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16. Abstract

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Assessing Driver Distraction Due to In-Vehicle Video Systems through Field Testing at the Pecos Research and Testing Center

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ABSTRACT

Nine drivers drove 5 laps in an instrumented vehicle around a 10.1 mile closed course containing numerous curves. Two laps were designated as controls, with each participant also driving one lap while watching a DVD program, one lap while listening to a DVD program and one lap while operating the DVD player. Participants watching and operating the DVD player were less likely to notice outside events like a lead vehicle applying its brake, or a light being illuminated in their periphery. During the laps involving the DVD player, they also reacted slower to the events presented in their periphery. Participants watching or operating the DVD player were also more likely to use their brake and take turns at higher lateral accelerations when negotiating the many curves throughout the test-track. Finally, participants drove significantly slower when watching the DVD player and marginally slower when operating it.

EXECUTIVE SUMMARY

With more and more electronic devices being used by drivers everyday, it is important to understand the affects this attention sharing has on driving performance. While distractions have always been part of the driving experience, whether it was a passing billboard, a sandwich or a passenger, today's new in-vehicle technologies put new demands on drivers. Beginning with the ubiquity of portable phones, and now stretching through navigation systems, text messaging and DVD players, drivers today have many options on how they would like to be distracted from the road. A study based on police reporting of crash statistics estimated that 25% of all crashes are attributed to driver distraction, with 8.2% caused by some distraction within the vehicle (Wang et al. 1996.) This number is likely lower than the actual fraction of crashes caused by driver distraction as drivers are generally hesitant to admit that they were distracted when involved in a crash.

While many states have leapt quickly to pass legislation outlawing the use of DVD players while driving, 15 states still have no laws in place restricting the use of in-car video screens in view of the driver. Of the 35 states with regulation in place, none mention any stipulations regarding the operation of the DVD player by the driver (Sundeen 2005).

The current study examined how watching, listening, and operating a DVD player affects driver performance. Nine participants (average age = 33.1) drove a roughly 10 mile test course located at the Pecos Research and Testing Center (RTC) in Pecos, Texas to evaluate the effects of an in-car DVD player on driver performance. A 2006 Toyota Highlander was used as the Subject vehicle. It was instrumented with a variety of systems which allowed assessment of speed, lateral acceleration, response time to two events: a lead vehicle braking and small lights illuminated in the vehicle's rear window. In all four measures were used to compare the participants' driving performance with and without the added distraction of the DVD-based tasks: Event detection, brake use, lateral acceleration around curves and longitudinal velocity.

Each participant drove 5 laps around the course. Participants were told to keep their speed at about 40 miles per hour. At this speed, each lap took approximately 14 minutes. An experimenter rode in the second row of seats on the passenger side where they were able to operate the computer system located principally behind the driver.

Throughout the 5 laps around the test track, the participants each drove 2 control laps, one lap in which they were asked to watch a DVD program, one lap in which they were asked to listen to a DVD program and one lap where they were sporadically given instructions to operate the DVD player in various ways. The order of the 3 DVD task laps was counter-balanced among participants. For the laps including the watching and the listening test conditions, participants were told that they would be asked 4 questions regarding the content of the program they had just seen or heard immediately after the lap.

The results of the study show that drivers were less likely to notice the lights to the rear of their vehicle while operating or watching the DVD. However, neither of these differences in PDT Hit percentage (between the "operate" lap or the "watch" lap and the "control 2" lap) was significant. This is partly a result of the small sample size.

For those trials where the driver did notice the rear lights, response time was analyzed. As expected, in the presence of a DVD task, participants responded slower on average to the rear light events, although not significantly slower. Despite having the highest Hit percentage of any condition including both "control" conditions, the "listen" condition had a slower reaction time than both "control" conditions. This could be because while they were not visually distracted (causing them to miss the light altogether,) mentally they could have been immersed in the DVD program, resulting in a delayed simple reaction time when pressing the response button.

On average drivers used their brake 1.43% of their total drive time over all drivers and all laps. As expected, drivers under both the "watch" and the "operate" test conditions used their brakes more often than driver under the "listen" condition, and drivers under the "control" conditions. Again, due to the small sample size no significant differences were found between conditions.

The lateral acceleration results collected seem to again confirm that drivers' performance declines when using a DVD player while driving. Drivers on both the "watch" and the "operate" laps both recorded average scaled lateral accelerations over the 6 curves of interest larger than those recorded on the "control 2" lap. Again, this illustrates that drivers under these conditions likely did not have complete preview knowledge of the degree of curvature in the upcoming road segment, and subsequently took the curves faster under the more distracting conditions.

Participants' average velocities over each lap again confirm that interacting with the DVD player affects driving. While all participants drove faster on their "control 2" lap (fourth lap) than on their "control 1" lap (first lap), participants reduced their speed on the laps where they were asked to watch or operate the DVD player.

All four performance measures examined show some performance decrement when interacting with a DVD player while driving. While the event detection results did not show a significant difference between distracted participants and non-distracted participants, a small difference was observed. Collecting data from more test participants would likely make the differences clearer.

As evident from the braking and lateral acceleration data, participants operating or watching the DVD player while driving had less preview knowledge of upcoming curves, resulting in more braking and potentially dangerous higher lateral accelerations. This illustrates the fact that interacting with a DVD player not only makes a driver less likely to notice unexpected events, it also makes drivers more likely to perform in a way that could lead to roll-over and run off the road crashes.

This project was the first full-scale test of the Texas Transportation Institute's new instrumented vehicle. All of the systems on the vehicle performed well during the testing and the research participants found the vehicle easy to handle.

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DISCLAIMER

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BACKGROUND

INTRODUCTION

With more and more electronic devices being used by drivers everyday, it is important to understand the effect this attention-sharing has on driving performance. While distractions have always been part of the driving experience, whether it was passing a billboard, eating a sandwich or talking to a passenger, today's in-vehicle technologies put new demands on drivers. Beginning with the ubiquity of mobile phones, and now stretching through navigation systems, text messaging and DVD players, drivers today have many options on how they could be distracted from the road. But at what cost?

Stutts (2001) explained driver distraction as occurring "when a driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object, or person within or outside the vehicle compels or induces the driver's shifting attention away from the driving task". Treat (1980) similarly defined distraction as "a diversion of attention from the driving task that is compelled by an activity or event inside the vehicle".

A study based on police reporting of crash statistics estimated that 25% of all crashes are attributed to driver distraction, with 8.2% caused by some distraction within the vehicle (Wang et al. 1996). This number is likely lower than the actual fraction of crashes caused by driver distraction as drivers are generally hesitant to admit that they were distracted when involved in a crash.

Watching a DVD while driving clearly appears to decrease safety and increase the likelihood of a driver not being completely aware of their surroundings at all times. However, to enact legislation curtailing individual freedoms in absence of valid research is not necessarily the best route to take. Concrete evidence of a performance decrement to drivers engaged with an in-vehicle DVD players are therefore warranted in order to better illustrate the danger presented when peoples' mind and eyes both leave the road at the same time.

While many states have leapt quickly to pass legislation outlawing the use of DVD players while driving, 15 states still have no laws in place restricting the use of in-car video screens in view of the driver. Of the 35 states with regulations in place, none mention any stipulations regarding the operation of the DVD player by the driver (Sundeen 2005). Perhaps the reason all 50 states have yet to act is because very little has been studied about the actual effects of interacting with a DVD player while driving (Regan 2005). While some research has been done dealing with portable phones and navigation systems, little had been done examining the effects of newer in-vehicle technologies.

Kirsher et al., (2004) evaluated 8 drivers watching a DVD while driving in a simulator. Kirsher reported that while longitudinal speed was not affected by the presence of the DVD player, longitudinal speed variance was. Also, Kirsher reported that drivers increased their following distance while watching the DVD, but did not find any performance decrement in terms of reaction time to a lead car braking event. A peripheral detection task was also incorporated and showed detection frequency differences across some but not all conditions.

White et al. (in press) evaluated 48 drivers watching and/or listening to a DVD player while driving in a simulator. It was reported that drivers watching and listening to the DVD player responded .25 seconds slower to a lead vehicle decelerating than when undistracted or when just listening to the DVD. When the DVD player was present drivers tended to significantly decrease their following distance behind a lead vehicle and their longitudinal speed.

Goals of Current Study

The current study examined driver distraction due to listening, viewing, and operating a portable DVD player placed on the front passenger seat of a vehicle.

Four measures were used to compare the participants' driving performance with and without the added distraction of the DVD-based tasks: Event detection (both of a lead vehicle braking, and a light periodically illuminated in the rear view mirror,) brake use, lateral acceleration around curves and longitudinal velocity.

How does interacting with a DVD player affect a driver's performance in terms of situational awareness?

Hypothesis 1: A driver is less likely to notice events in their forward view when interacting with a DVD player in view

Hypothesis 2: A driver is less likely to notice events in their periphery when interacting with a DVD player in view

Hypothesis 3: A driver is less likely to have an accurate picture of the road ahead (especially curves) when interacting with a DVD player in view

Hypothesis 4: A driver is likely to drive slower through a winding course when interacting with a DVD player in view.

EXPERIMENTAL METHOD

PARTICIPANTS

Participants were recruited from the town of Pecos, Tx by distributing flyers at community centers, local businesses and schools, and through word of mouth. Four men and five women were tested. The average age of the participants was 33.1 years with a standard deviation of 14.4. The youngest participant was 19 years of age, while the oldest was 66 years of age. On average, the participants had been driving for 16.5 years. Each participant was paid $30 for the two hour session.

Participants completed an informed consent form, a demographic and driving history form and a short questionnaire about their use of vehicle entertainment systems. In addition, each participant was asked about their level of fatigue at that moment. These questionnaires are presented in Appendices A and C.

All but one participant indicated that they drove several times per day.Six of the nine participants indicated that they used electronic devices other than the radio while driving at least once per day. One participant indicated that they used electronic devices while driving only a few times per year. Seven of the ten participants drove cars on a regular basis, while the other three drove an SUV or truck (i.e. a vehicle with a higher clearance and greater visibility). Participants 3 and 9 had used a DVD player in their car before. Participants 1, 3, and 6 indicated their alertness as something other than “very alert”, with participant 6 indicating that they were “very drowsy”.

PROCEDURE

Participants drove 5 laps around a 10.1 mile closed course during daylight hours. Each lap took approximately 14 minutes. The course is located at the Pecos Research and Testing Center (RTC) in west Texas. This course is a winding two lane roadway with no pavement markings located in a desert environment. A 2006 Toyota Highlander was used as the test vehicle and is described in the Equipment section below. An experimenter rode in the second row of seats on the passenger side where they were able to operate the computer system located principally behind the driver.

Participants were met in downtown Pecos, Texas and driven to the Pecos RTC about 20 minutes outside of town. During the drive the participants were administered the Informed Consent as well as the Pre-drive Questionnaire.

Once at the staging area at the Pecos RTC, participants were asked to get into the driver’s seat of the Highlander and make themselves comfortable. A detailed script of instructions was then read to each participant. This script can be found in Appendix B

Instructions

These instructions outlined the basic driving expectations (speed, lane keeping,) the function of the lead car (maintain separation distance, provide route guidance, display stimuli for brake event,) and the operation of the Peripheral Detection Task (PDT) stimulus mounted on the rear window. During these explanations, the participants were given a response button to attach to their left index finger which they would use to indicate the presence of a stimulus. A photograph of the finger-mounted button is displayed in Figure 8 in the Equipment section below.

Participants were told to keep their speed at about 40 miles per hour. They were told informally that they would only be verbally corrected if their speed exceeded 50 mph or dropped below 30.

Throughout the 5 laps around the test track, the participants each drove 2 control laps, one lap in which they were asked to watch a DVD program, one lap in which they were asked to listen to a DVD program and one lap where they were sporadically given instructions to operate the DVD player in various ways. (The script listing the DVD operating tasks is presented in Appendix C). For the laps including the watching and the listening tasks, participants were told that they would be asked 4 questions regarding the content of the program they had just seen or heard immediately after the lap. This was intended to provide extra incentive to the participants to actually pay some level of attention to the program being presented either visually and or aurally. (These questions are presented in Appendix D).

During the drive, two outside event detection tasks were presented. The Peripheral Detection Task (PDT) was comprised of one yellow LED light was located in the rear window of the vehicle and participants were asked to press a response button attached to their left index finger to indicate when the light was illuminated. Along with this PDT stimuli viewed in the rear-view mirror, drivers were also asked to press the button when they noticed the lead vehicle's brake lights (BRAKE events). These events occurred when the driver of the lead vehicle momentarily tapped the brake pedal just enough to illuminate the brake lights for roughly 1 second.

After hearing the instructions and the overview of the experiment, participants were shown the DVD player and given practice performing the operations they would be asked to do later while driving. While the DVD player's functionality was straightforward and consistent with many other electronic devices in terms of button layout and icon use, participants were still given the chance to familiarize themselves with this specific unit. Ideally this would somewhat even out the skill level of all participants in their ability to operate this DVD player.

Lead Car

At a separation of roughly 150 feet, a Lead car drove the route in front of the Subject car. While the Subject car was to maintain a speed of around 40 mph, the driver of the Lead Car tried to maintain a stable leading distance of about 150 feet by accelerating and deceleration along with the Subject Car. The Lead car served a number of functions including providing visual route guidance to the test participant and monitoring the surroundings for large wildlife which could have posed a danger to the subject vehicle (and its distracted driver). The lead vehicle was also in place to present the Brake event stimuli to the test participant as discussed above.

Timing/Location of Events

The timing of the PDT events and the Brake events had to be coordinated. Ten locations were found spaced around the track, each at some inconspicuous landmark so that the experimenters could repeatedly trigger the events at the same locations. Locations where the sight distance would allow the participant to see the brake lights on the Lead car were chosen. For each lap, 4 PDT events and 4 Brake events were presented to the participant. No stimuli were presented at 2 of the 10 locations on each lap in order to prevent the participants from learning the 10 locations after 5 laps. A map of the test track, with the 10 stimuli presentation locations marked is presented in Appendix F.

One other issue regarding the placement of the outside events was the fact that they had to be timed in coordination with the timing of the "operate" tasks. If the participants were presented with the outside stimuli between DVD operating tasks, the effects of the DVD tasks on their performance would be lost. Participants were read instructions for each "operate" task at a specific location on the track, chosen so that it was likely they would still be operating the DVD player when they passed one of the event presentation locations.

EXPERIMENTAL DESIGN AND ANALYSIS

Block Design

The experiment was designed to reduce the effects of learning by blocking for the run order of each treatment for each participant. Of the 5 laps around the track, the first lap was always a control lap where no interaction of the DVD player was required. While not necessarily treated as practice, for the first lap the experimenter interacted more with the participant than on the other 4 laps. Feedback was given verbally by the experimenter indicating that the finger button responses were received, and there was some instruction regarding one small section of the course with 2 large dips in the road where it was necessary to slow the vehicle below 40 mph.

After the first lap, the next two laps each had a DVD task included. Two of the three DVD tasks (listen, watch, operate) were used in laps 2 and 3. Lap 4 functioned as another control loop, this one being treated like another treatment, with no mention of practice. Data from this lap was used as baseline data. Lap 5 asked the participants to perform the third of the DVD-related tasks.

After Lap 5, the participant followed the lead car off of the test track and back to the staging area. During this time the participant was asked the four content comprehension questions if they drove Lap 5 under the Watch or Listen condition. Once back at the staging area, the participant was paid and given the Post-drive Questionnaire to complete on the drive back into town. The Post-drive Questionnaire is located in Appendix E.

Data Analysis Plan

Along with the outside event detection data, velocity, brake use, and lateral acceleration data were collected to help quantify the driving performance of the participants. At the proscribed speed of 40 mph, participants could safely navigate the entire course without needing to brake for curves. Use of the brake was therefore regarded as somewhat of an "emergency response" occurring when simply letting off the throttle did not result in the necessary deceleration to comfortably navigate an upcoming curve.

Six curved locations around the track were chosen in order to analyze the lateral acceleration generated by each participant under the test conditions. These data were then scaled within-subject to determine which condition caused the largest lateral acceleration for each participant, and then aggregated over all participants.

The final measure analyzed was average longitudinal velocity. As the combination of the driving task and the DVD task became more difficult, drivers may have reduced their speed in order to maintain a comfortable level of safety. This drop in velocity may give some indication of an increased level of distraction.

EQUIPMENT

The Instrumented Vehicle used as the subject car for this experiment was a 2006 Toyota Highlander. The Highlander was ordered with both the "Tow Prep Package" (larger alternator, radiator, fan coupling,) and the "Assurance Package." The "Tow Prep Package" was ordered to increase the capacity of the alternator to power instruments in the vehicle, while the "Assurance Package" was purchased to add driver and passenger seat-mounted, and side curtain airbags, as well as an 8-way power seat in order to best accommodate test participants. The vehicle is pictured in Figure 1 below.

Figure 1: TTI Instrumented Vehicle

The principle system within the instrumented vehicle is the Dewetron DEWE-5000. Essentially a large portable computer, the DEWE-5000 served as the data acquisition device for all the peripheral systems in the vehicle. The DEWE-5000 runs an Intel Pentium 4 processor at 2.8 Ghz. It has 512 MB of RAM and a 160 GB hard disk drive. It runs the Microsoft 2000 Operating System. The data collection is done in a virtual environment within Dewesoft version 6.2, an acquisition and post processing software package made by Dewetron. The DEWE-5000 is capable of sampling at 5000 Hz. For this experiment, data was collected at 100Hz. A picture of the DEWE-5000 is displayed below in Figure 2.

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Figure 2: Dewetron DEWE-5000

The DEWE-5000 was mounted in place of the driver's-side rear seat, which had been removed. In place of the seat a wood table was built (top dimensions 56" x 16"). The DEWE-5000 was securely fastened to the table using an OEM seat-mounting kit. The table itself was secured to the vehicle using the original seat-mounting anchor points.

Also mounted to the table, near the rear of the vehicle was a Samlex 600 watt pure sine wave power inverter. This was connected to the Highlander's battery using 2 gauge wire and a 60 amp fuse. It provided two standard 120 volt, 3 pronged outlets. A 6 outlet power strip was connected to each plug on the inverter to expand out capacity to power equipment.

A Trimble DSM232 Global Positioning System (GPS) was used to track the position of the subject vehicle around the course. It employed a Differential GPS antenna which was mounted on the roof of the vehicle directly over the driver's seat. The GPS system also used the Omnistar

VBS Service in order to provide sub-meter accuracy in position data. The GPS sampled data at 10 Hz, a critical feature not available on most GPS systems. The receiver was mounted under the table holding the DEWE-5000. This receiver is displayed in Figure 3 below.

Figure 3: Quad Splitter and Trimble GPS Receiver

Three Potentiometers made by Advantage Motorsports were used to collected data on the position of the brake pedal, the gas pedal and the steering wheel.

A Crossbow Piezoresistive Accelerometer was used to collect acceleration data for 3-axis. It had a sensitivity of .6218 mV/g. The accelerometer was mounted on the same table as the DEWE-5000 behind the driver.

Video data of the experiment was collected by three cameras. One camera, facing the participant, was a 170 degree, Wide Angle Bullet Color Camera (CFC2010WA). The camera used the NTSC standard and had a resolution of 510 x 492. This camera was primarily used to determine whether the driver was watching the DVD screen or watching the road ahead. A picture of this camera is presented in Figure 4 below.

Figure 4: Windshield-mounted Driver Face Camera

An identical camera was mounted on an arm connected to the DEWE-5000 mounting table and rising up between the front seats. This camera was positioned to determine whether the participant was operating the DVD player, and if so what buttons the participants was using. A picture of this camera is presented in Figure 5 below.

Figure 5: Center-mounted DVD View Camera

A black and white Bullet Camera made by ProVideo was used as a forward scene camera. It had a resolution of 420 lines. A picture of this camera is presented in Figure 6 below.

Figure 6: Windshield-mounted Forward Scene Camera

All three cameras were run through an Appro B/W & Color Quad Processor (model number FIO-8046,) which was mounted on the same table as the GPS system. The quad splitter signal, containing the video feed from all three cameras was then fed into the DEWE-5000 through a standard RCA video plug.

The DVD player used was an Audiovox Personal DVD player with a 7" screen. The screen had an aspect ratio of 16:9 and a resolution of 480 x 234. The DVD player included a second, separate screen. This screen was mounted on the back of the passenger seat using the included mounting straps. This provided the experimenter in the back seat with a view of what the participant was seeing or hearing. While not necessary for the "watching" or "listening" task, this was helpful for the "operate" task as occasionally participants performed incorrect operations, and the subsequent "operate" instruction starting condition needed to be set up. A remote control also provided with the DVD player allowed the experimenter to operate the DVD player from the backseat.

The participants were given the option to orient the DVD player in the passenger seat in order to provide the best viewing angle. After the participant was comfortable with the position of the DVD player, it was fastened to the passenger seat with electrical tape. The DVD player is displayed in Figure 7.

Figure 7: DVD Player mounted in Passenger Seat

The DVD viewed by the participants was an animated children's program named "VeggieTales: Sheerluck Holmes and the Golden Ruler." This DVD had multiple programs and special features not all of which were used. While watching the DVD, participants were shown the short program "The Asparagus of La Mancha." For the Listen lap, participants heard the title story, Sheerluck Holmes and the Golden Ruler." For the Operate lap, participants saw and heard small clips of some of the special features. This is explained in more detail in the Operate lap script in Appendix C.

In order to study the situational awareness of the participant, a peripheral detection task was used. This was explained in the Methods section. This task was composed of a 5000mcd yellow light emitting diode (LED) hanging in the rear window being illuminated for 1 second. The participant was then asked to respond to noticing the light by pressing a small button affixed to their left index finger. The button was attached with a Velcro strap. A picture of this button is displayed below in Figure 8.

Figure 8: Finger-mounted Response Button

Another measure of the situational awareness of the driver was their ability to notice the brake lights of a lead vehicle being illuminated. This procedure was explained in the Methods section. The lead vehicle used was a maroon 2006 Ford Taurus.

RESULTS AND DISCUSSION

RESULTS

Four measures were used to compare the participants' driving performance with and without the added distraction of the DVD-based tasks: Event detection, brake use, lateral acceleration around curves and longitudinal velocity.

Event Detection

The first measure to be examined was the ability of the participant to notice outside events while driving and/or while performing the DVD-based tasks. As discussed in the Method sections, participants were presented with detection tasks both in front of them (on a lead vehicle,) and behind them (an LED mounted on the rear window). The light mounted in the rear actually functioned as a peripheral detection task (PDT) as the participant was forced to notice it in their rear-view mirror, located in a driver's periphery.

Each light (brake lights, LED) was presented 4 times on each lap for each participant, although the participants were not aware of this frequency. If either light was illuminated and the participant noticed and responded, this trial was scored as a "Hit." If the participant missed the light event, the trial was scored a "Miss." Data for each participant and their "Hit" percentages are displayed below in Table 1 and Table 2.

Table 1: Peripheral Detection Events by Participant

Participant	PDT hits	PDT possible	Hit %
1	12	19	63%
2	9	20	45%
3	9	20	45%
4	10	20	50%
5	13	19	68%
6	17	20	85%
7	4	20	20%
8	9	20	45%
9	17	20	85%
Overall	100	178	56%

From Table 1 above, one can see participants Six and Nine recorded the highest Hit percentage at 85% over all 5 laps. Participant Seven recorded the lowest Hit percentage at 20%. Overall, participants correctly responded to the PDT in 56% of trials. Two participants only saw the PDT 19 times; this was a result of experimenter error.

Table 2: Lead Vehicle Brake Light (Brake) Events

Participant	Brake hits	Brakes possible	Hit %
1	18	20	90%
2	10	19	53%
3	13	20	65%
4	17	20	85%
5	17	20	85%
6	19	20	95%
7	13	20	65%
8	14	20	70%
9	15	20	75%
Total	136	179	76%

As expected, the Lead Vehicle Brake Light event (Brake event) recorded a higher hit percentage than the PDT. This makes sense as the Brake events were presented in front of the driver where they were looking for the majority of any lap. Participant Six recorded the highest hit percentage at 95%, missing only one Brake event (this miss occurred on the Watch lap). As mentioned above, participant Six also recorded the highest Hit percentage for the PDT. Participant 2 recorded the lowest Brake event Hit percentage, noticing and correctly responding only 53% of the time. Overall, participants correctly responded to the Brake event in 76% of the trials.

When these results are broken down by the test condition for each lap, one can examine the effects of the secondary tasks on situational awareness. These results are presented below in Table 3 and Table 4.

Table 3: PDT Hit Percentages for Each Test Condition

Task	PDT Hits	PDT Possible	Hit %
Control 1	21	36	58%
Control 2	20	35	57%
Watch	18	35	51%
Listen	25	36	69%
Operate	16	36	44%

From Table 3 above, participants operating the DVD player correctly responded to only 44% of the PDT's. This was lower than for all other treatments. When a statistical test of two population proportions was performed on the data, comparing the Hit percentage for the Operate condition versus the Control 2 lap, the difference was not significant, ($z = 1.07$, $p=-.143$). When comparing the participants' performance for the PDT under the Watch condition to the Control 2 condition, overall a smaller percentage of hits were recorded. However, the difference was not significant ($z=.48$, $p=.32$). In the case of the Listen condition, the opposite effect was found. Participants actually noticed *more* of the PDT lights under the Listen condition than they did during the Control 2 lap. This difference was not significant either ($z=-1.08$, $p =.14$).

Interestingly, participants performed significantly better on the PDT task while listening to the DVD-based program than they did while operating the DVD player (z=2.21, p=.01,) or watching the DVD-based program (z= 1.71, p=.04).

Table 4: Lead Vehicle Brake Light (Brake) Event Hit Percentages for Each Test Condition

Task	Brake hits	Brakes possible	Hit %
Control 1	23	36	64%
Control 2	29	35	83%
Watch	27	36	75%
Listen	30	36	83%
Operate	27	36	75%

Table 4 above presents the results from the Brake event for each condition. Results across the different test conditions were very similar with the exception of the Control 1 condition. Participants on their first lap (Control 1 condition) noticed significantly less Brake events than participants on the Control 2 lap (z=1.85, p=.03,) and participants under the Listen condition (z=1.91, p=.03). Again, outside of the Control 1 condition, the Watch condition and the Operate condition received the lowest Hit percentages.

Response times were also recorded for the Peripheral Detection Task events. This data is presented below in Table 5 and Table 6.

Table 5: Response Times to Peripheral Detection Task Events for Each Participant.

Participant	PDT hits	PDT Reaction Time (s)
1	12	1.45
2	9	1.46
3	9	0.94
4	10	1.67
5	13	1.47
6	17	1.24
7	4	1.98
8	9	1.19
9	17	1.22
Overall	100	1.35

Table 5 above presents response times to the PDT events. Overall, the average response time to a PDT event was 1.35 seconds. Participant Three had the shortest average response time to the PDT events, while Participant Seven had the longest average response time. The difference between the average response times for these two participants was more than a full second. Participant Seven also had the fewest Hits in regard to the PDT, illustrating that this participant had some difficulty with this task.

Table 6: Response Times to Peripheral Detection Task Events for Each Test Condition

Task	PDT Hits	PDT Reaction Time (s)
Control 1	21	1.30
Control 2	20	1.24
Watch	18	1.43
Listen	25	1.38
Operate	16	1.43

Table 6 above presents response times to the PDT events broken down by test condition. Both the Control 1 condition (M=1.30, SD=.42) and the Control 2 condition (M=1.24, SD=.45) recorded the shortest response times, while the Watch condition (M=1.43, SD = .47), and the Operate condition (M=1.43, SD = .61) recorded the longest response times. However, none of these differences proved significant. (Control 2 vs. Watch, $F(1,36) = 1.67$, $p = .20$. Control 2 vs. Operate, $F(1,34) = 1.19$, $p = .28$).

Brake Use

A second measure used to quantify the effects of an in-car DVD player on driving performance was brake use. At the proscribed speed of 40 mph, participants could safely navigate the entire course without needing to brake for curves. Use of the brake was therefore regarded as an "emergency response" occurring when simply letting off the throttle did not result in the necessary deceleration to comfortably navigate an upcoming curve. Two measures of brake use were collected. First, the overall amount of brake use over time was examined, as participants employing the brake more frequently probably had less preview knowledge of the upcoming curves, and thus were forced to brake more often. Also, brake pressure was recorded, as participants taken by surprise by the small radius of curvature of an upcoming curve would be forced to brake harder to achieve their comfortable speed through the curve.

Table 7: Total Time Applying Brake for Each Participant

Participant	Time Applying Brake (s)	Total Time (s)	% of Time Applying Brake
1	62.7	3741.3	1.676%
2	59.9	3754.9	1.595%
3	44.4	3771.5	1.177%
4	48.1	3836.2	1.254%
5	45.9	3725	1.232%
6	7.7	3964.3	0.194%
7	103.6	3837.1	2.700%
8	79.5	4014.8	1.980%
9	41.4	3766.3	1.099%

Table 7 above displays the fraction of time each participant had the brake applied over the course of all 5 laps around the track. While most participants used the brake between 1 and 2 percent of the drive, Participant Six used the brake .2% of the time, a total of only 7.7 seconds over the roughly 1 hour driving session. Participant Seven employed the brake more frequently than all other participants, using it in 2.7 percent of their drive. Overall, participants used the brake 1.43% of the total drive time.

Table 8: Average Brake Force for Each Participant

Participant	Average Brake Force
1	15.70
2	6.12
3	18.73
4	22.70
5	23.51
6	3.51
7	22.08
8	17.66
9	20.89

Table 8 above displays the average brake force for each participant over all 5 laps of their drive. Similar to the brake use frequency in Table 7 above, Participant Six used the lowest amount of force when applying the brakes. Participant Two, who used the brakes at a slightly above average frequency also used very low pressure when braking.

Table 9: Total Time Applying the Brake for Each Test Condition

Task	Total time applying brake(s)	Total Time (s)	Percent of time with brake use
Control 1	75.1	7034	1.068%
Control 2	78.3	6731.3	1.163%
Watch	121.2	6907.4	1.755%
Listen	85.8	6871.6	1.249%
Operate	132.8	6867.1	1.934%

Table 9 above displays the fraction of time the brake was used over each test condition. The Control 1 test condition (M=1.068%, SD=.84%) saw the lowest frequency of brake use over all participants, with the brake being used only 1.068% of the time on Control 1 laps. The Operate condition (M=1.934%, SD=1.65%) and the Watch condition (M=1.755%, SD=1.04%) elicited the highest frequency of brake use. Neither of these percentages were significantly different from the baseline, (Control 2 vs. Watch, $F(1,16)=1.73$, $p=.21$), (Control 2 vs. Operate, $F(1,16)= 1.57$, $p = .23$).

Table 10: Average Brake Force for Each Test Condition

Task	Average Brake Force
Control 1	12.86
Control 2	13.48
Watch	13.73
Listen	14.09
Operate	13.27

Table 10 above displays the average brake pressure over all drivers for each test condition. Similar to the data in Table 9, participants in the Control 1 lap applied the least pressure on average when using their brake. Inconsistent with the brake use data, participants under the Listen condition applied the most pressure to the brake pedal when they chose to use it.

Lateral Acceleration

Six curved locations around the track were chosen in order to analyze the lateral acceleration generated by each participant under the test conditions. Because each location recorded different magnitudes of lateral acceleration, in order to compare between each test condition, the lateral acceleration values had to be scaled to each location's average lateral acceleration. For example, Location 1 of 6 recorded lateral accelerations smaller than those for the other locations. Thus, lateral accelerations for Location 1 for each participant for all laps was averaged together to determine the average way in which each participant passed each location. Then, the individual lateral accelerations recorded at each location were scaled for each participant. If Participant One's average lateral acceleration for all laps through Location 1 was .5 g's, then .5 g received a scaled value of 1 for that participant at that location. If then, Participant One on a given loop passed through this location and recorded a lateral acceleration of .75 g's, this would receive a scaled value of 1.5.

Table 11: Average Scaled Lateral Accelerations for Each Test Condition

Task	Average Scaled Lateral Acceleration
Control 1	0.927
Control 2	0.964
Watch	1.020
Listen	0.992
Operate	1.098

From Table 11 above, one can see that the three DVD-based test conditions recorded the highest average scaled lateral accelerations over all participants. Average scaled lateral accelerations recorded under the Operate condition (M=1.098, SD=.47) proved to be significantly higher than those recorded under the Control 1 condition (M=.927, SD=.30), (F(1,106)=5.07, p =.03) and marginally higher than those recorded under the Control 2 condition (M=.964, SD=.30), (F(1,106)=3.16, p=.08).

Average Velocity

Average velocities were calculated for each lap for each participant. These data are displayed below in Table 6.

Table 12: Average Velocities for Each Test Condition

Task	Average Velocity (km/hr)
Control 1	63.7
Control 2	66.0
Watch	64.2
Listen	64.7
Operate	64.5

From Table 12 above, participants drove with the highest velocity under the Control 2 condition (M=66.0, SD=1.7), and with the lowest velocity under the Control 1 condition (M=63.7, SD=2.9). Under the Watch test condition (M=64.2, SD=1.6), participants drove significantly slower than under the Control 2 condition (F(1,16)=5.46, .03). Under the Operate condition (M=64.5, SD=1.8), participants drove marginally slower then under the Control 2 condition (F(1,16)=3.15, p=.09).

Content Comprehension Questions

At the end of both the Watch and Listen laps, participants were asked 4 questions relating to the content of the program they had just watched or listened to. This was explained to the participants in advance in order to provide encouragement to pay some level of attention to the programs.

Table 13: Results of Content Comprehension Questions

	Number Correct out of 4	
Participant	"Watch" Lap	"Listen" Lap
1	4	4
2	4	4
3	4	4
4	0	1
5	3	2
6	2	1
7	2	2
8	2	1
9	4	4
	2.8	2.6

Table 13 above displays the compiled results of the Content Comprehension Questions. Four participants correctly answered all 8 questions (participants 1,2,3 and 9). One participant answered all four questions incorrectly regarding the program presented during the Watch lap, and answered only 1 question correctly regarding the program presented during the Listen lap.

Participant Glance Information

During the Watch lap, participants were encouraged to watch the DVD in order to be able to answer questions about the content at the end of the lap. This motivation had varying levels of success. Table 14 below displays the participant glance data. Participant 8 spent far more time with their eyes off the road than all other participants, watching the DVD screen for roughly 31% of the 13.6 minute Watch lap. In contrast, Participant 4 glanced at the DVD player only once throughout the Watch lap. Participants 1, 2 and 3 watched the DVD more than all other Participants after Participant 8. On average, participants watched the DVD 15% of the time.

Table 14: Participant Glance Data

Participant	Time with Eyes on DVD (s)	Total Time (s)	Percent of time w/ Eyes on DVD
1	170	774.1	22%
2	129	750	17%
3	174	754.4	23%
4	2	742.9	0%
5	92	770.1	12%
6	99	776.5	13%
7	99	771.2	13%
8	251	816.3	31%
9	48	751.9	6%
Mean	118.2	767.5	15%
Std. Dev.	73.7	21.9	

Post-Drive Questionnaire

Question 1: Task Difficulty

Participants scored the difficulty of driving safely while interacting with the DVD on a Likert Scale ranging from 1-7, with 7 representing “very difficult” and 1 representing “very easy,” Driving safely while watching the DVD was rated as the most difficult, receiving an average score of 3.8. All but one participant rated this condition as the most difficult. This data is presented in Table 15 below.

Table 15: Subjective Ratings of Difficulty of Driving Safely While Interacting with DVD Player.

	How difficult was driving safely while…..		
Participant	listening to the DVD?	watching the DVD?	controlling the DVD?
1	4	6	6
2	2	3	3
3	2	5	3
4	3	4	3
5	4	3	2
6	6	6	4
7	1	1	1
8	3	3	3
9	1	3	6
Mean	2.9	3.8	3.4
Std. Dev.	1.6	1.6	1.7

Question 2. Alertness

Participants were asked to rate their alertness before the drive and after on a Likert Scale ranging from 1 to 7. A score of "1" indicated that the participant was "Very Alert," while a score of 7 indicated that the participant was "Very Drowsy." Four participants became less alert by the end of the drive, while 3 participants became more alert. Participant 4 exhibited the largest change in alertness going from a 1 at the beginning to a 5 after the drive; the task must have been more tiring to them than the other participants. Overall, participants were slightly less alert at the end of the drive.

Question 4: Task Interferences

Participants were asked to rank the four test conditions (watch, listen, operate, control) based on how much the task affected their driving performance. This data is displayed in Table 16 below.

Table 16: Subjective rankings of the Difficulty of Driving Safely While Interacting with the DVD Player

Part.	Your ability to maintain the appropriate speed… Listening to a DVD	Watching the DVD	Controlling the DVD	NO DVD task	Your ability to maintain the appropriate position in your lane… Listening to a DVD	Watching the DVD	Controlling the DVD	NO DVD task
1	4	1	1	4	4	1	1	4
2	3	3	2	4	3	2	2	4
3	3	1	2	4	3	1	2	4
4	3	1	2	4	3	2	1	4
5	3	1	2	4	3	1	2	4
6	2	1	3	4	3	1	2	4
7	4	2	2	4	4	3	2	4
8	2	1	3	4	3	2	1	4
9	3	2	1	4	3	2	1	4
Mean	3.0	1.4	2.0	4.0	3.2	1.7	1.6	4.0

Part.	Your ability to remain attentive to outside events… Listening to a DVD	Watching the DVD	Controlling the DVD	NO DVD task
1	4	1	1	4
2	4	2	2	4
3	3	1	2	4
4	3	1	2	4
5	3	1	2	4
6	3	1	2	4
7	4	2	1	4
8	3	1	2	4
9	3	2	1	4
Mean	3.3	1.3	1.7	4.0

These ratings illustrate the effects the interaction with the DVD player had on drivers. For example, watching the DVD hindered drivers the most in their ability to maintain the correct speed. Watching the DVD was also rated the worst when it came to remaining attentive to outside events. In general, participants felt that watching the DVD made it the most difficult to maintain their speed and notice outside events, while operating the DVD had a greater effect their ability to maintain their lane position. Listening to the DVD had the smallest effect on all three driving performance measures considered here.

RESULTS INTERPRETATION

This study had three primary objectives: First it was meant as a pilot study to determine the feasibility of running a more comprehensive research project at a newly acquired facility in a rural location. Second, this study was used to evaluate a newly assembled instrumented vehicle in terms of general functionality, ease of data collection and ease of data analysis. Third, this study hoped to find a relationship between in-vehicle DVD use and driver performance.

Initially this study was planned to include 12 participants, but because of the newness of the research program in Pecos, Texas, there was difficulty filling 12 slots. Only 10 participants were recruited and run (including a pilot subject,) which limited the prospects of statistically detecting small differences in the data.

Data was recorded at 100Hz in order to collect as much data as possible without overwhelming our storage capacity. When analyzing the data it proved much more manageable when the files were cut down to 10Hz. A macro was used to pare down the data automatically. While 10Hz seems adequate to examine the measures of interest in this study, collecting video requires storing data at at least 30Hz. Because of synchronization issues, it was determined that storing data at 100Hz provides the most reliable video collection, while not overloading the storage space we had allotted.

Ideally, along with the data collected, data on Brake event reaction time, and steering reversals would have also been collected. Brake event reaction time could not be determined because no mark was made in the data at the point the brake lights became illuminated. The video coding, (where the event time would be determined simply by seeing the lights illuminate in the forward scene video,) proved too difficult based on a number of factors explained in the Lead Vehicle Brake Light Event Reaction Times section below. In the future, a sensor could be spliced into the brake light power source and could transmit a signal via wireless communication back to the DEWE-5000 when the voltage rises in the brake light wire. This would insert a mark in the data at the point where the stimuli was activated, and with that data and the existing system in place, Brake event reaction times could be collected.

Also, steering reversals may give some indication of the level of mental workload being experienced by the driver. A potentiometer was in place to record the position of the steering wheel, but proved unreliable as it was unable to hold calibration. Throughout each participant the steering wheel zero position continually changed, making it impossible to determine the actual steering wheel position at any given time. Steering reversals could potentially be coded from the face camera video, but it would likely be extremely labor intensive and may not prove anything in the end as the DVD is more likely to lead drivers to be distracted than mentally overloaded. In the case in which a driver did feel that the mental demands were too great, they could simply neglect the DVD for a few moments in order to relax the situation. Regardless, in the future a more reliable method of collecting steering wheel position will be determined.

One issue that proved difficult was standardizing the level of interest in the DVD programs across all participants. Obviously, because this experiment was performed in a real vehicle, safety must be the first priority. Because of this, the motivation given to the participants to encourage them to intently watch the DVD while driving cannot be so compelling that they jeopardize their safety. On the other hand, the motivation must be compelling enough that they do indeed watch (or listen) to the program as if they were actually interested in the content. For this study, participants were told they would be asked questions relating to the content of the programs (for results see Table 13). While initially this seemed adequate, some participants clearly showed more interest in watching the DVD program than others. A review of participant glance data showed that at least one participant paid almost no visual attention to the DVD video. Subsequently this participant answered all 4 content comprehension questions incorrectly. While further prodding by the experimenter located in the subject vehicle was considered to further motivate participants to watch the DVD, it was not employed as it may have encouraged the participants to compromise their safety.

After analyzing the glance data, it is clear that participants had varying levels of motivation to watch the DVD video, with one participant watching the video over 30% of their drive, and another only looking at it once. This makes the analysis of drivers watching DVD's more difficult, because of the introduction of the variable amount of attention paid to the screen. When the glance data is compared to the responses from the content comprehension questions a slight correlation can be seen between the amount of time a participant watches the DVD, and their success answering the questions. Participants 1, 2 and 3 answered all questions correctly, and also watched the DVD more than all but one participant. Participants 4, 5, 6 and 7 watch the DVD less, and also answered fewer questions correctly. This validates the level of difficulty of the questions, and indicates that the response accuracy was somewhat sensitive to the proportion of the DVD program each participant watched. In the future, perhaps low scores on the content comprehension questions could be a signal that a given participant failed to watch the DVD intently enough to provide valid data.

The definitions of driver distraction included in the Introduction share the concept that distraction comes when the driver's attention is deliberately shifted somewhere other than on the driving task. In a real-world case where a driver is watching or listening to a DVD, they would likely be compelled by the suspense or excitement in the program simply because it would likely be of interest to them. In this experiment, the program wasn't necessarily something of interest, and so the degree to which the participant was actually compelled to divert attention away from the road was potentially only a function of their desire to correctly answer the questions presented at the end of the lap. As evident from the glance data and the content comprehension question responses, this desire was widely varied across the participants.

PDT Event Hit Percentage

Participants on average noticed only 56% of the lights for the rear peripheral detection task and 76% of the lead vehicle brake light events.

In relation to the PDT Hit/Miss percentage, the lower Hit percentages recorded for the "operate" and the "watch" laps were to be expected. Drivers motivated to occasionally look toward the DVD player were clearly more likely to fail to notice lights flashing ahead of or behind them. However, neither of these differences in PDT Hit percentage (between the Operate lap or the Watch lap and the Control 2 lap) was significant. This is partly a result of the unexpectedly small sample size.

On the surface it would appear that the relatively high Hit percentage for the Listen laps was due to some anomaly, but after observing the participants, it may be that the presence of the auditory task actually kept the participants more alert than in the absence of any secondary task (in the control laps).

When examining the effect of run order on the PDT Hit percentage no trend was found. The Hit percentages were very similar (58.3, 57.1) for the "control 1" and "control 2" laps, (laps 1 and 4 for all participants).

Lead Vehicle Brake Light (Brake) Event Hit Percentage

Similar results were found for the Brake event Hit percentage as were found for the PDT event Hit percentage. For this measure the "control 1" lap actually recorded the lowest Hit percentage. Consistent with the PDT results, under the "watch" and "operate conditions, participants again scored a lower hit percentage than under either the "listen" condition or the 'control 2" condition.

The first lap was regarded as somewhat of a practice lap. While the experimental protocol was the same as for the four following laps, participants needed time to acclimate themselves to the research procedures, possibly resulting in some missed Brake events.

Some run order effect was observed for the Brake events. The first lap, (always the "control 1" lap) which was treated as a practice lap, recorded the lowest scores for this measure. The trend doesn't hold once the other test conditions are introduced. This may be affected by the fact that the smaller than expected participant pool caused the experiment to become slightly unbalanced, with more of the participants experiencing the "operate" test condition on the final lap than any other lap. As participants scored poorly by this measure under the "operate" condition, the run order effect was artificially diluted with more low scores from the "operate" condition being posted on participants' fifth lap.

PDT Event Reaction Times

As expected, in the presence of a DVD task, participants responded slower on average to the PDT events, although not significantly slower. Despite having the highest Hit percentage of any condition including both "control" conditions, the "listen" condition had a slower reaction time than both "control" conditions. This could be because while they were not visually distracted (causing them to miss the light altogether,) mentally they could have been immersed in the DVD program, resulting in a delayed simple reaction time when pressing the response button.

Lead Vehicle Brake Light Event Reaction Times

No reaction times were recorded for the Brake events. While the participants' responses were coded into the data files, the exact time at which the brake lights were activated could not be determined.

Initially, it was planned that the Brake event reaction times could be coded from the forward scene video simply by watching the video and recording the time at which the lead vehicle brake lights became illuminated. This was successful in pilot testing on a flat track under low light conditions. When the experiment was performed at the actual test track though, a couple factors interacted to make this coding method infeasible. Primarily, the bright sunlight we saw at the track in West Texas, especially when the sun was at lower angles (morning, evening,) washed out the brake lights on the video. In pilot testing, using a monochromatic camera, these lights showed up well, but the system was only tested in limited light conditions. Also, the separation used in the pilot testing between the lead vehicle and the subject vehicle proved insufficient for the Pecos Test Track, and had to be lengthened. This effectively reduced the size of the brake light image on the camera, making it more difficult to discern whether or not the light was illuminated. For this reasons, only Hit/Miss data is provided for the Brake events at this point.

Braking

Two measures examined in this experiment were the frequency and amplitude of brake pedal use. It was hypothesized that a participant would be more likely to hit the brake more frequently and with greater amplitude when they are paying less attention to the road ahead. This was especially true on this specific test course, with many sharp curves, and few visual cues to give drivers warning far in advance. While it was possible to navigate the entire course at the prescribed 40 mph without braking, this required the full attention of the driver in order to anticipate upcoming curves (and their radii,) and decelerate appropriately. The lead vehicle driver never applied the brakes when entering a curve as that would give a cue to the participant to brake even though they may not have found it necessary on there own.

On average drivers used their brake 1.43% of their total drive time over all drivers and all laps. As expected, drivers under both the “watch” and the “operate” test conditions used their brakes more often than driver under the “listen” condition, and drivers under the “control” conditions. Again, due to the small sample size no significant differences were found between conditions.

Average brake pedal displacement proved to be less predictable than brake use as the listen condition received the largest average brake pedal displacement. The “watch” condition received the second highest average displacement.

The unexpectedly smaller average brake pedal displacement for the “operate” condition is likely due to the fact that drivers under the “operate” condition were not constantly operating the DVD player. While they were told to be ready at any time to take instructions for the DVD operations, at some points in the course on turns that were likely to elicit braking the participants were performing no task and consequently showed no increase in brake pedal displacement overall in comparison to the “control 2” lap.

Lateral Acceleration

The lateral acceleration results collected seem to again confirm that drivers’ performance declines when using a DVD player while driving. Drivers on both the “watch” and the “operate” laps both recorded average scaled lateral accelerations over the 6 curves of interest larger than those recorded on the “control 2” lap. Again, this illustrates that drivers under these conditions likely did not have complete preview knowledge of the degree of curvature in the upcoming road segment, and subsequently took the curves faster under the more distracting conditions.

Average Velocity

Participants' average velocities over each lap again confirm that interacting with the DVD player affects driving. While all participants drove faster on their Control 2 lap (fourth lap) than on their Control 1 lap (first lap), participants reduced their speed on the laps where they were asked to watch or operate the DVD player.

GENERAL DISCUSSION

All four performance measures examined show some performance decrement when interacting with a DVD player while driving. While the event detection results did not show a significant difference between distracted participants and non-distracted participants, a small difference was observed. Collecting data from more test participants would likely make the differences clearer.

As evident from the braking and lateral acceleration data, participants operating or watching the DVD player while driving had less preview knowledge of upcoming curves, resulting in more braking and potentially dangerous higher lateral accelerations. This illustrates the fact that interacting with a DVD player not only makes a driver less likely to notice unexpected events, it also makes drivers more likely to perform in a way that could lead to roll-over and run off the road crashes.

Although some performance decrements were found when participants were interacting with the DVD player, they may only be an underestimation of the actual effects of using a DVD player while driving. Using the threat of a quiz at the end of their drive did motivate most participants to pay some attention to the DVD program. However, if a driver was watching a program that they were actually interested in, especially one with a high level of suspense or action, they may show an even larger decline in driving performance as they would likely be even more distracted and engrossed in their program.

While 35 states have taken action to prohibit the viewing of video screens by drivers, these results should demonstrate to all legislators the dangers of allowing drivers to distract themselves to this extent through watching as well as simply operating a DVD player in their vehicles.

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APPENDIX A: PRE-DRIVE DRIVER DEMOGRAPHICS QUESTIONNAIRE

PRE-DRIVE QUESTIONNAIRE Subject #__________

DEMOGRAPHICS

1. Sex: ☐ Male ☐ Female Birth date: ______________

DRIVING HISTORY

2. How long have you been driving? ______________________________________

3. How often do you drive a motor-vehicle?
   - ☐ A few times a year
   - ☐ A few times a month
   - ☐ A few times a week
   - ☐ Once a day
   - ☐ Several times a day

4. How often do you use a cell phone or other electronic device while driving? (not counting in-dash radio/stereo/CD player)
   - ☐ A few times a year
   - ☐ A few times a month
   - ☐ A few times a week
   - ☐ Once a day
   - ☐ Several times a day

5. What make and model of vehicle do you normally drive? _____________________

6. Do you ever use a DVD player in your vehicle? (Circle one) **YES** **NO**

7. How alert do you feel right now? (Circle a number on the scale below)

Very Alert 1 2 3 4 5 6 7 Very Drowsy

8. Do you have any thought on the use of electronic devices such as cell phones or DVD players while driving?

____

____

APPENDIX B: SCRIPT OF INSTRUCTIONS FOR PARTICIPANTS

First I'd like you to make yourself comfortable (mention 8 way seat). *After you get your seat adjusted, put your seat belt on and take a minute to adjust your mirrors. We don't expect any other traffic out here today, but we'd like to try to make this vehicle as much like your everyday car as possible.*

(Attach finger button) *Put this button on your finger. I'll explain what I want you to do with it in just a minute.*

Today, I'm going to ask you to drive 5 times around a roughly 10 mile course. For the experiment today, I'd like you to try to keep your speed around 40 miles per hour. There will be some curves that will likely force you to slow down below 40, but once back in a straightaway; I'd like you to try to get back to around 40 miles per hour. Also, despite the fact that there no lines on the road, I'd like you to do your best to stay within an imaginary "lane" on the right half of the road.

While you drive there are a few things I want you to pay attention to. I added these tasks to try to make you pay attention to your surroundings even though we're on an isolated test track.

First, throughout your drive today, you will be following that car right there (point to lead vehicle*). From time to time, the driver of that vehicle will momentarily apply the brakes. Don't worry, they would never press the brakes if you were close behind them, and when the brakes are pressed it will only be to flash the lights, not to slow the vehicle. When you see the brake lights flash, I want you to press the button on your finger to indicate that you noticed the lead vehicle start to brake.*

Now, I'd like you to look in your rear-view mirror. Do you see that light illuminated? (**Flash light**) *Another way in which I'm trying to see if you're paying attention to your surroundings is by occasionally flashing this light in your rear-view mirror. When you see this light, I'd like you to press the little button on your finger.*

Remember, for both of these tasks, I'd like you to respond, by pushing the finger button as soon as you see either light.

I will ask that you do these two tasks on all 5 laps around this track.

Additionally, for each lap around the track, you're going to be using this DVD player while you drive. At this point I'd like to make clear that while we'd like you to try to perform these DVD tasks, I always want you to put safe driving first. If at any time you don't feel safe performing any of the tasks I ask of you, simply tell me and we'll move on.

On one of the laps today, you will be driving while watching a short video clip of a DVD while you drive around the track. Obviously you will be trying to split your attention between the video and the road. But to make sure you are paying attention to the DVD, I'm going to ask you some questions about the movie at the end of each lap.

Today, as I said before we will drive 5 laps around the course (stopping shortly between laps). On two of the laps, I will simply ask you to drive around the track, with no DVD player, and just try to respond to all the light as quickly and accurately as possible. On one of the laps, as I said before, I will be asking you to watch a DVD movie and answer some questions about it. On another lap, you will be only listening to a DVD movie clip and answering some questions, and finally on one lap you will be performing some basic DVD functions like fast-forwarding or pausing the movie. **(DVD operations demo**)

(**drive to start line**)

For the first lap you drive around the course there will be no DVD task, but I still need you to try to respond to the brake lights in front, and the small light behind you.

At this point I'm going to have the lead vehicle open about 100 feet of space in front of you.
(Radio lead vehicle to move forward (some pavement mark at spot))

This is roughly the following distance I'd like you to try to keep. The lead vehicle driver knows this and will be working with you to try to keep the following distance at about this far.

APPENDIX C: OPERATE LAP SCRIPT OF TASKS

site	landmark	Operation
0	Start	*Turn on the DVD player*
1	Rock before 55	(At "minionites") *Press menu to access the main menu* *When menu pops up, select favorite scenes*
2	yellow plant before 55	(at backwards sign after dots) *Can I have you play scene 5?* (at first words) *Actually, can I have you play 6?*
3	green plant after 45	(@45 mph (left arrow)) *Can I have you press back once, and then forward to start scene over?*
4	backwards sign between dips	*Can I have you press back and then forward again, and turn up volume?*
5	red sign	(@backwards sign) *Press menu, play favorite scenes, play "#1, bob's letter"*
6	second red sign on way back	(With second red sign in view) *Press pause* (wait 5 seconds) *press play*
7	bypass pavement change	(with bypass in view) *Can I have you go to menu and play the bonus features*
8	40mph	(with black/white road in view) *Okay, go back to the main menu, select favorite scenes*
9	under stoplight	(@45 (right arrow)) *Can I have you select scenes 7 through 12?*
10	white triangle	(right after stoplight) *Can you play scene #10, titled Dr. Watson's surprise*

APPENDIX D: CONTENT COMPREHENSION QUESTIONS, ASKED AFTER WATCH AND LISTEN LAP

After "Watch" lap

Q. The clip begins with Don having a dream. Does he have a good dream or a bad dream?

A. Bad dream

Q. What game does Don and Pancho play a couple times in the video clip?

A. Checkers

Q. Early in the clip, a pea comes into the restaurant with "terrible news." What is this news?

A. Another restaurant is opening across the street

Q. Later in the clip, a man walks into the restaurant to ask Pancho something. What does he ask Pancho?

A. If he wants a job in the new restaurant

After "Listen" lap

Q. Who were the two main characters in this clip?

A. Sheerluck Holmes and Dr. Watson

Q. What problem do they have between them throughout the clip?

A. Sheerluck takes all the credit and doesn't appreciate Dr. Watson's help

Q. Later in the clip, the Golden Ruler is stolen, but earlier in clip, what is also stolen?

A. The Golden Key

Q. Where was the Golden key and the Golden ruler stolen from?

A. Buckingham Palace

APPENDIX E: POST DRIVE QUESTIONNAIRE

POST-DRIVE QUESTIONNAIRE SUBJECT #____________

1. **How difficult were the tasks you just performed? (Circle the number that best represents the experience you just had)**

A. Driving safely while listening to the DVD-based program

Very Easy 1 2 3 4 5 6 7 Very Difficult

B. Driving safely while watching the DVD-based program

Very Easy 1 2 3 4 5 6 7 Very Difficult

C. Driving safely while controlling the DVD player

Very Easy 1 2 3 4 5 6 7 Very Difficult

2. Fatigue

A. At the beginning of the experiment, you rated your alertness level, please rate that level again now on the following scale

Very Alert 1 2 3 4 5 6 7 Very Drowsy

3. Which of the following would you feel comfortable doing while driving you own vehicle? (Circle YES or NO for each of the following)

A. Listening to a DVD-based program with the screen out of view. YES NO

B. Watching a DVD-based program with a screen in the front seat. YES NO

C. Controlling a DVD player for passengers in the back seat. YES NO

4. Effects on Driving

Rank the tasks you performed earlier from 1-4 based on their effect on the following driving behaviors. A rank of "1" means that this task had the largest effect on the specific performance measure. A rank of "4" means that the task had the smallest effect on the specific performance measure.

A. Your ability to maintain the appropriate speed

Listening to the DVD ________
Watching the DVD ________
Controlling the DVD ________
NO DVD task ________

B. Your ability to maintain the appropriate position in your lane

Listening to the DVD ________
Watching the DVD ________
Controlling the DVD ________
NO DVD task ________

C. Your ability to remain attentive to outside events

Listening to the DVD ________
Watching the DVD ________
Controlling the DVD ________
NO DVD task ________

5. Had you ever seen a Veggietales program before?

Yes No Maybe, but only a little bit

APPENDIX F: MAP OF TEST TRACK AT PECOS RTC