Comparison of Teen Cell Phone and Passenger Conversation

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Abstract

Many states in the U.S. have begun to implement graduated licensing systems to reduce beginner driver crashes. Graduated licensing limit exposure to high risk conditions such as night-time driving and having multiple teen passengers, for the first six months to two years after their 16th birthday. Previous literature on driver distraction has shown that driver’s cell phone use produces higher risk than in-vehicle conversations. This study assessed the joint effects of these two factors: cell phone use and inexperience. It also compared distraction due to cell phones and due to in-vehicle passengers.

The study used a fixed base driving simulator with a 165° field of view to measure newly-licensed 16 year olds’ driving performance while talking on cell phones and also while talking to passengers within their vehicle. Continuous data on lane position as steering and pedal inputs were collected in baseline and emergency scenarios. Emergency response scenarios included sudden braking by a lead vehicle, a pedestrian stepping off the curb, and a car pulling out of a blind driveway. Situational awareness scenarios include amber traffic signals, a rear-approaching emergency vehicle, and construction work zone lane closures. University students, close in age to the participants, served as conversation partners both on the phone and in the vehicle. The paper describes the scenario development process and the challenges of data reduction and scoring. Data from nine pilot subjects are presented and illustrate some of the unique challenges of working with teen drivers who have highly idiosyncratic driving habits.
Introduction

Studies show that young drivers, specifically 16 year olds who have just received their licenses, are more likely to be involved in a crash than experienced drivers and even older teenagers. Many states in the US have begun to implement graduated licensing systems to reduce beginner driver crashes. Graduated licensing is used to expose beginners to the driving experience by removing or decreasing high risk conditions such as night-time driving, unsupervised driving, and multiple teen passengers for the first 6 months to 2 years after their 16th birthday.

There have also been extensive studies on the use of cell phones and their negative effects on a driver’s performance. These studies have also shown that the cell phone use of a driver produces a higher risk than in-vehicle conversations. The combination of cell phone use and inexperienced drivers may create an even higher risk of crashes.

Since the introduction of graduated licensing in the US, crash reductions have been reported in several states using the system. As mentioned above, one criterion that is often used is limiting the number of non-family teen passengers in the vehicle with a novice driver. If there is concern that this type of in-vehicle interaction between teens is a high risk, then cell phone use by a novice driver may produce the same or even higher risks. This study compared these two types of driving situations and will inform policies on prohibiting cell phone as an appropriate recommendation to a graduated licensing program. The state of Texas recently enacted legislation prohibiting use of any wireless communication device during the 6 month probationary license period for novice drivers.

The study described here primarily served as a pilot study to establish institutional approval for the methods used. It also provided a manageable-sized data set with which to develop analytic methods and scoring criteria for driving performance. This paper details the procedural and analytical challenges faced and should provide researchers with lessons-learned from our laboratory.

Method

Participants, Recruiting and IRB requirements – Unique challenges with teens

Prior to the study recruitment, the research team obtained study approval from the University’s Institutional Review Board (IRB) for Ethical Treatment of Human Research Participants. The application required special consideration due to the involvement of minors. It was decided to require a parent to accompany their child to the session. The

parent was also asked to drive the teen from the study in case of any unanticipated side
effects of having driven in the simulator either due to sickness or due to a shift in
perceived risk. Another IRB requirement was to have the parent first sign a parental
consent form, before the minor signs an informed consent form. Also the parent was
required to fill out a separate consent form of their own for the paper survey they would
be asked to complete concerning their own driving habits.

Participants were recruited via word of mouth and flyer distribution. The researchers
distributed flyers at social events such as church and community meetings, and among
friends and colleagues. Local driving instruction schools were also contacted, but proved
to be unproductive since we were recruiting for graduates of these programs and the
schools were unwilling to share lists of recent graduates. Recruitment for this study
proved to be unexpectedly challenging. We discovered that teenagers are hard to reach
on the phone, are irresponsible about returning phone calls. Scheduling a time
convenient to both a parent and teen also was difficult. We found that if we were able to
make initial contact with the parent, recruiting was easier as the parents liked the idea of
their children participating in a study.

Nine teen drivers participated in the study: 5 males and 4 females, all were aged 16.
Participants were required to have obtained their drivers licenses in the past 6 months
from the time of their study. Participants reported having received their licenses ranging
from 2 weeks to 5 months prior to the study.

Simulator
The study was conducted using a DriveSafety™ simulator with a 1995 Saturn SL mid-
sized sedan with full instrumentation which provides a realistic interactive driving
experience. The system includes a 150-degree wraparound visual field with high
resolution (1024x768 pixels) projectors for each of the three projection screens
positioned in front of the car. Rear and side-view mirrors are super-imposed on the scene
as picture-in-picture insets on the display screens. Research participants control the
accelerator and brake pedals and the steering wheel as they do in an actual vehicle. For
the present study, a custom driving environment was created using the HyperDrive™
Authoring Suite software.

The Driving Simulator’s integrated computer was programmed to calculate measures of
vehicle velocity, acceleration, steering, braking, lane position, x and y coordinates, time,
and collision data. An intercom system in the vehicle allowed an experimenter and the
participant to freely speak back and forth.

Conversation Development
In order to add to the comfort of the teen participants, undergraduate student workers
were used to conduct the conversations on the cell phones and within the vehicle. We felt
that the teen drivers would perhaps talk and drive more naturally with experimenters
close to their own ages. The student workers were also used to develop the questions that
would guide the topics of conversations. In development of the conversation topics, the
students were encouraged to stay away from any topics that could become too
emotionally charged or personal for the participants. The students were encouraged to
include a variety of questions that would keep the conversation rotated through quick one answer responses, to more elaborate thought-provoking or calculated responses.

During the in-vehicle passenger distraction conditions, the student worker (seated in the front passenger seat) tried to avoid any signs of anticipation of the events that would occur; although, after each event, the student could encourage the teen driver to continue and could incorporate the event into the conversation, as would happen in a real-world situation.

For the cell phone distraction condition, a hands free land-line phone device was used to simulate the cell phone. The student worker, located in a room outside of the simulator facility, would make a call to the teen driver. Since the student could not see the simulated environment, they were unaware of the events that were happening to the teen unless the teen spoke about them.

**Scenario Development**

One simulator program or “world” was created to test the three experimental conditions of no distraction, a cell phone distraction, and an in-vehicle passenger distraction. The world made a complete driving in loop consisting of two legs. Each leg contained all 7 event types (described below), but allowed for some variation in the drive to avoid anticipation of the events to come. In order to experience all three experimental conditions, each participant would drive the entire loop, experience both legs, and then after an optional break, would drive half of the loop, experiencing the third leg. The order of the three experimental conditions was counter-balanced among the nine participants, as well as the order of the various legs of the drive. This was accomplished by created two different start points along the loop.

**Measures of Effectiveness**

Seven measures of effectiveness governed the layout and scenario scripting of the simulator worlds. Figure 1 is a rough map of the worlds showing the points of interests where the different measures lay. At the points where specific events occur, the simulator records the appropriate data variables that are mentioned in the list of measures following the map.

**Event Types**

1. Baseline Driving – For each distraction condition speed, lane position, accelerator, and brake pedal values were recorded on open freeway to establish the teen’s baseline driving.

2. Emergency Vehicle Rear Approach – This segment involved a fire engine with flashing lights approaching the participant vehicle at a high speed from the rear. The vehicle could be seen in the side and rear view mirrors and remained behind the participant until they pulled over on the side of the road to let the vehicle pass. Speed, lane position, turn signal activation, and accelerator and brake pedal values were recorded from the driving simulator for further analysis.
3. Amber Light Dilemma Zone – For this scenario, as the participant approached an intersection, the traffic signal turned amber 3 seconds from arrival at the intersection. Speed, accelerator and brake pedal values were recorded to determine the participant’s reaction to the amber light.

4. Hidden Pedestrian – As the teen drove through a densely urban area with cars parked along the side of the road, a hidden pedestrian stepped out between two
parked cars and crossed the street. The participant’s braking and speed were recorded and also collision data with the pedestrian.

5. **Lead Vehicle Braking** – In a no-passing zone along a stretch of 2 lane rural road, a SUV turned in front of the participant vehicle and began travelling down the road. This lead vehicle then randomly varied its speed between 35 and 55 mph with no activation of its brake lights. The participant’s speed, accelerator and brake values were measured, as well as the driver’s headway to the lead vehicle.

6. **Lane closure** – Along a segment of urban freeway, the teen is forced into the left of two lanes to ensure that all drivers will need to make a lane change. A warning sign warns of construction ahead with the left lane closed. The detection time and distance from the closure was measured from the first of the following events: right turn signal, release of accelerator, significant turn to the right of the steering wheel.

7. **Hidden Car Pullout** – Along a segment of 2 lane rural road with a speed limit of 65 MPH, the teen drivers suddenly encountered a car that pulls out of a hidden driveway. The reaction time was determined by the participant’s speed, accelerator and brake pedal values, lane position, as well as possible collision information with the vehicle.

While the experimental drive was in session, an experimenter roughly recorded the driver’s response at each event, as well as what their conversation was at that particular moment. This was used for quick reference of the subjects’ responses without having to look at the simulator data files.

**Results**

**Baseline Driving**

Lane position and velocity during the baseline driving were compared across distraction conditions and are shown in Table 1. A repeated measures ANOVA revealed a significant effect of distraction condition on lane position. Drivers in the no distraction condition stayed more to the right of the lane line than drivers in the phone and passenger distraction conditions, but varied in their lane more. A test on the standard deviation of lane position confirmed this as a significant difference. An ANOVA was also performed on the velocity data and failed to reach significance. Foot activity on the brake and accelerator were also examined but showed no effects of distraction condition. Variation in velocity and pedal activity were also examined and no significant effects of distraction were found.

| Table 1. Lane Position and Velocity for Baseline Driving Condition |
|---------------|-----------------|---------------|-----------------|
| Lane Position (meters) | No Distraction | Phone | Passenger |
| Mean | -0.085 | -0.297 | -0.375 |
| Standard Deviation | 0.313 | 0.15 | 0.232 |
Velocity (meters/second) | Mean | 28.747 | 28.548 | 28.935  
| Standard Deviation  | 1.606 | 2.037 | 2.103  

Emergency Vehicle Rear Approach

Detection of the fire truck in the rear view mirror was determined using a strict and a lax criterion for scoring when the driver pulled the car onto the shoulder. The strict criterion required the center of the vehicle to cross the edgeline while the lax criterion only required the right tire to cross the edgeline. The time elapsed between the appearance of the emergency vehicle and when these maneuvers took place was the dependent variable. The results are shown in Table 2. The differences between these times was marginally significant (p=.08).

<table>
<thead>
<tr>
<th>Table 2. Time (sec) to Respond to Emergency Vehicle.</th>
</tr>
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<tbody>
<tr>
<td>Time to Center of Vehicle Crossing Edgeline (strict)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Time to Right Time Crossing Edgeline (lax)</td>
</tr>
</tbody>
</table>

Amber Light Dilemma Zone

The performance in the amber light task was assessed a number of ways (see Table 3). More drivers ran the light in the no distraction condition. For those who did stop, the response point was determined by examining each data file and looking for a release of the accelerator pedal which persisted to a stop. This accelerator release was taken as the time and distance of a response and deceleration and lead-in velocity were determined from that point. The response time for no distraction was significantly longer than the response times for the two distraction conditions. The lead-in velocity was also higher for the no distraction condition. These two factors may explain why more subjects ran the light; subjects were driving faster and detected signal change sooner so felt they had a chance to cross the intersection before the signal turned red.

<table>
<thead>
<tr>
<th>Table 3. Performance in Amber Light Task</th>
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<tbody>
<tr>
<td>Measure</td>
</tr>
<tr>
<td>Number who Ran Light</td>
</tr>
<tr>
<td>Response Time (sec)</td>
</tr>
<tr>
<td>Response Distance (m)</td>
</tr>
<tr>
<td>Deceleration (m/s)</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
</tr>
</tbody>
</table>
Hidden Pedestrian

This performance measure was the most difficult to score because the appropriate driving maneuver, short of striking the pedestrian, is not as clear cut. No driver in the study ever struck the pedestrian. This task certainly has real-world validity, but proved to be particularly difficult to interpret. We attempted to look at braking and swerving, but could not get good inter-rater agreement as to when drivers performed these evasive maneuvers. The most objective measure of performance was the minimum proximity to the pedestrian and is shown in Table 4. Drivers had “closer calls” with the pedestrian in the distraction conditions than in the no distraction condition.

<table>
<thead>
<tr>
<th>Closest proximity to pedestrian (m)</th>
<th>No Distraction</th>
<th>Phone</th>
<th>Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.27</td>
<td>6.25</td>
<td>5.87</td>
</tr>
</tbody>
</table>

Lead Vehicle Braking

This measure also required extensive interpretation of the data on a case-by-case basis and proved equally difficult to interpret and achieve good inter-rater agreement. Because the lead car was varying its speed between 35 and 55 mph, the standard deviation of the subject’s speed was not an appropriate performance measure. The lag time to respond to the lead vehicle’s change in speed also proved difficult to score as the choice of response (accelerator release or brake) was dependent on headway. If subjects happened to be following closely when the lead vehicle slowed, they stepped on the brake while if there was adequate following distance they would simply release the accelerator and coast. Headway by distraction condition was examined, but due to the large variance, was not significant. The large variation was due to the accordion-like nature of the lead car speed variation. Further analytical work on this dependent variable is underway.

Lane closure

The criterion for determining when the subject noticed the upcoming lane closure was either the activation of the right turn signal or the initiation of a lane change as indicated by lane position, whichever came earliest. Again, this measure required individual review of data files by two experimenters and involved some subjective interpretation in cases where the turn signal was not used. The data were highly variable, somewhat due to the uncertainty in scoring when a lane change had been initiated. Some drivers made slow, shallow lane changes without using a turn signal, while others always used the signal and made short cutting lane changes. This variable did not show any effects of distraction, but further analyses within subjects are underway. By looking at lane change driving habits in other sections of the experiment, we hope to be able to compare those to the lane closure scenario.

Hidden Car Pullout

The number of collisions with the car that pulled out was tabulated and is shown in Table 5. For those trials where there was no collision, the minimum headway between the subject’s car and the pullout car was isolated and is also shown in the table. We attempted to isolate response times by looking at steering angle, accelerator release, and
brake activation. But, as in similar variables, consistency across judges could not be assured.

<table>
<thead>
<tr>
<th>Table 5. Performance on the Pullout Car Task.</th>
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<tbody>
<tr>
<td>Closest Distance to Pullout Car</td>
</tr>
<tr>
<td>---------------------------------</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Number of Collisions</td>
</tr>
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</table>

**Discussion**

This preliminary analysis of the data suggests that distraction due to in-vehicle passengers has a more detrimental effect on driving performance than does telephone conversations. Both types of distraction are worse than having no conversation task.

The main purpose of this study for our laboratory was to develop scenarios and data analysis techniques for each of the performance measures. The full details of the statistical analysis can be found in the technical report. Due to the small number of participants, a full analysis of the order effects was not possible. Certainly one would expect some learning to have taken place and the surprise nature of some of the events (e.g. pedestrian and emergency vehicle) to have dissipated in later trials.

Several of the performance measures required interpretation of response (e.g. lane closure, emergency vehicle response) and some degree of “reading the tea leaves”. Scoring of these variables required experimenters to examine each event and try to judge when a lane change or deceleration was initiated. This type of individual analysis was very time consuming and required at least two experimenters to review each data file to assure consistency, particularly in this pilot study where performance criterion had not been established enough to automate this scoring. Applying this level of analysis to a large sample of subjects would be very costly. We hope to take the fine-grained analyses conducted on these data and develop algorithms to apply to future data sets to speed up the analysis process.

Variables with discrete behaviors were much easier to identify. In hindsight, we should have instructed participants to use their turn indicator for every lane change. This would have eliminated the judgement calls required to score the emergency vehicle and lane closure scenarios. Time of turn signal activation can easily be flagged in the data file and does not require individual review of the data file.

Overall, the participants found the study to be engaging and challenging. They did not report noticing repeating events and genuinely seemed surprised by the emergency events even on the third trial. The conversations may have served as enough distraction to mask the experimental manipulations. We initially had been concerned about the possibility that requiring so many emergency braking responses would induce simulator sickness in our participants. This was not the case with this group of participants. Experience in
other studies in our laboratory suggests that younger participants are less prone to sickness. We believe that with older (age 55 or older) drivers, many of these scenarios would produce very high rates of sickness. This will limit our ability to compare the performance of teens to mature drivers.