

Age vs. Experience: Evaluation of a Video Feedback Intervention for Newly Licensed Teen Drivers

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16 Abstract This project examines the effects of age, experience, and video-based feedback on the rate and type of safety-relevant events captured on video event recorders in the vehicles of three groups of newly licensed young drivers: <ol style="list-style-type: none"> 1. 14.5- to 15.5-year-old drivers who hold a minor school license (see Appendix A for the provisions of the Iowa code governing minor school licenses) 2. 16-year-old drivers with an intermediate license who are driving unsupervised for the first time 3. 16-year-old drivers with an intermediate license who previously drove unsupervised for at least four months with a school license <p>METHODS</p> <p>The young drivers' vehicles were equipped with an event-triggered video recording device for 24 weeks. Half of the participants received feedback regarding their driving, and the other half received no feedback at all and served as a control group. The number of safety-relevant events per 1,000 miles (i.e., "event rate") was analyzed for 90 participants who completed the study.</p> <p>RESULTS</p> <p>On average, the young drivers who received the video-based intervention had significantly lower event rates than those in the control group. This finding was true for all three groups. An effect of experience was seen for drivers in the control group; the 16-year-olds with driving experience had significantly lower event rates than the 16-year-olds without experience. When the intervention concluded, an increase in event rate was seen for the school license holders, but not for either group of 16-year-old drivers.</p> <p>There is strong evidence that giving young drivers video-based feedback, regardless of their age or level of driving experience, is effective in reducing the rate of safety-relevant events relative to a control group who do not receive feedback. Specific comparisons with regard to age and experience indicated that the age of the driver did not have an effect on the rate of safety-events, while experience did. Young drivers with six months or more of additional experience behind the wheel had nearly half as many safety-relevant events as those without that experience.</p>			
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EXECUTIVE SUMMARY

BACKGROUND

More than 3,100 teenagers lost their lives in motor vehicle crashes in 2010. Young drivers have higher crash risk due to inexperience, immaturity, and a tendency to engage in high-risk driving behaviors (Williams, 2003). Crash risk is relatively low when young drivers are learning to drive with an adult in the vehicle, but increases about 10-fold when independent driving begins (Mayhew, Simpson, & Pak, 2003). Six states, including Iowa, have some type of restricted minor license or school permit allowing drivers under the age of 16 to operate a motor vehicle unsupervised. While these license types limit drivers to travel between school and school related activities, little is known about how these younger drivers compare to the traditional 16-year-old driver—or how this early experience might influence their driving later. Recent studies of 16- and 17-year-old drivers in rural and suburban settings have shown that event-triggered, video-based interventions may have the potential to improve driving safety among young drivers (Carney, McGehee, Lee, Reyes, & Raby, 2010; McGehee, Carney, Raby, Reyes, & Lee, 2007; McGehee, Raby, Carney, Lee, & Reyes, 2007). One limitation of these previous studies is that they did not include a true control group, and so could not evaluate the role maturation plays in developing drivers.

OBJECTIVE

This project examines the effects of age, experience, and video-based feedback on the rate and type of safety-relevant events captured on video event recorders in the vehicles of three groups of newly licensed young drivers:

4. 14.5- to 15.5-year-old drivers who hold a minor school license (see Appendix A for the provisions of the Iowa code governing minor school licenses)
5. 16-year-old drivers with an intermediate license who are driving unsupervised for the first time
6. 16-year-old drivers with an intermediate license who previously drove unsupervised for at least four months with a school license

METHODS

The young drivers' vehicles were equipped with an event-triggered video recording device for 24 weeks. Half of the participants received feedback regarding their driving, and the other half received no feedback at all and served as a control group. The number of safety-relevant events per 1,000 miles (i.e., "event rate") was analyzed for 90 participants who completed the study.

RESULTS

On average, the young drivers who received the video-based intervention had significantly lower event rates than those in the control group. This finding was true for all three groups. An effect of experience was seen for drivers in the control group; the 16-year-olds with

driving experience had significantly lower event rates than the 16-year-olds without experience. When the intervention concluded, an increase in event rate was seen for the school license holders, but not for either group of 16-year-old drivers.

CONCLUSIONS

There is strong evidence that giving young drivers video-based feedback, regardless of their age or level of driving experience, is effective in reducing the rate of safety-relevant events relative to a control group who do not receive feedback. Specific comparisons with regard to age and experience indicated that the age of the driver did not have an effect on the rate of safety-events, while experience did. Young drivers with six months or more of additional experience behind the wheel had nearly half as many safety-relevant events as those without that experience.

INTRODUCTION

Motor vehicle crashes are the leading cause of death for teenagers in the US. More than one-third of all deaths of people ages 12-19 are caused by unintentional injury due to motor vehicle crashes (Miniño, 2010). Even though the annual number of teenage motor vehicle deaths has been on the decline for several years—in part because of the broad implementation of graduated drivers licensing—more than 3,500 teens lost their lives in 2009 (Insurance Institute for Highway Safety, 2010). The fatal crash rate for newly licensed teenagers is approximately four times the rate for drivers of all ages (Insurance Institute for Highway Safety, 2008). A number of factors, such as inexperience, immaturity, and a tendency to engage in risky driving behaviors (e.g., speeding, not wearing safety belts, being distracted or drowsy, driving at night, and driving while using drugs or alcohol) contribute to the disproportionate number of teens involved in motor vehicle crashes (Williams, 2003).

Because supervised driving with an adult in the vehicle is typically the first step toward a full driver's license, parents are usually very involved in the initial phase of their teen's development as a driver. Crash rates for supervised learners are the lowest of all young drivers (Mayhew et al., 2003). A review of the literature on parental involvement in novice driving suggests that during the supervised driving period, much of what the teen learns is basic vehicle control (Simons-Morton & Ouimet, 2006). This conclusion was confirmed in a naturalistic study that used event-triggered video to observe families during a full year of supervised driving (Goodwin, Foss, Margolis, & Waller, 2010). During this supervisory period, parents tend to limit driving to safe conditions, restrict risky behaviors, and act as an involved passenger, providing the driver with feedback regarding the driving environment. As a result, young drivers still have much to learn once they begin to drive independently. Independent driving means young drivers are responsible for more of the higher-order skills, such as scanning and decision-making, that parents may have been assisting with while being present in the vehicle (Simons-Morton & Ouimet, 2006). This may help to explain the research showing that relative to supervised driving, crash rates increase more than tenfold when young drivers first begin driving independently, regardless of the amount of supervised practice they have had (Mayhew et al., 2003).

Currently, six states have some type of restricted minor license or school permit allowing drivers under the age of 16 to operate a motor vehicle unsupervised: Kansas (15 years), Montana (15 years), North Dakota and Iowa (14 years, 6 months), South Dakota (14 years, 3 months), and Nebraska (14 years, 2 months). The restrictions accompanying these licenses, such as time of day, trip purpose, the number of passengers, seat belt use, and cell phone use, vary by state.

While early licenses have been available in some rural states for over 75 years, there is concern that such licenses result in higher crash and fatality rates, putting at risk not only these very young drivers but their passengers, and the general public as well. According to the Iowa DOT (2006), 14.5- to 16-year-old school license holders are 6.5 times more likely to receive a moving violation conviction and 11.5 times more likely to be involved in a traffic crash than drivers in the same age group who only hold an instruction permit.

A number of technical solutions to help parents monitor their young drivers are currently on the market. Some employ global positioning systems (GPS) to track location, together with data recorders that connect to a vehicle's on-board diagnostics port to record speed and other

measures. The effectiveness of one such device with the ability to provide in-vehicle auditory alerts to young drivers and/or web-based feedback to parents for speeding, sudden braking/accelerating, and non-use of seatbelts, was reported by Farmer, Kirley, & McCartt (2010). The results suggested that the device reduced risky driving behaviors with parental involvement, but that in-vehicle alerts alone did little to affect driving behavior.

Another in-vehicle system that uses event-triggered video feedback has been evaluated in two studies conducted at the University of Iowa. The first study examined twenty-five rural drivers ages 16 and 17 who had held driver's licenses for 6 to 12 months (McGehee, Carney et al., 2007; McGehee, Raby et al., 2007). Their vehicles were equipped with event-triggered video recorders for one year. Results showed that the intervention significantly reduced the rate of safety-relevant events, especially for the drivers who had the highest rates of safety-relevant events before the intervention.

The second study was similar in design but examined a group of thirty-six suburban young drivers, who were 16 years old and had held driver's licenses for less than 5 months (Carney et al., 2010). Results of this study showed again that the intervention was effective in reducing the rate of safety-relevant events. In particular, it was effective in reducing the frequency of improper turns. Results also indicated that even after the intervention ended, the frequency of events remained significantly lower than baseline driving. While it is possible that parents may use technology, particularly GPS-based systems, to monitor their young drivers and enforce restrictions on driving behavior, this study suggested that the video-based feedback can also be used to mentor teens, training them to detect hazards and targeting areas that require additional practice.

Although both of these studies showed significant benefits to this type of video feedback, due to their pre-post experimental design and with all participants receiving the intervention they could not examine the natural maturation of young drivers. In addition, while both studies showed rapid decline in safety-related events among the drivers with the most events, there was no way to compare how such events vary in relation to a young driver's development.

This study of age and experience fills several research gaps that have not been examined previously. First, unsupervised drivers under the age of 16 have never before been studied in the naturalistic driving context. Little is known about how these younger drivers compare to the traditional 16-year-old driver. Second, if a young driver has this independent experience when they obtain a traditional intermediate license, how does it affect their driving both with and without the video feedback? This study will provide data to help understand how age and experience affect young driver behavior when feedback is given and when it is not.

In particular, we examine the following:

1. The effect of video-based feedback: Relative to a control group, does the video intervention reduce safety-relevant events among—
 - School license holders (14.5- to 15.5-year-old drivers)?
 - Inexperienced intermediate drivers (16-year-old drivers who just obtained their intermediate licenses but have not driven independently)?

- Experienced intermediate drivers (16-year-old drivers who just obtained their intermediate licenses but have been driving independently with a school license for at least four months)?
- 2. The effect of age: How do the two different age groups without independent driving experience (the school license holders and the inexperienced intermediate drivers) compare, with and without the intervention?
- 3. The effect of experience: How do the inexperienced and experienced intermediate drivers compare, with and without the intervention?

METHODS

PARTICIPANTS

Ninety participants were recruited and enrolled from high schools within a 30-mile radius of the Iowa City, Iowa area. These schools include West High School, City High School, and Regina High School in Iowa City; Clear Creek Amana High School in Tiffin; Solon High School; West Branch High School; and Williamsburg High School. A map with these school districts can be found in Figure 1. Parents of ninth and tenth grade students were mailed a recruitment letter (Appendix B) providing them with information about the study. If interested, parents were instructed to contact the study team for additional details and further screening to determine their son or daughter's eligibility.

Potential participants were required to fit into one of the following categories in order to participate:

- Group 1 (32 participants) - Drivers between the ages of 14.5 and 15.5 who are obtaining a school license
- Group 2 (28 participants) - Drivers age 16 and older who are obtaining their intermediate license and who never drove with a school license
- Group 3 (30 participants) - Drivers age 16 and older who are obtaining their intermediate license and who had a school license for more than four months

Potential participants also had to be the primary driver of a vehicle and drive approximately 90 minutes per week (15 minutes/day). Parents and teens had to be fluent in English and have access to a computer on which they could view the safety-relevant events.

A total of 92 participants completed the study. Data for two participants had to be excluded from analysis. Appendix C details the circumstances of these two cases, along with those for an additional 17 participants who enrolled in the study but did not complete it. Table 1 shows the breakdown of participants whose data was included in the analyses by license group.

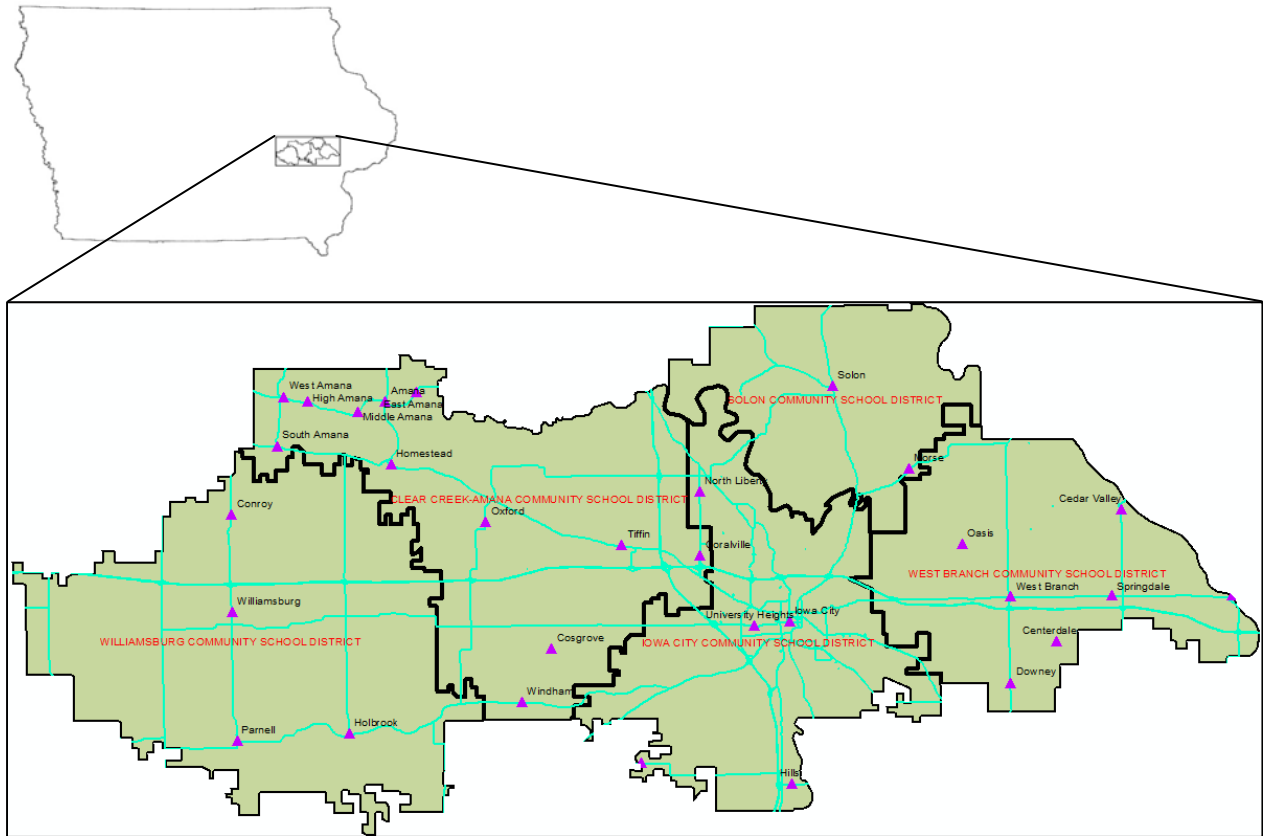


Figure 1. Newly Licensed Drivers Were Recruited From Five School Districts in East-Central Iowa: From Left to Right, Williamsburg Community School District (CSD), Clear Creek-Amana CSD, Iowa City CSD, Solon CSD, and West Branch CSD

Table 1. Participants by License Group

	Intervention	Control	Total
School Group (School License)	16	16	32
Inexperienced Intermediate Group (Intermediate License without prior School License)	14	14	28
Experienced Intermediate Group (School License before Intermediate License)	15	15	30
Total	45	45	90

INSTRUMENTATION

Each participant's vehicle was equipped with an event-triggered video recording system made by DriveCam. The system is a palm-sized device that integrates two video cameras, a two-axis accelerometer, a 12-second video data buffer, an infrared illuminator for lighting the vehicle's interior at night, and a cellular transmitter. The device is mounted on the inside of the vehicle's windshield behind the rearview mirror (Figure 2). It captures video from both inside and outside the vehicle (see Figure 3), as well as audio.



Figure 2. DriveCam Event-Triggered Video Data Recorder



Figure 3. Exterior and Interior Video View Captured by DriveCam Cameras

Video data is continuously buffered but only writes to internal memory when an acceleration threshold is exceeded. Each video clip captures the 8 seconds preceding and the four seconds following a threshold exceedance.

DriveCam uses thresholds that roughly correspond to g-forces (+/- 10 percent). These thresholds refer to accelerometer readings that reflect changes in vehicle velocity or the lateral

forces acting on the vehicle when cornering. If the acceleration exceeds the threshold value, then an event is triggered. The trigger thresholds for this research project were:

- *Shock trigger threshold:* The force level for a “shock trigger” from any direction. Shock triggers are most often caused by severe impacts. The threshold setting for this study was $\pm 1.50g$.
- *Longitudinal trigger threshold:* The force level required to trigger the system with a positive or negative acceleration. Longitudinal triggers are most often caused by hard braking. The threshold setting used for this study was $\pm 0.45g$.
- *Lateral trigger threshold:* The force level required to trigger the system with a lateral acceleration. Lateral triggers are most often caused by hard cornering or swerving. The threshold setting used for this study was $\pm 0.50g$.

Settings were determined based on the guidance and experience of the manufacturer, as well as on those used in another naturalistic driving study. In the 100-car study, Dingus et al. (2006) used $-0.5g$ as the threshold for defining hard braking and $\pm 0.4g$ as the threshold for defining rapid steering maneuvers. Our objective was to maximize the number of truly safety-relevant events captured, while reducing the number of invalid triggers to be analyzed.

All data are encrypted and automatically uploaded to DriveCam’s fleet services server on a daily basis via a secure cellular connection, usually between 2 AM and 3 AM. Once downloaded, the encrypted data are filtered to remove invalid triggers such as bumps. The data are then compiled for coding. DriveCam performs a preliminary examination of the videos to ensure that only valid triggers are being captured before these data are made available to the University of Iowa team for detailed coding (see Appendix D for coding method).

PROCEDURE

The installation of each DriveCam system was completed at the local Best Buy store and took approximately 30-45 minutes per vehicle. During installation, window clings were placed inside the vehicle (i.e., on the front passenger side window and both rear passenger side windows) in an effort to notify all occupants that there was a possibility they could be recorded (Figure 4).

The cameras were adjusted to ensure that the view inside the vehicle captured all occupants, and that the starting odometer reading was recorded. Participants were required to report their weekly odometer reading on the same day of the week on which their participation began. A reminder was sent each week via e-mail, and most participants simply responded to the e-mail.

Participants were assigned to either the intervention or control condition in blocks of two within license group. The first participant in a block was randomly assigned to one of the conditions, and the next participant enrolled in the same license group was then assigned to the other experimental condition to complete the block. This method ensured that enrollment between the two conditions was uniform throughout the study.



Figure 4. Window Cling Notifying Occupants of Video Recording

Table 2 summarizes each of the three phases of the experiment for those participants assigned to the intervention group, including the duration of each and the type of feedback provided. The participants who were assigned to the control group were in the study for the same duration (24 weeks), but were not provided with feedback from the event recorder or project staff. For them, there was no distinction as they moved from one phase of the project to another.

Table 2. Phases of the Experimental Design for Participants in the Intervention Group

Phase	Duration	Feedback Provided
Baseline	4 weeks	None
		Real-time flashing of the LED on the event recorder immediately after an event was triggered.
Intervention	16 weeks	A report card showing weekly and cumulative event frequency relative to a peer group.
		A CD containing the driver's safety-relevant videos for the week.
Follow-up	4 weeks	None

As described above, data were first collected for a four-week period to establish a baseline estimate of driver behavior. No feedback of any kind was provided during the baseline period.

During the next sixteen weeks, those in the intervention condition were provided with three types of feedback. The first was real-time and consisted of a flashing LED on the event recorder immediately after an event was triggered. This informed the driver that the maneuver

just completed exceeded the safety limits defined by lateral and longitudinal acceleration thresholds.

The second type of feedback was a weekly report card. The report showed the driver's weekly and cumulative performance regarding unsafe behaviors. A written description was given for each of the safety-relevant events that were triggered that week. Information was provided regarding seatbelt use for the driver, as well as for any passengers riding in the vehicle. The number of times cell phone use was captured was also recorded for the week.

The third type of feedback was a DVD containing all safety-relevant video clips for that week. Parents were encouraged to review the videos and report card with their teen each week.

For purposes of the analysis, the 16-week intervention was divided into four, four-week segments. This was done to make the intervention segments the same length as the four-week baseline and follow-up segments, as well as to smooth out week-to-week differences.

During the four-week follow-up phase of the project, no feedback of any kind was provided. This phase assessed whether the effect of the intervention persisted for drivers in each condition.

After the follow-up phase, event recorders were removed from the participants' vehicles. Participants and their parent were asked to complete a questionnaire regarding their driving. The participants in the intervention condition were also asked questions about their experiences with the intervention.

VIDEO CODING

Every event captured by the system was reviewed and coded to determine its cause, and then classified into one of the categories shown in Table 3. Once an event cause was determined, those requiring feedback were coded further. The events were coded to populate a database containing the nature of the event, its cause, the number of vehicles involved, and the driver action that caused the event (e.g., cornering or braking). Safety-relevant data were also recorded, including information about safety belt use, the presence of loud music, and aggressive or reckless driving. Information about the number, location, and age of passengers, and whether or not they were belted was also entered into the database. Environmental factors such as weather, lighting, road conditions, road geometry, and road type were also recorded. Driver-related factors such as distraction, fatigue, and social influence of passengers were coded, if present (see Appendix D for coding method and Appendix E for de-identified data).

For this analysis, a final check of the data was completed by a second reviewer. The spreadsheet was examined for inconsistencies in the data coding, and these were reconciled by performing an additional review of the videos in question.

DATA ANALYSIS

Data analyses were completed on the safety-relevant events described above (good responses were not included in the analysis). Safety-relevant events were comprised of true triggers (i.e., incidents, near-crashes, and crashes), as well as invalid triggers where safety concerns were present. It should be noted that true triggers were less likely to be affected by characteristics of the driving environment, while invalid triggers were directly related to the prevalence of things like rough roads. However, both cases provided a window into driving behavior and captured potential safety-related events. Therefore, invalid triggers that contained safety-relevant behaviors were included in the analyses of safety-relevant events.

Table 3. Classification of Event Types

Safety-relevant events	<ul style="list-style-type: none"> • <i>Incident</i>: a threshold exceedance in which the driver’s action, whether intentional or unintentional, was responsible for a safety-relevant event. • <i>Invalid trigger with feedback</i>: activation of the system due to something other than unsafe driving behavior (e.g., the vehicle hitting a bump/pothole in the roadway or manual activation by someone in the vehicle). However, as the video was reviewed, a safety-relevant concern was revealed (e.g., unbelted driver/passenger, cell phone use, or traffic violations such as failing to stop for traffic signs/signals, etc.). • <i>Near-crash</i>: a threshold exceedance in which an evasive maneuver was performed in order to avoid a collision. • <i>Crash</i>: a collision with an object or vehicle occurred. • <i>Good response</i>: a threshold exceedance in which the driver's action occurred in response to an external event.
Invalid events	<ul style="list-style-type: none"> • <i>Invalid trigger</i>: activation of the system due to something other than unsafe driving behavior (e.g., the vehicle hitting a bump/pothole in the roadway or manual activation). • <i>Non-participant</i>: an event that occurred while someone other than the participant was driving the vehicle. These video events were not reviewed.

RESULTS

SUMMARY OF EVENTS

A total of 6,867 events were captured for the 90 participants that completed the study. Table 4 shows the number and percent of events for the different event types. About 74% of the events were classified as incidents. Of the 5,448 safety-relevant events included in the analysis, 83% involved improper cornering (i.e., going too fast, cutting the corner, or accelerating through when making a turn or negotiating a curve), as may be seen in Table 5. A collision with any object was coded as a crash.

Table 4. Summary of Events Captured by Event Type

	Number of events	Percent
Events triggered by teen participants	6,867	100%
Invalid triggers	1,163	16.9%
Safety-relevant (included in analysis)	5,448	79.3%
<i>Invalid with feedback</i>	215	3.1%
<i>Incident</i>	5053	73.6%
<i>Near-crash</i>	69	1.0%
<i>Crash</i>	111	1.6%
Good responses	60	0.9%

Table 5. Summary of Safety-Relevant Events Categorized by Driver Action

	Number of events	Percent
Safety-relevant (included for analysis)	5,448	100%
Cornering	4,533	83.2%
Braking	456	8.4%
Accelerating	63	1.2%
Other action	396	7.3%

Table 6 describes the 111 crash events, which include 77 events where the collision was with a curb or traffic island and collision with another vehicle, as well as the number that involved driver distraction.

Table 6. Summary of the 111 Crash Events by Crash Type and Distraction

Crash Type	Number of crashes	Number with crash object as curb or traffic island	Number with crash object as another vehicle	Number involving distraction
Lane Departure	35	35	0	12
Road Departure	33	27	0	18
Loss of Control	11	7	0	4
Intersection	1	0	1	0
Head on	12	5	0	3
Rear-end	4	0	4	3
Backing	6	2	0	2
Strike	6	1	0	3
Other	3	0	1	0

In addition, 69 near-crashes were recorded. Forty-four of these near-crashes involved some form of distraction, and 25 of the 44 nearly resulted in a rear-end collision with the vehicle ahead. All crashes were minor, with little or no property damage and no injuries to study participants or other parties involved.

MILEAGE

Odometer readings were texted weekly by the participants to the study coordinators. The mileage reported by the drivers were aggregated for each four-week segment of the study, and analyzed to see if there were significant differences between the license groups, the intervention condition, or over the course of the study. A mixed-effects linear model was created using Proc MIXED in SAS 9.3 (Statistical Analysis System from the SAS Institute) and included repeated measures analysis for each participant. A main effect of license type was found to be significant, $F(2, 87) = 14.51, p < 0.0001$. The post-hoc comparisons were adjusted using the Tukey-Kramer method. The experienced intermediate license group drove significantly more miles on average compared to both the inexperienced intermediate ($t(87) = 3.30, p = 0.0004$) and the school license ($t(87) = 5.34, p < 0.0001$) groups. The difference in the miles driven by the inexperienced intermediate and school license groups was not significant ($t(87) = 1.89, p = 0.1474$). Figure 5 shows the mean mileage for each license group along with the 95% confidence limits.

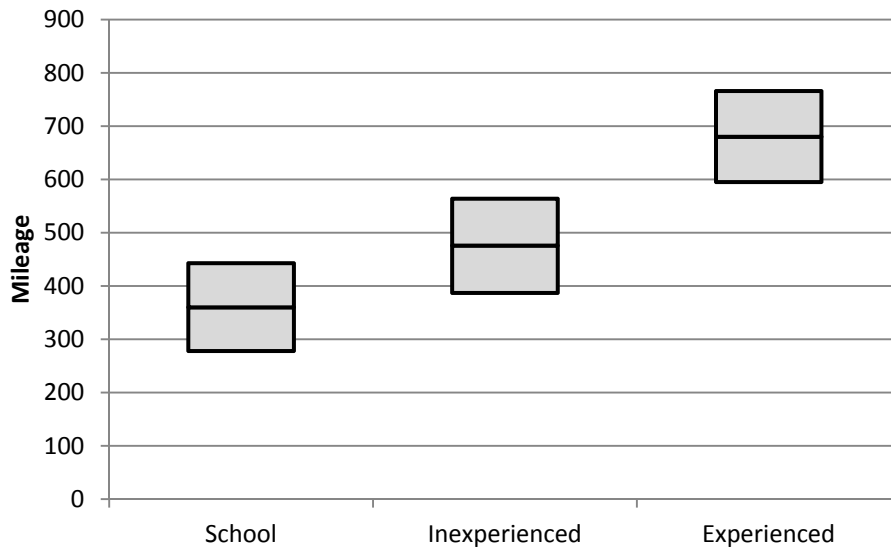


Figure 5. Mean Mileage Per Four-Week Segment by License Group (center bar), 95% Confidence Lower Limit (lower bar) and 95% Confidence Upper Limit (upper bar). From Left to Right, School License, Inexperienced Intermediate License, and Experienced Intermediate License.

ANALYSIS OF SAFETY-RELEVANT EVENTS PER 1,000 MILES DRIVEN

The next set of analyses considered the number of safety-relevant events per 1,000 miles driven, summarized over each four-week segment of the study. For all of these analyses, a negative binomial regression model was created using Proc GENMOD in SAS 9.3 and including repeated measures analysis for each participant. The log of the mileage for each four-week segment was the offset variable. A variety of contrasts were created in order to directly compare different license groups, intervention conditions, study segments, or combinations thereof. For the remainder of this report, “event rate” is equivalent to “number of safety-relevant events per 1,000 miles.” One male participant in the inexperienced intermediate group had an extremely high event rate over the course of the entire study: almost 238 events per 1,000 miles driven. The next highest event rate was about 135, and 17 drivers had an overall event rate between 90 and 136. Preliminary analyses were completed both with and without this participant’s data. They were found to influence the results so their data were excluded from the final analyses.

Equivalent Control/Intervention Groups Within License Groups

The event rates were evaluated to see if the participants in the control and intervention conditions within each license group were equivalent. As expected, there were no significant differences between control and intervention groups found in the initial baseline phase of the study, i.e., the confidence intervals include 1 (Table 7).

Table 7. Comparison of Number of Safety-Relevant Events Per 1,000 miles for the Intervention and Control Conditions Within License Groups During the Baseline Segment

License group	Intervention condition	Event rate	Lower 95% CL	Upper 95% CL	X ² value for difference	P > X ²
School	Control	24.3	10.7	55.6	0.21	0.65
School	Intervention	17.5	5.5	55.5		
Inexperienced	Control	23.3	11.6	46.6	2.57	0.1092
Inexperienced	Intervention	49.4	27.0	90.2		
Experienced	Control	18.7	7.2	48.3	0.56	0.45
Experienced	Intervention	32.0	11.4	90.1		

Effectiveness of Intervention

The rate of safety-relevant events summarized over each four-week segment of the study was analyzed to determine if the video intervention resulted in lower event rates compared to the control condition. Main effects of license group, intervention condition, and study segment, as well as all interactions, were included in the model. The main effect of license was not significant ($X^2(2) = 11.46, p = 0.1903$) in the full model, so it was reduced to include only the other two effects and interactions. A main effect of intervention condition was found to be significant, $X^2(1) = 10.61, p = 0.0011$. On average, the control condition had a rate of 32 events (95% CL = 23, 43), while the intervention condition had a rate of 12 events (95% CL = 8.0, 17) per 1,000 miles. The main effect of phase was marginally significant ($X^2(5) = 10.54, p = 0.0613$), with a trend of decreasing event rate during the first four segments of the study, leveling out on during the fifth segment and increasing during the sixth segment. The interaction between feedback condition and phase was significant, $X^2(5) = 19.95, p = 0.0013$.

The main effect of intervention condition evaluated in the full model considered the entire study, not just the 16-week intervention phase. Contrasts that averaged over the four, four-week intervention segments and compared the control and intervention conditions for each license group were constructed. Table 8 shows the rate of safety-relevant events during the intervention phase.

More specific research questions for the overall study were:

Does the intervention reduce safety-relevant events among 14.5-year-old drivers (school license holders) relative to a control group? School license holders in the control group had an average rate of 35.3 events during each of the four, four-week intervention segments of the study. Those in the intervention group had a rate of about 5.7 events during the same segments. This difference was found to be significant, $X^2 = 12.16, p = 0.0005$.

Table 8. Effect of video-based feedback for each license group

License group	Intervention condition	Event rate	Lower 95% CL	Upper 95% CL	X ² value for difference	P > X ²
School	Control	35.3	21.5	58.1	12.16	0.0005
School	Intervention	5.7	2.3	14.0		
Inexperienced	Control	39.1	23.5	65.0	9.42	0.0021
Inexperienced	Intervention	12.6	7.6	21.0		
Experienced	Control	21.5	13.6	33.9	4.28	0.0385
Experienced	Intervention	9.0	4.6	17.9		

Does the intervention reduce safety-relevant events among 16-year-old drivers who have independent driving experience relative to a control group? Experienced intermediate drivers in the control group had an average rate of more than 21.5 events during each of the four, four-week intervention segments of the study. Those in the intervention group had a rate of about nine events. This difference was found to be significant, $X^2 = 4.28$, $p = 0.0385$.

Does the intervention reduce safety-relevant events among 16-year-old drivers who did not drive independently (i.e., inexperienced intermediate drivers) relative to a control group? Inexperienced intermediate drivers in the control group had about 39 safety-relevant events per 1,000 miles during each of the four, four-week intervention segments of the study. Those in the intervention group only had about 12.6 safety-relevant events per 1,000 miles. This difference was found to be significant, $X^2 = 9.42$, $p = 0.0021$.

EFFECT OF AGE: COMPARISON OF INEXPERIENCED GROUPS

One of the research objectives of this project was to compare the two participant groups without independent driving experience (i.e., those with a school license and those with an intermediate license who did not drive with a school license) to look for an effect of age. Figure 6 shows the event rates for each phase of the study for the two groups of participants without independent driving experience.

First a contrast was constructed to see if there is evidence that the event rates recorded for these two license groups were significantly different during the baseline segment of the study. A significant difference between these two groups in baseline would indicate an effect of age, as the participants with intermediate licenses are 16 years old while the school license drivers are 14 or 15 years old. No significant differences between the school license and inexperienced intermediate participants were found during the baseline period, $X^2 = 1.32$, $p = 0.2513$.

Comparisons of the average event rate during the four intervention segments of the study were made separately for the two control groups and for the two intervention groups. For the control groups, no significant difference in event rates was found, $X^2 = 0.08$, $p = 0.7825$. For the intervention groups, those with a school license had an average event rate of about 5.7 while the inexperienced intermediates had about 12.6 safety-relevant events per 1,000 miles driven; this difference, however, was not statistically significant, $X^2 = 2.26$, $p = 0.1328$.

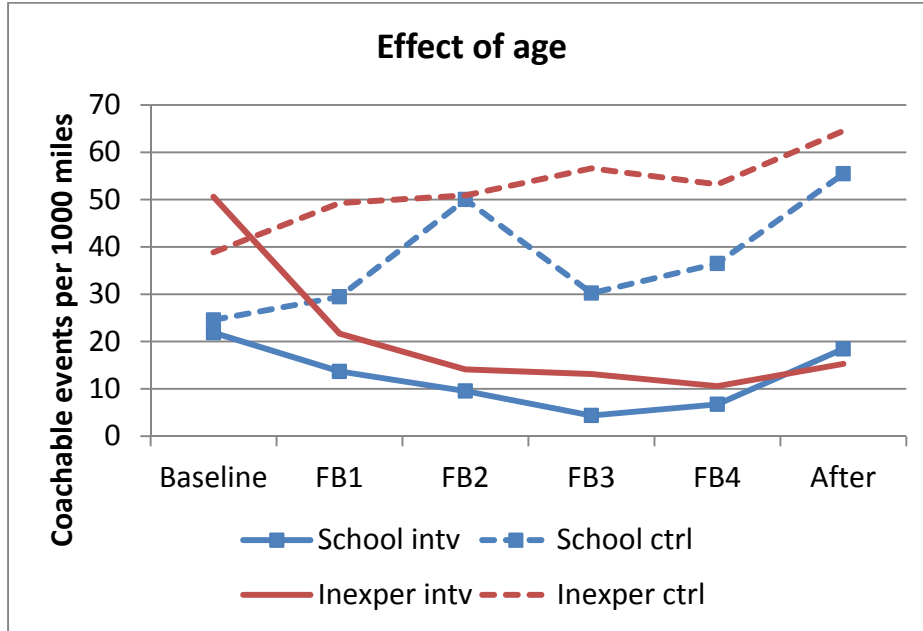


Figure 6. The Number of Safety-Relevant Events per 1,000 Miles for Each Four-Week Segment of the Study (Baseline, Intervention Segments 1-4, and Follow up) for the School License Control, School License Intervention, Inexperienced Intermediate Control, and Inexperienced Intermediate Intervention Participant Groups

EFFECT OF EXPERIENCE: COMPARISON OF 16-YEAR-OLD GROUPS

Another research question concerns the effect of previous driving experience on the behavior of 16-year-old drivers who have just obtained their intermediate license. Figure 7 shows the mean number of safety-relevant events per 1,000 miles for each phase of the study for the two groups of sixteen-year-old participants without independent driving experience.

The event rate recorded in the initial baseline segment of the study by the inexperienced 16-year-olds was not significantly different than that recorded by the 16-year-olds who had previously driven with a school permit, about 43 events per 1,000 miles driven compared to 24, $X^2 = 0.58$, $p = 0.4451$.

Next the event rate averaged over the four intervention segments was compared for the two control groups. Here the inexperienced 16-year-olds had significantly more safety-relevant events per 1,000 miles than the experienced 16-year-olds, 39 compared to 21.5, $X^2 = 2.92$, $p = 0.0872$. When comparing the two 16-year-old groups who received the intervention, the inexperienced intermediate drivers had about 3.6 more safety-relevant events per 1,000 miles on average than the experienced group. This difference was not statistically significant, however, $X^2 = 0.59$, $p = 0.4411$.

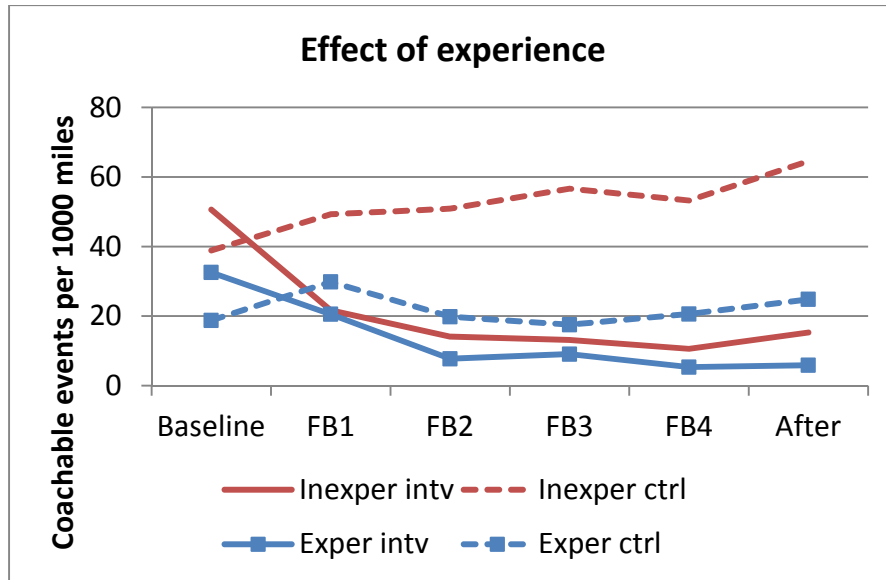


Figure 7. The Number of Safety-Relevant Events Per 1,000 miles for Each Four-Week Segment of the Study (Baseline, Intervention Segments 1-4, and Follow up) for the Inexperienced Intermediate Control, Inexperienced Intermediate Intervention, Experienced Intermediate Control, and Experienced Intermediate Intervention Participant Groups

EFFECT OF REMOVING THE INTERVENTION

For each license group that received the intervention, a contrast was constructed to compare the rate of safety-relevant events recorded per 1,000 miles averaged over all four intervention segments to the rate of events recorded in the follow-up period. For both the inexperienced and experienced intermediate drivers, no significant difference was found. However, a significant increase in safety-relevant events was found for the school license group after the intervention ended, with 5.7 events per 1,000 miles during the feedback phase compared to 13.9 after the feedback ended, $X^2 = 30.07$, $p < 0.0001$.

DISCUSSION

The results of this study offer strong evidence that providing video-based feedback to young drivers and parents about safety-relevant events is very effective at reducing the occurrence of these events relative to a control group of participants who did not receive any kind of feedback. These results further corroborate evidence from two other studies (Carney et al., 2010; McGehee, Carney et al., 2007; McGehee, Raby et al., 2007). The intervention is effective for all three license groups: 14.5 to 15.5-year-olds with school licenses, 16-year-olds without independent driving experience, and 16-year-olds who previously held a school license.

With regard to the effect of age, there is no evidence that school license holders have a different event rate than inexperienced intermediate participants, either with or without feedback. With regard to the effect of experience, there is evidence to suggest that among 16-year-old

drivers who did not receive any feedback, those with previous independent driving experience have a lower rate of safety-relevant events than those without.

After the intervention ended, event rates for both the inexperienced and experienced intermediate drivers were not found to be significantly different than when the intervention was in place. This suggests that the changes in behavior seen with feedback for these participants were not solely the result of their parents participating in the intervention, and that the feedback led to some changes in driving behavior that appear to be lasting. This same trend occurred in the two previous studies as well. It is hoped that calming young drivers' behavior early will lead to lasting habits where speed while cornering is reduced and attention to the forward roadway is increased (e.g., fewer abrupt braking events).

Among the very small sample of school license drivers, however, there is evidence that suggests that these drivers have a significant increase in safety-relevant events when the intervention is removed. There are a number of factors that may have contributed to this increase: (1) perhaps these very young drivers are less able to learn from the feedback than the 16-year-old drivers, as cognitive capacity increases throughout the teenage years (Keating, 2007) (2) because the school license holders tend to have both a lower number and a lower rate of safety-relevant events than the 16-year-old drivers, perhaps they did not receive enough video-based feedback throughout the course of the study to affect long-term behaviors (3) teens are still physiologically developing the ability to self-regulate and control impulsive behavior (Keating, 2007) so the younger drivers drive differently when their parents cannot monitor their driving (4) the nature of the school license lends itself to few miles—half the miles than that of the experienced intermediate group (restricted to path between home and school) and the school license holders have also had their learner permits for a shorter time, which means they have had less exposure to driving, i.e., have not had time acquire much expertise (Keating, 2007), or (5) combinations of these factors. This suggests that younger drivers may need to have the intervention in place longer in order to form more lasting driving habits. Both our previous studies of video-based feedback examined the intervention over the course of one calendar year—and it would likely make sense to consider such an implementation with the youngest drivers.

There is also evidence that *with* feedback inexperienced intermediate drivers are not significantly different from experienced intermediate drivers. However, *without* feedback the inexperienced intermediate drivers have significantly higher event rates than experienced intermediate drivers. Interestingly, there is no effect of experience in the baseline segment, i.e., the 16-year-olds with and without experience do not begin the study with significantly different event rates.

LIMITATIONS

There are a number of limitations inherent to this type of research that should be considered. Clearly, it is important to mention the potential for self-selection bias associated with this study. While the teen who would willingly agree to have a camera in their vehicle would most likely fall within a certain demographic group, self-selection bias is an unavoidable limitation for nearly all research involving human subjects. Even so, the drivers who participated

in this study registered a wide range of event rates, as shown in Figure 8, with both experimental conditions having a range of event rates from near 0 to around 100 events per 1,000 miles.

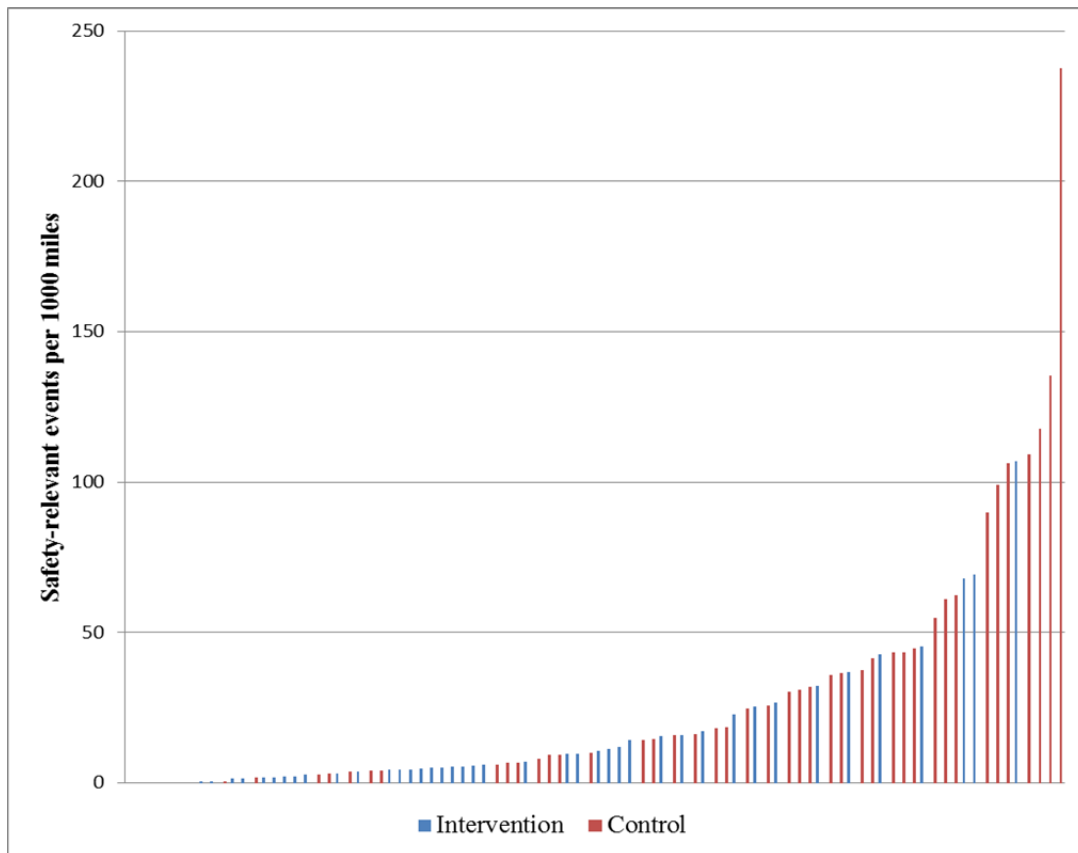


Figure 8. Safety-Relevant Events Per 1,000 Miles Over the Entire 24-Week Study for Each Participant, Sorted From Low to High

The occurrence of crashes and near-crashes is relatively infrequent, so these analyses are based on the assumption that the measure we used, number of safety-relevant events per 1,000 miles, is representative of crash rates, and that lowering the rate of these events reflects a decrease in actual crash risk.

While there is some evidence that, for the 16-year-old drivers, the changes in their driving persisted after the feedback was removed, it is possible that these effects may fade over time. We cannot speculate on the long-term effects, since the follow-up period only lasts for four weeks. Even if the effects are fleeting, the reduction in safety-relevant events while the system is in place could have significant safety benefits. It should be noted that our two previous studies, both of which had longer second baseline periods (8 weeks and 6 weeks), also showed no significant increase in events after the intervention was removed.

Although our estimates of exposure in terms of the participants' mileage have greatly improved over our first two studies of this type of feedback technology and intervention, the

estimates are still not perfect. They rely on self-report data collected weekly from the drivers. While there is no reason to suspect that participants would intentionally provide false mileage, it nonetheless should be mentioned. In addition, even with accurate mileage, it is unknown how much time (e.g., minutes per week and number of trips) the teens spend driving. Finally, it is not possible with the current technology to quantify the time or distance driven with teen passengers on board or while using electronic devices.

Lastly, because it was not an aim of this study, we are unable to observe or verify the interactions between parents and teens after they receive report cards and videos. While discussions between parents and teens about driving can be a source of frustration and conflict, parents in our previous studies have commented that the objectivity of the videos can be an asset. A current NIH funded study at the University of Iowa is investigating the in-vehicle technology in combination with training in communication strategies for parent/teen discussions regarding driving.

CONCLUSIONS

This study of age and experience fills several research gaps that have not been examined previously. First, unsupervised drivers under the age of 16 had never before been studied in the naturalistic driving context. Little was known about how these younger drivers would compare to the traditional 16-year-old driver. Second, if a young driver has this independent experience when they obtain a traditional intermediate license, how would it affect their driving both with and without the video feedback? This study provided data to help researchers understand how age and experience affect young driver behavior when feedback is given and when it is not.

Results showed that while the age difference between school-licensed teens and intermediate-licensed teens did not significantly affect the rate of safety-relevant events, additional driving experience did. Teens from the control group that had an additional 6-18 months of experience prior to obtaining their intermediate license had rates of safety-relevant events approximately 50% lower than those who did not have the additional experience. Perhaps because the experience for these teens was limited to particular times of day and trip types, as well as in terms of the number of passengers allowed to be present, the additional months of driving were shown to be advantageous. They increased the amount of experience young drivers got in an environment that limited their exposure to the most dangerous situations (e.g., without passengers and late at night). In addition, regardless of driver age or experience, a video-based intervention was found to be an effective way to reduce the number of safety-relevant events for young drivers. Providing teens and their parents with personalized, concrete, safety-relevant driving information in the form of a video, allows for constructive review of specific situations and creates an opening for honest discussions. It allows parents to be more aware of and involved in their teen's driving—to continue to mentor and train without being present, and to enforce restrictions that might otherwise be unenforceable.

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APPENDIX A: IOWA MINOR SCHOOL LICENSE (MSL)

MOTOR VEHICLES AND LAW OF THE ROAD, §321.194

321.194 Special minors' licenses.

1. *Driver's license issued for travel to and from school.* Upon certification of a special need by the school board, superintendent of the applicant's school, or principal, if authorized by the superintendent, the department may issue a class C or M driver's license to a person between the ages of fourteen and eighteen years whose driving privileges have not been suspended, revoked, or barred under this chapter or chapter 321J during, and who has not been convicted of a moving traffic violation or involved in a motor vehicle accident for, the six-month period immediately preceding the application for the special minor's license and who has successfully completed an approved driver education course. However, the completion of a course is not required if the applicant demonstrates to the satisfaction of the department that completion of the course would impose a hardship upon the applicant. The department shall adopt rules defining the term "*hardship*" and establish procedures for the demonstration and determination of when completion of the course would impose a hardship upon an applicant.

a. The driver's license entitles the holder, while having the license in immediate possession, to operate a motor vehicle other than a commercial motor vehicle or as a chauffeur:

(1) During the hours of 5 a.m. to 10 p.m. over the most direct and accessible route between the licensee's residence and schools of enrollment or the closest school bus stop or public transportation service, and between schools of enrollment, for the purpose of attending duly scheduled courses of instruction and extracurricular activities within the school district.

(2) To a service station for the purpose of refueling, so long as the service station is the station closest to the route the licensee is traveling on under subparagraph (1).

(3) At any time when the licensee is accompanied in accordance with section 321.180B, subsection 1.

b. Each application shall be accompanied by a statement from the school board, superintendent, or principal, if authorized by the superintendent, of the applicant's school. The statement shall be upon a form provided by the department. The school board, superintendent, or principal, if authorized by the superintendent, shall certify that a need exists for the license and that the board, superintendent, or principal authorized by the superintendent is not responsible for actions of the applicant which pertain to the use of the driver's license. Upon receipt of a statement of necessity, the department shall issue the driver's license. The fact that the applicant resides at a distance less than one mile from the applicant's school of enrollment is prima facie evidence of the nonexistence of necessity for the issuance of a license. The school board shall develop and adopt a policy establishing the criteria that shall be used by a school district administrator to approve or deny certification that a need exists for a license. The student may appeal to the school board the decision of a school district administrator to deny certification. The decision of the school board is final. The driver's license shall not be issued for purposes of attending a public school in a school district other than either of the following:

(1) The district of residence of the parent or guardian of the student.

(2) A district which is contiguous to the district of residence of the parent or guardian of the student, if the student is enrolled in the public school which is not the school district of residence because of open enrollment under section 282.18 or as a result of an election by the student's district of residence to enter into one or more sharing agreements pursuant to the procedures in chapter 282.

c. (1) A person issued a driver's license under this section shall not use an electronic communication device or an electronic entertainment device while driving a motor vehicle unless the motor vehicle is at a complete stop off the traveled portion of the roadway. This subparagraph does not apply to the use of electronic equipment which is permanently installed in the motor vehicle or to a portable device which is operated through permanently installed equipment.

(2) For the period beginning July 1, 2010, through June 30, 2011, peace officers shall issue only warning citations for violations of subparagraph (1). The department, in cooperation with the department of public safety, shall establish educational programs to foster compliance with the requirements of subparagraph (1).

Thu Dec

2. *Suspension and revocation.* A driver's license issued under this section is subject to suspension or revocation for the same reasons and in the same manner as suspension or revocation of any other driver's license. The department may also suspend a driver's license issued under this section upon receiving satisfactory evidence that the licensee has violated the restrictions of the license or has been involved in one or more accidents chargeable to the licensee. The department may suspend a driver's license issued under this section upon receiving a record of the licensee's conviction for one violation. The department shall revoke the license upon receiving a record of conviction for two or more

violations of a law of this state or a city ordinance regulating the operation of motor vehicles on highways other than parking violations as defined in section 321.210. After a person licensed under this section receives two or more convictions which require revocation of the person's license under this section, the department shall not grant an application for a new driver's license until the expiration of one year.

3. *Citations for violation of restrictions.* A person who violates the restrictions imposed under subsection 1, paragraph "a" or "c", may be issued a citation under this section and shall not be issued a citation under section 321.193. A violation of the restrictions imposed under subsection 1, paragraph "a" or "c", shall not be considered a moving violation.

Additional information and answers to frequently asked questions can be found at:

<http://www.iowadot.gov/mvd/ods/msl.htm>

APPENDIX B. RECRUITMENT LETTER

FOR IRB USE ONLY
APPROVED BY: IRB-02
IRB ID #: 200810739
APPROVAL DATE: 03/24/11
EXPIRATION DATE: 03/23/12



UNIVERSITY OF IOWA TEEN DRIVING RESEARCH

The University of Iowa is in the process of recruiting participants for a study entitled "Evaluation of a video feedback intervention for newly licensed teen drivers." The study is the third of its kind to be performed by the University of Iowa.

Teenagers between the ages of 14½ and 16 are eligible to participate in this study. They must:

1. be in the process of obtaining either a school permit or an intermediate license,
2. have a vehicle that they will be the main driver of, and
3. drive at least 90 minutes per week (about 15 minutes/day).

If your teen does not currently meet these criteria, but will within the next 6-9 months, please call to be placed on our waiting list.

Teens who choose to participate will have their vehicles instrumented with a small video device. The device records a 20-second clip of video both inside and outside the vehicle when abrupt braking and/or steering occur. This could happen by braking hard at an intersection, turning a corner too quickly, or going too fast over a speed bump, for example. Some teens in the study and their parents will be given the videos and information about the behaviors shown in the video. All teens and parents will be asked to complete surveys about their driving behaviors and participation in the study. Students will be paid \$75 for the first and last month and \$25 for the four months in between.

We believe that this study will help to provide a major advance in reducing teens' unsafe driving behaviors. If this project is something you and your teen would like to participate in, please call us toll free at 1-877-611-4971. Thank you in advance and we look forward to hearing from you.

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**APPENDIX C: REASONS ENROLLED PARTICIPANTS
WERE UNABLE TO COMPLETE THE STUDY**

Group	Time in Study	Reason participant was unable to complete the study
School	8 weeks	Participant had multiple issues with car battery. In addition, the event recorder was not in stealth mode during the control condition—participant was able to see flashing light when events were triggered and had to be removed from the study.
School	4 weeks	Participant broke arm snowboarding, was in a full arm cast and unable to drive.
School	5 weeks	Participant had car trouble and was unable to afford to fix it. Participation ended after they missed nearly 4 weeks of data collection.
School	4 weeks	Participant had trouble with their vehicle and was unable to resolve the problem or replace the vehicle.
Inexperienced Intermediate	6 weeks	Participant crashed the vehicle. The participant was unable to replace the vehicle and decided to leave the study.
Experienced Intermediate	1 week	Teen requested to leave the study. Father asked that we keep participant in the study. Father was contacted and issues of coercion and study procedures and policies were discussed.
Experienced Intermediate	< 1 week	Parent forgot that the odometer did not work in the vehicle. Family chose not to have it fixed and had to be removed from the study.
Inexperienced Intermediate	5 months	Parent asked to end their participation for "personal" reasons. They assured UI staff that their dropping out had nothing to do with the study.
School	2 months	Family requested removal of the system. Due to family issues, they were unable to maintain the vehicle.
Experienced Intermediate	6 months	After participant was removed from control and coding of videos began, it was discovered that a wire came loose during the study and video data was not collected.
Experienced Intermediate	6 months	After participant was removed from control and survey analysis began, it was discovered that the participant had received feedback while assigned to the control group
Experienced Intermediate	n/a	Enrolled in study before four-month criteria had been determined. Participant had school license for less than the four months required to be eligible for the experienced intermediate condition.
Experienced Intermediate	n/a	Enrolled in study before four-month criteria had been determined. Participant had school license for less than the four months required to be eligible for the experienced intermediate condition.
School	n/a	Participant and parent signed consent but did not respond to phone calls thereafter.
School	n/a	Participant and parent signed consent but participant started driving with school license before event recorder was installed so they were no longer

Group	Time in Study	Reason participant was unable to complete the study
		eligible for the school license group.
School	n/a	Participant and parent signed consent then later decided that the teen would not be driving during the summer, making them ineligible for the study.
Inexperienced Intermediate	n/a	Participant was not able to obtain a vehicle until 3 months prior to turning 16. Participant would have had school license for less than the four months required to be eligible for the experienced intermediate condition.
Inexperienced Intermediate	n/a	Participant and parent signed consent to enroll at the time of school licensure. However, parent did not feel that the teen was ready to drive and delayed licensure until age 16. At that time, the teen no longer wished to participate.
School	n/a	Participant and parent signed consent and had the camera installed. However, before the participant began the study, the family requested to have it removed stating that the cost of fuel was too much to justify their two teenagers driving to school separately.

APPENDIX D: DATA CODING

APPENDIX E: DEIDENTIFIED DATA