without receiving the force (buckled before the end of the start of trip criterion). Eight of the participants showed upward trend in the percentage of trips that they buckled without receiving the force (P 1, 3, 9, 10 13, 15, 16, and 18). Two participants (P 4 and 14) showed a downward trend in the percentage of trip that they buckled without receiving the force. Four participants (P 6, 8, 11, and 17) never received the force after receiving the demonstration at the start of the treatment condition.
Figure 1. Mean scores for each measure for each of the participants.

**Trip Characteristics.** The average number of trips per day was somewhat higher during baseline (5.4 trips per day) than during treatment (4.6 trips per day) however, average trip duration was somewhat higher during treatment (12.1 minutes per trip than during baseline (10.6 minutes per trip). Average top trip speed was similar between the two conditions with a baseline mean of 44.0 mph and a treatment mean of 44.9 mph. The percentage of trips less than 5 minutes duration, between 5 and 10 minutes duration and over 10 minutes duration were very similar across the two conditions.

**Trust and Acceptance Measures**

The scores on the Trust and Acceptance scale (Appendix C) are presented in Figure 2(below). Participants tended to rate the device as very reliable, predictable, trustworthy and accurate with all scores higher than 9.5
out of 10. High scores on these indicate that they agree that the device has the above-mentioned attributes. This is compatible with the results of all of the testing completed to insure reliability of the device. The average rating for pleasing was 8.3 and for annoying was 3.1. The average rating for acceptable and agreeable was 9.

Figure 2. Compiled results of the trust and acceptance evaluation for each participant.
Figure 3 (below). Graphs of the percentage seatbelt use (left) and percentage of trips without receiving the force (right) are presented for each participant.
Figure 3. Participant Graphs
CHAPTER IV
DISCUSSION

Accelerator pedal force feedback increased seatbelt use to perfect or near perfect performance for each of the 20 participants. Only three participants had a single unbuckled trip while all the rest of the participants had no unbuckled trips. In each case the unbuckled trip was of less than 2 minutes in duration. Although all drivers responded by buckling to escape the force, some drivers also showed evidence of learning to avoid the force over time. For example, four participants never experienced the force following the demonstration of the device because they always fastened their seatbelt before attaining trip speed for 20 seconds (the criterion that determined the onset of the force) while eight driver showed evidence of learning to avoid the force over time. Two participants showed an increase in the percentage of times they triggered the force criterion and the remaining participants showed a steady level of triggering the force. These data show that more than half the participants either learned to avoid the force following one trial during the demonstration, or gradually over the course of a week. It is possible that the remaining drivers would learn to avoid the force over a longer time period. Future research should follow participants over a much longer time period.

The results of the trust and acceptance evaluation indicate that drivers judged the device to be very dependable though somewhat aversive. One
might assume that the device would be rated highly aversive given its high level of efficacy. However, the rating may have been mitigated because the system did not require seatbelt use when moving the vehicle and did allow participants to buckle following placing the vehicle in motion. It may be that a contingency, which does not frustrate the individual’s attempt to place the vehicle in motion, may be less aversive than one that frustrates placing the vehicle in motion. Another advantage of this system is that it can directly apply force contingency if the driver unbuckles and then fails to re-buckle when they resumed their trip. In these instances they would received pedal resistance until they re-buckled their seatbelt. The seatbelt was not removed during trips in this study.

During the demonstration participants often commented that they would rather buckle their seatbelt than drive with the force. The data from this study validates these comments. It is unclear how much force is needed to produce consistent compliance. Future research should conduct a parametric evaluation comparing force level with system efficacy over a wide range of force values.
REFERENCES


Appendix A

Driving Behavior Survey/Informed Consent
Driving Behavior Survey/Informed Consent

Informed Consent Document

PROJECT TITLE: National Highway Traffic Safety Administration Driving Study

INTRODUCTION
This survey is to provide us with information about student driving practices.

RESEARCHERS
Responsible Principal Investigator: Ron Van Houten, PhD, Arts & Sciences, Psychology, Western Michigan University
Other Investigator: Sarah Castella and Bryan Hilton, Graduate Student, Arts & Sciences, Western Michigan University

WHAT WE ARE TRYING TO FIND OUT IN THIS STUDY?
There has been a lot of recent attention to the driving behavior of young drivers. Most drivers engage in risky driving behaviors some of the time although the actual incidence of risky driving varies from person to person. You can take a look at the survey before deciding whether you wish to complete it. Even if you choose to complete it you can decide to stop at any point. The last question on the survey asks if you would like to have the opportunity to be considered for participation in driving studies on risky driving behavior. These studies involve giving you a test vehicle to drive and compensating you for your participation. If you agree you will be asked to provide your name, phone number and your e-mail address. If you contact us we would send you information about the study and you could then decide whether you would like further information so you can consider whether you want to participate in the study.

If you decide to participate we will collect the papers and enter the responses into a spreadsheet. If you decided to provide contact information we will record this separately. All surveys will be kept confidential and will be stored in a locked filing cabinet in the principal investigator’s office for at least 3 years after which they will be destroyed.

If your instructor agrees, you will receive one extra credit point for participating in the study.

WHO CAN PARTICIPATE?
Anyone taking this class can participate in the study.

WHAT WILL YOU BE ASKED TO DO IF YOU CHOOSE TO PARTICIPATE IN THIS STUDY?
You will fill in the survey. You do not need to sign your name unless you wish to be considered for participation in studies that examine new safety technology.
WHAT INFORMATION IS BEING MEASURED DURING THE STUDY?
Information on how frequently you engage in risky driving behaviors and whether you have taken driver training and a question on whether you drive on a regular basis.

WHAT ARE THE RISKS OF PARTICIPATION IN THIS STUDY AND HOW WILL THE RISKS BE MINIMIZED?
If you decide to participate in this study, someone might see how you responded. However, we will keep the surveys private until the data are entered into the spreadsheet after which we will store the surveys in a locked filing cabinet.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?
Although there may not be any direct benefits to you for participating in the survey, the results may assist traffic safety planners in deciding how to focus educational outreach to reduce risky driving behaviors.

ARE THERE ANY COSTS ASSOCIATED WITH PARTICIPATION IN THIS STUDY?
There are no costs of participating.

IS THERE ANY COMPENSATION FOR PARTICIPATING IN THIS STUDY?
The researchers want your decision about participating in this study to be absolutely voluntary, yet they recognize that your participation may pose some inconvenience. Therefore we are offering one extra credit point for participation if your instructor agrees.

WHO WILL HAVE ACCESS TO THE INFORMATION COLLECTED IN THIS STUDY?
The researchers will take reasonable steps to keep these surveys confidential. Surveys will be kept in the Principal Investigator’s office and only the researchers will have access to them.

WHAT IF YOU WANT TO STOP PARTICIPATING IN THIS STUDY?
You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. There will be no consequences either academically or personally if you choose to withdraw from this study.

VOLUNTARY CONSENT
By completing the survey you are saying several things. You are saying that you have read this form or have had it read to you. The researchers should have answered any questions you may have had about the research. If you have any questions later on, you may contact: Dr. Ron Van Houten, 269-387-4471; Bryan Hilton, 269-387-4471. You may also contact the Chair, Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) if questions or problems arise during the course of the study.
Driving Survey

Please answer the questions as truthfully as possible. There is no “right” or “wrong” answer.

1. How often do you talk of a cellular (mobile) phone while driving? Please circle the percentage of trips you talk on your phone while driving.
   100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%

2. Before receiving your drivers license, did you take a drivers education course?
   1. yes  2. No

3. Which of the following statements best describes your driving?
   a. I tend to pass other cars more often than they pass me.
   b. Other cars tend to pass me more often than I pass them.
   c. About equally

4. In your opinion, what percentage of time do you drive 5 MPH or more above the speed limit?
   100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%

5. In your opinion, what percentage of trips do you text while driving?
   100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%

6. What percentage of time do you wear your seatbelt?
   100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%

7. When you drive a motor vehicle, what percentage of the time do you have a cellular phone with you?
   100%  90%  80%  70%  60%  50%  40%  30%  20%  10%  0%
   If you talk on your phone while driving, do you hold your phone with your hand or do you use a hands-free option?
   1. Hold Phone
   2. Hands-free

8. Do you drive 15 miles per day on average?
   1. yes
   2. no
9. Do you drive at least 15 miles a day on average?
   Yes_______   No_______

10. If you would like to participate in a follow-up study that would involve driving a test vehicle and financial compensation please provide a name and e-mail address.
   Name: __________________________
   e-mail: __________________________

11. If you are interested in follow-up participation, will you be near Kalamazoo this summer?
    Yes_______   No_______

12. If yes, please indicate which semesters you will be available.
    SU I_________   SU II_________
Appendix B

Experimental Informed Consent
Experimental Informed Consent

Informed Consent Document

PROJECT TITLE: National Highway Traffic Safety Administration Driving Study

INTRODUCTION
The purpose of this form is to give you information that may affect your decision whether to say YES or NO to participation in this research, and to record the consent of those who say YES. This research project will take place in the Kalamazoo and Portage areas.

RESEARCHERS
Responsible Principal Investigator: Ron Van Horn, Ph.D., Arts & Sciences, Psychology, Western Michigan University
Other Investigator: Sarah Cassella and Bryan Hildreth, Graduate Student, Arts & Sciences, Western Michigan University

WHAT WE ARE TRYING TO FIND OUT IN THIS STUDY?
Several studies have been conducted looking into the subject of new technologies that may improve highway traffic safety. If you decide to participate, then you will join a study involving research of driving behavior in a real-world setting. The research is to test a new traffic safety system. You will be provided a vehicle that you will drive for the duration of the study. The study will last between 3 days and 2 weeks. Various driving behaviors such as miles driven per trip, time of trip, hard braking, seatbelt use, etc. will be digitally recorded throughout the study. The risks associated with the study are no more than those present during participants' normal daily driving. During the first week of driving the vehicle will collect data on your driving behavior prior to the system being activated. During the second week a safety system will be explained and demonstrated to you and you will be asked to drive the vehicle with the safety system activated. You will be given a complete description and complete demonstration on how it operates. This is an experiment safety device that is not currently available on the market. Although the device has been safety tested, there is always a chance there could be unintended consequences. If you decide to continue participating, then you will join a study involving research of driving behavior in a real-world setting. You will also be given a short questionnaire at the end of the study to assess your views on the driving system.

WHO CAN PARTICIPATE?
The fact that you are here indicates that you meet the criteria associated with your driving record (age, years of licensure, no impaired driving citations, no reckless driving citations, no license suspensions for moving violations). Additionally, to the best of your knowledge, you usually drive at least 15 miles per day, and you usually drive at least half of these miles on roads with speed limits of 60 mph or greater. Not meeting these criteria would keep you from participating in this study. You also must agree to sign a statement that says you will be the only person who drives the vehicle. You may take
passengers in the vehicle provided you do not let them drive but you may not use it for trips beyond a 50 mile radius from Western Michigan University.

WHERE WILL THE STUDY TAKE PLACE?
This study will take place in the Kalamazoo Portage and surrounding areas. We would like you to use the test vehicle rather than your own vehicle for the duration of the study. You may drive the test vehicle within a 50-mile range of Western Michigan University.

WHAT IS THE TIME COMMITMENT OF THIS STUDY?
You will be asked to drive the test vehicle for a minimum of 3 days and a maximum of two weeks.

WHAT WILL YOU BE ASKED TO DO IF YOU CHOOSE TO PARTICIPATE IN THIS STUDY?
You will be asked to drive the vehicle you are given for up to two weeks for your normal driving trips. During the second week a safety device will be activated. The device will be completely explained to you at that time and you will have the option of not participating further in the study at that time.

WHAT INFORMATION IS BEING MEASURED DURING THE STUDY?
Various driving behaviors such as miles driven per trip, time of trip, hard braking, etc. will be digitally recorded throughout the study. You will also be asked to evaluate the safety technology at the end of the study.

WHAT ARE THE RISKS OF PARTICIPATION IN THIS STUDY AND HOW WILL THE RISKS BE MINIMIZED?
If you decide to participate in this study, then you may face a risk of becoming involved in a car crash in the provided vehicle. However, this risk should not be more than your normal driving risk. As with any research, there is some possibility that participants may be subject to risks that have not yet been identified. If you are involved in a crash you will be covered by the Insurance policy (a copy is in the glove compartment). The collision deductible will be paid by the research contract and the remainder by the insurance policy. As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or additional treatment will be made available to you except as otherwise stated in the consent form. The vehicles are equipped with standard safety equipment (air bags, seatbelts, and anti-lock brakes). You will be familiarized with the vehicle and the operation of the various options such as lights, windshield wipers, etc. If the vehicle is damaged in a crash the Owner will pay for repairs up to the deductible limit and the insurance will pay for the remainder of the repairs.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?
The main benefit to you for participating in this study is that it may assist you in being a safer driver and it may help the National Traffic Safety Administration in selecting improved safety standards for vehicles.

**ARE THERE ANY COSTS ASSOCIATED WITH PARTICIPATION IN THIS STUDY?**
There are no costs of participating.

**IS THERE ANY COMPENSATION FOR PARTICIPATING IN THIS STUDY?**
The researchers want your decision about participating in this study to be absolutely voluntary. Yet they recognize that your participation may pose some inconvenience. To help defray your costs you will receive $11 per day participating in this study and $154 for completing all two weeks of the study. You will receive a free tank of gas in the vehicle you will drive. You will pay for any gas required beyond this, but you will not need to fill the vehicle up upon return. Because you are driving the government owned vehicle during the study, you will save wear and tear upon your personal vehicle.

**WHO WILL HAVE ACCESS TO THE INFORMATION COLLECTED IN THIS STUDY?**
The researchers will take reasonable steps to keep confidential information, such as questionnaires, driving history, and research findings, confidential. The researcher will remove identifiers from the information, destroy driving records after coding the necessary information, and store information in a locked filing cabinet in the Principal Investigator's office prior to its processing. All data will be stored in a locked filing cabinet in the principal investigator's office for 3 years after which time it will be destroyed. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you.

**NEW INFORMATION**
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

**WHAT IF YOU WANT TO STOP PARTICIPATING IN THIS STUDY?**
It is OK for you to say NO. Even if you say YES now, you are free to say NO later, or withdraw from the study — at any time. Your decision will not affect your relationship with Western Michigan University, or otherwise cause a loss of benefits to which you might otherwise be entitled. The researchers reserve the right to withdraw your participation in this study, at any time, if they observe potential problems with your continued participation.

**COMPENSATION FOR ILLNESS AND INJURY**
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm, injury, or illness arising from this study, Western
Michigan University, nor the researchers are able to give you any money, insurance coverage, free medical care, or any other compensation for such injury. In the event that you suffer injury as a result of participation in any research project, you may contact Dr. Ron Van Houten at 269 387 4471 who will be glad to review the matter with you.

VOLUNTARY CONSENT
By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later on, you may contact: Dr. Ron Van Houten, 269 387 4471; Brynn Hillman, 269 387 4471. You may also contact the Chair, Human Subjects Institutional Review Board (269-874-393) or the Vice President for Research (269-874-393) if questions or problems arise during the course of the study.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner.

Do not participate in this study if the stamped date is older than one year. Please provide a check below to indicate that you have seen the stamped date and signature in the upper right hand corner.

I have seen the stamped date and signature at the top of this consent form and checked that it is not older than a year.

INVESTIGATOR'S STATEMENT
I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely induce this subject into participating. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during the course of this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature

Date
Appendix C

Trust and Acceptance Scale
Trust and Acceptance Scale

Consider the accelerator pedal/searbelt feedback system you have experienced. Please rate the following statements on a scale of 1 to 10, with “1” indicating complete disagreement and “10” indicating complete agreement.

1) The accelerator pedal was reliable.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

2) The accelerator pedal was predictable.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

3) The accelerator pedal was trustworthy.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

4) The accelerator pedal was acceptable.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

5) The accelerator pedal was pleasing.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

6) The accelerator pedal was annoying.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

7) The accelerator pedal was accurate.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree

8) The accelerator pedal was agreeable.
   1 2 3 4 5 6 7 8 9 10
   Disagree  Agree
Appendix D

Reliability Test Sheet
Reliability Sheet

Test Participant Number:

Date:

Age    Sex    Height    Estimated Weight

Parking Lot Test —
Each task to be completed three times. The first to be assessed by the experimenter, the second and third by the participant.

While System engaged:

1. Could you accelerate from a “stop” to 25 miles per hour? (Y/N) (Y/N) (Y/N)
2. After slowing to 15 mph could you increase speed to 30 miles per hour? (Y/N) (Y/N) (Y/N)
3. While driving could you functionally turn off the system by buckling your seatbelt? (Y/N) (Y/N) (Y/N)
4. Was control maintained while driving when the system turned off/on? (Y/N) (Y/N) (Y/N)

On Road —
Each task to be completed three times. The first to be assessed by the experimenter, the second and third by the participant.

While system engaged

1. Could you accelerate from a stop light with the system engaged? (Y/N) (Y/N) (Y/N)
2. Could you maintain control of the vehicle while buckling your seatbelt (simulated by firing the off switch)? (Y/N) (Y/N) (Y/N)
3. Could you change lanes while the system was engaged? (Y/N) (Y/N) (Y/N)
4. Could you pass another vehicle while on the expressway with the system engaged? (Y/N) (Y/N) (Y/N)
5. Can you maintain a speed of 40 mph with the system engaged? (Y/N) (Y/N) (Y/N)
Appendix E

Signed HSIRB Letter
Signed HSIRB Letter

Date: February 4, 2011

To: Ron Van Houten, Principal Investigator
    Bryan Hilton, Student Investigator
    Sarah Casella, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 10-03-15

This letter will serve as confirmation that your research project titled “The Effect of an Innovative Technology on Seatbelt Use-Phase 2 (Student Drivers)” has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: April 21, 2011