Car crashes rank among the leading causes of death in the United States.

Distracted Driving Among Newly Licensed Teen Drivers

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AAA Foundation for Traffic Safety

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About the Sponsor

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Executive Summary

Although distracted driving among teenagers is of great concern to traffic safety professionals and has received considerable media attention in recent years, rigorous research on this issue has been limited. Most of the research to date has concentrated on the risks associated with teen passengers and driver cell phone use. Almost no research has examined the many other potential driving distractions often believed to be common and problematic among teenage drivers.

In an ongoing study with the AAA Foundation, we collected a sizeable dataset of video data on teen drivers during the provisional licensing stage of GDL. This in-vehicle data provided a unique opportunity to study distracted driver behaviors and potentially distracting conditions among young, beginning drivers. For the present analysis, we sampled and coded video data with the specific purpose of studying the nature and prevalence of distracted driving among teenagers. The study addressed a number of questions:

- Which distracted driver behaviors are most common among teenage drivers?
- Do males and females differ in how often they engage in distracted behaviors, or the kinds of distractions they experience?
- Do distracted driver behaviors vary based on the number of passengers and the characteristics of those passengers (e.g., teens vs. adults vs. young siblings)?
- Are distracted driver behaviors more common during certain times of day or week (e.g., weekday vs. weekend), and do these behaviors bear any relation to the amount of traffic or other characteristics of the driving environment?
- Do drivers who engage in distracted behaviors spend more time looking away from the roadway than drivers who are not distracted?
- Are distracted driver behaviors associated with serious incidents such as near collisions, or events involving hard braking or swerving?

Methods

The data used to address these questions were collected during a previous investigation of 50 families of novice drivers (Goodwin, Foss, Margolis & Waller, 2010). Event-based data recorders were placed in the vehicles of participating families at the outset of the learner stage so parent and teen behaviors during practice sessions could be directly observed. These data recorders, obtained from DriveCam, collected video, audio and accelerometer data when a triggering "event" occurred such as sudden braking or an abrupt turn. The data recorders were returned to the family vehicles during the initial 6 months of unsupervised driving, a very high risk time for new drivers. The data reported in the present study are from this initial period of independent driving. Because vehicles were sometimes shared, we also have data on some more experienced teen drivers – the siblings of the original target teen. In total, the sample for this study included 52 drivers: 38 newly licensed teens as well as 14 high-school aged siblings. It is important to note this was a "naturalistic" study of teen driving behavior. No interventions were conducted with participating families.

During the 228 total months data recorders were installed in vehicles during the intermediate license stage (6 months x 38 vehicles), 24,085 driving clips were recorded for the 52 teens in the study. A sample of 7,858 clips was selected for coding. Clips with passengers were oversampled to ensure a sufficient sample size for comparisons between different passenger combinations (e.g., driving with teenage peers versus siblings or parents). A coding system was developed to analyze the selected video clips. This system included detailed information about electronic device use by drivers, other distracted driver behaviors (e.g., adjusting controls, personal hygiene), and distracting conditions that may occur when passengers are present (e.g., horseplay, loud conversation).

Results

Frequency of Electronic Device Use and Other Distracted Driver Behaviors

In total, teenage drivers were observed using an electronic device in 6.7% of all driving clips. Nearly twice as many were operating (or suspected of operating) an electronic device than were observed holding a cell phone to their ear (4.3% versus 2.3% of clips). The frequency of electronic device use varied considerably by driver. Nine drivers (17%) did not use an electronic device in any of their driving clips. By comparison, six drivers (12%) were observed using an electronic device in over 15% of their clips. Females were twice as likely as males to be using an electronic device.

The other distracted driver behaviors we examined included adjusting controls, eating or drinking, personal hygiene, reading, turning around, reaching for an object, and communicating with someone outside the vehicle. All of the behaviors we examined were relatively rare. Adjusting controls in the vehicle was the most common behavior; reading was the least common. Females were more likely than males to be observed adjusting controls or reaching for objects in the vehicle. Males were approximately twice as likely as females to turn around while driving. Altogether, excluding electronic devices, teenage drivers engaged in at least one of the distracted driver behaviors in 15.1% of all driving clips. Once again, the frequency of distracted behaviors varied considerably by driver, but the incidence was not concentrated so heavily among a small subset of drivers as was the case with use of an electronic device.

Frequency of Distracting Conditions Involving Passengers

Loud conversations were evident in 12.2% of driving clips when passengers were present. Horseplay was less common, at 6.3% of clips. Other potentially distracting conditions, such as dancing by passengers or physical contact between the driver and passengers, were quite rare. There were few, if any, notable differences for male and female drivers in distractions involving passengers.

As might be expected, the frequency of potentially distracting conditions depended not only on the presence of passengers, but also on *who* those passengers were. Compared to when one teenage peer was in the vehicle, loud conversation and horseplay were more than twice as likely when teens were carrying multiple teenage peers. Conversely, the likelihood of loud conversation and horseplay were markedly less likely with one sibling passenger or when a parent/adult was present.

We also examined whether the frequency of driver electronic device use and other distracted driver behaviors (e.g., adjusting controls, personal hygiene) was related to the combination of passengers. Generally speaking, electronic device use and other distracted driver behaviors were most common when teens were carrying *no* passengers. Teen drivers used an electronic device in 8.1% of clips and engaged in other distracted behaviors in 16.9% of clips when driving alone. Not surprisingly, these behaviors were least common when a parent or other adult was in the vehicle.

Distractions and Characteristics of the Driving Setting

Overall, the frequency of distracted driver behaviors and distracting conditions varied little by day of week. However, noteworthy differences were observed by time of day. Distracted driver behaviors (e.g., adjusting controls, personal hygiene) showed a small, gradual decline over the course of the day. By contrast, loud conversation and horseplay increased, especially at night. In the specific setting of driving at night on weekends with one or more teenage peers (and no adults or siblings), loud conversation was observed in 20.2% of clips and horseplay was observed in 11.2% of clips.

A few studies suggest drivers may be more likely to engage in potentially distracting activities when the driving environment seems "safer." Consequently, we examined whether distracted behaviors were less common in more challenging conditions such as busy traffic or rain. Overall, there was no clear relationship between the frequency of distracted driver behaviors or distracting conditions and the amount of traffic. The frequency of distractions was relatively similar in light or moderate/heavy traffic, or when there was no traffic. However, the frequency of distracted driver behaviors and distracting conditions was slightly lower during rain.

Distractions and Looking Away from the Roadway

We coded whether the driver looked away from the roadway at any point during the 10 seconds preceding the vehicle movement that triggered the camera to record. Drivers looked away from the roadway, at least briefly, in 45% of the driving clips where the vehicle was moving and a clear determination could be made of where the driver was looking. Females were somewhat more likely to look away from the roadway than males. Most drivers who looked away from the roadway did so only briefly. A third (35%) of drivers who looked away did so for one second or less. A similar proportion (31%) looked away for 1.25 to 2 seconds. However, 12% of drivers looked away from the roadway for at least four seconds during the 10 second period prior to the event. The median amount of time that drivers looked away was 1.50 seconds. We also measured the longest continuous glance away from the roadway among drivers who looked away. In clips where drivers looked away from the roadway, half the time (51%) the longest glance was one second or less. In 39% of clips, the longest glance away was 1.25 to 2.0 seconds, and in 10% of clips the longest glance was more than 2 seconds.

Next, we examined the relationship between distractions and looking away from the roadway. Drivers were three times as likely to look away from the roadway when using an electronic device. In fact, drivers using an electronic device spent a full second longer looking away during the 10 seconds preceding the event that triggered the camera to record, than drivers who were not using an electronic device. Drivers were also two and a half times as likely to look away when engaging in some other distracted driver behavior (e.g., adjusting controls, personal hygiene), and they were more likely to look away when there was loud conversation or horseplay in the vehicle.

Distractions and Potentially Serious Events

In the final section of the report, we examined the association between distractions and potentially serious events, such as near collisions or events involving high g-forces (indicating hard braking or turning). Of the 7,858 driving clips, only 52 (0.7%) involved a serious incident. Twenty-seven of the 52 teenage drivers had no serious incidents during the six month period the event data recorder was installed. By contrast, seven teens accounted for 58% of the serious incidents, with three teens having five incidents each. Drivers were approximately six times more likely to have a serious incident when there was loud conversation in the vehicle. Although driver electronic device use and horseplay were also associated with driving incidents, the confidence intervals were too wide for these associations to be considered meaningful.

Finally, we examined whether distracted driver behaviors and distracting conditions were associated with higher g-force events, defined as events in the top 10% of the g-force distribution. Horseplay was consistently associated with high g-force events, whether the events were triggered by acceleration, deceleration, left or right turns. High g-force decelerations and left turns were also more common when loud conversation was present. Driver electronic device use and other distracted driver behaviors were not strongly related to high g-forces. In fact, the general trend was for high g-force events to be *less* common when drivers were using electronic devices or engaging in other distracted behaviors.

Conclusions

This study is among the first to directly measure the occurrence of distracted driver behaviors and distracting conditions among teenage drivers. It also describes how distractions vary based on the presence of passengers, time of day, sex of the driver, and other potentially important factors. Finally, it documents how distracting activities were related to several aspects of driving performance, including serious incidents. Similar to adults, teenagers engage in a wide variety of distracted behaviors while driving. However, substantial individual differences were observed between teenagers in the frequency of distracted behaviors, and there was some evidence teenagers tempered these behaviors in a setting that places greater demands on the driver (rainy conditions). The study also provides insight into the increased crash risk for teenage drivers when carrying passengers. The presence of teenage peers – especially multiple peers – sometimes resulted in horseplay and loud conversation in the vehicle. Both horseplay and loud conversation were particularly common after 9 p.m. on weekends, a time when much of teen driving may be "recreational." By contrast, carrying parents – and to a lesser degree siblings – was associated with a substantially lower likelihood of horseplay and loud conversation. Potentially distracting conditions in the vehicle such as horseplay went hand-in-hand with serious incidents and high g-forces. However, causality cannot be inferred. Carrying multiple passengers may have caused these incidents, but it is also possible that riskier drivers are simply more likely to carry multiple, rowdy passengers. Finally, electronic device use and other distracted driver behaviors were strongly associated with looking away from the roadway, although electronic device use was only weakly related to serious incidents.

Background

Driver distraction has long been recognized as a potential contributor to motor vehicle crashes (Treat et al., 1977). Drivers have always had the opportunity to eat, chat with passengers, and engage in a variety of non-driving related activities while operating a vehicle. However, over the years the potential for distraction has increased as in-vehicle technology has expanded. Car radios first became commercially available in the 1930s when the Galvin brothers introduced the "Motor-ola," and quickly became commonplace in new vehicles. The 1970s saw the arrival of cassette players, which eventually were replaced by CD players during the 1990s. It wasn't until the past decade, however, that distracted driving came to the forefront of public awareness, stemming in large part from the rapid increase in cell phone ownership and the explosion in portable and in-vehicle devices that have become available. These devices allow drivers to engage in activities that were previously inconceivable (e.g., browsing the Internet), and have the capacity to absorb drivers' attention to a whole new degree. Distracted driving has received so much attention it was designated the 2009 "Word of the Year" by Webster's New World College Dictionary (U.S. DOT, 2010). The U.S. Department of Transportation has held two summits to discuss distracted driving and to identify opportunities for addressing the problem.

Despite widespread attention and interest, there is presently no generally accepted definition of distracted driving. In its broadest sense, distractions are objects, events or activities that divert drivers' attention from driving (NCHRP, 2005). They can include physical tasks (e.g., eating or inserting a CD), auditory or visual diversions (e.g., a crying baby), or cognitive activities (e.g., talking on a cell phone). Some behaviors can be distracting in multiple ways. Texting, for example, can result in a driver being physically, visually and cognitively distracted simultaneously. Sometimes the terms "distraction" and "inattention" are used interchangeably. However, distraction is just one aspect of driver inattention. The latter can also result from fatigue or the driver's physical or emotional status (NHTSA, 2010a).

The potential influence of a particular type of distraction depends on a number of factors, including the degree of risk posed by a distraction, its frequency and duration (NHTSA, 2010b). Although reaching for an object that has fallen likely entails a high degree of risk, this is a relatively rare and generally quite brief occurrence. By contrast, having a cell phone conversation may involve less risk, but a driver can place (or answer) several calls during a trip, and each conversation can last several minutes. Consequently, the aggregate or attributable risk of driver cell phone use can be quite high. The context of a distraction is also important. A cell phone conversation in busy traffic likely involves greater risk of a crash than the same conversation in light traffic (or at a stoplight). There is some evidence that drivers attempt to minimize risks by waiting until "safer" moments to engage in potentially distracting activities (Atchley, Atwood, & Boulton, 2011; O'Brien, Goodwin & Foss, 2010; Stutts et al., 2005). However, drivers may underestimate the risks of distracting activities and may not realize when their driving is impaired (Horrey, Lesch, & Garabet, 2008; Lerner, Singer, & Huey, 2008; Lesch & Hancock, 2004).

The contribution of distracted driving to crashes is not well-established. Pre-crash distractions often leave behind no evidence at the scene of a crash. Drivers understandably may be reluctant to admit they were distracted, but they also may not know. Unlike the case of alcohol use, there is no objective way for an officer to know whether a driver was distracted at the time of the crash. Even when distracted driving is apparent, many state crash report forms do not include a code for officers to record that the driver was using a cell phone or was otherwise distracted (NCHRP, 2005). For all of these reasons, distracted driving is believed to be underreported in crash records. Despite these challenges, several groups have tried to estimate the number of crashes and fatalities that result from distracted driving. According to NHTSA, 5,474 people were killed and 515,000 injured in motor vehicle crashes involving distracted driving during 2009 (NHTSA, 2010a). The highest proportion of distracted driving was among drivers under the age of 20: 16% of fatal crashes among this age group were judged to involve distraction. Other studies also have found that roughly 10-15% of crashes may be attributed to distracted driving (McEvoy, Stevenson, & Woodward, 2007; Royal, 2003; Stutts, Reinfurt et al., 2001). As mentioned, these are all estimates. Beginning December 2011, NHTSA has adopted a new measure called "distraction-affected crashes," which is intended to focus more narrowly on crashes in which a driver was likely to have been distracted.

There is greater uncertainty about the contribution of cell phones to motor vehicle crashes. Two case-crossover studies examining the relative risk of using a cell phone while driving estimated that cell phone use quadruples a driver's risk of crashing (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997). Based on these studies, the National Safety Council estimated that 28% (1.6 million) of all crashes during 2008 were the result of drivers using handheld or hands-free cell phones to talk or text (NSC, 2009). More recently, some researchers have begun to question these estimates. Farmer, Braitman & Lund (2010) point out that with the upsurge in driver cell phone use, crashes should be increasing if the estimated fourfold increase in crash risk associated with phone use is correct. However, fatal crashes in the United States were essentially flat before declining partly as a result of the economic downturn in the late 2000s. Another recent study provides evidence that previous case-crossover studies may have overestimated driving exposure during control periods, thus inflating the estimated crash risk resulting from cell phone use while driving (Young, 2012).

Prevalence of Distracted Driving

Researchers have employed several methodologies to measure the frequency of distracted driver behaviors. A number of studies have relied on self-report. For example, in a nationally representative survey of 4,010 licensed drivers (Royal, 2003), most respondents reported talking with passengers (81%) and changing the radio station or CD (66%) on at least some trips. Half (49%) reported eating or drinking, while fewer reported making calls (25%), dealing with children in the back seat (24%), personal grooming (8%), or reading (4%). The survey was conducted in 2002, before the proliferation of cell phones and other wireless technologies.

The accuracy of self-reported distracted behaviors is questionable. Many drivers may be unaware of how often they engage in these behaviors. Consequently, a number of studies have used observational techniques to examine the prevalence of distracted driving. The vast majority of these studies have focused specifically on the prevalence of cell phone use among drivers (Eby, Vivoda, & St. Louis, 2006; Horberry et al., 2001; Johnson et al., 2004;

NHTSA, 2010c). NHTSA conducts an annual nationwide probability-based observational survey of driver electronic device use. In 2009, 5% of drivers were observed holding cell phones to their ears, and an estimated 9% of drivers were using some type of phone (hand-held or hands-free) for any purpose during daylight hours (NHTSA, 2010c). Observational studies rely on trained data collectors who watch drivers from the roadside. They are limited in several respects, including: (1) observations are generally limited to the daytime; (2) most observations are conducted when vehicles are stopped, even though the frequency of cell phone use and other distracted behaviors may be different when vehicles are stopped than when they are moving (Stutts et al., 2005); (3) some behaviors that occur below shoulder level (e.g., texting) may be difficult for observers to see; and (4) cognitive distraction (e.g., a driver who is upset or lost in thought) cannot be reliably observed.

In recent years, technologic advances have allowed better measurement of distracted driving. Unobtrusive cameras and other recording equipment placed inside vehicles have allowed researchers to directly observe driver behavior. Stutts et al. (2005) installed video cameras in the vehicles of 70 drivers to examine how often drivers engage in potentially distracting behaviors. They found drivers were occupied in one or more distracting behaviors 14.5% of the time while their vehicles were moving. The most common distractions were eating and drinking, internal distractions (e.g., manipulating the vehicle controls or reaching or looking for an object), and distractions outside the vehicle. Many potential distractions were more common when the vehicle was stopped, suggesting drivers were exercising some discretion. There was also evidence that distractions might impair driving performance. For example, distractions were associated with the driver having no hands on the steering wheel or having eyes off the roadway while the vehicle was moving (Stutts et al., 2005).

In another naturalistic study, Klauer et al. (2006) installed cameras and other recording equipment in 100 vehicles and examined whether drivers were distracted just prior to crashes or near-crashes. They also examined the frequency of crashes and near-crashes during "normal" driving to estimate the relative risk of driving when distracted. Some of the highest risk activities included reaching for a moving object, reading, applying makeup, and dialing a hand-held device. Other tasks, such as talking/listening to a hand-held device, entailed less risk. However, the authors also examined the population attributable fraction, which calculates the percent of crashes and near-crashes in the population at-large that could be attributed to secondary tasks. Using this measure, talking/listening to a hand-held device was second highest in degree of risk, only slightly behind dialing a hand-held device. In sum, the number of crashes and near-crashes that can be attributed to cell phones is quite high because cell phone conversations occur much more frequently than other distracting behaviors (Klauer et al., 2006).

Hanowski, Perez and Dingus (2005) conducted a similar study with long-haul truck drivers. The researchers examined critical incidents (defined as crashes, near-crashes or other crash-relevant conflicts) among 41 truck drivers who drove special vehicles that had been modified to collect video and driver performance data. Seven percent of all critical incidents were associated with distraction. The most common distractions during these incidents were looking off to the left or right, reaching for an object in the vehicle, looking at the instrument panel, or adjusting or talking on a Citizens' Band (CB) radio. Interestingly, two of the 41 drivers accounted for 24% of the distraction-related incidents, suggesting large individual differences in the frequency of distracted driving behavior (Hanowski et al., 2005).

Distracted Driving Among Teenagers

Much of the research on distracted driving has concentrated on adults. By contrast, relatively little is known about distracted driving among teenagers. There are several reasons to be especially concerned about teenagers and distracted driving. Young drivers are among the strongest users of cell phones, and they tend to be early adopters and aggressive users of new technology (Lee, 2007). Moreover, distractions likely entail greater risk for novices than more experienced drivers. Driving is less automated for novices; consequently, they must devote more of their attentional capacity to the multiple tasks involved in driving (Lansdown, 2002). With less attentional capacity to spare, they may be more susceptible to a distraction-related crash (Lee, 2007). For drivers of any age, distractions can increase overall cognitive load, which can impair the driver's ability to detect changes in the driving environment (Lamble et al., 1999). With novices, however, the threshold for 'impairment' may be lower since driving requires more cognitive resources (even in the absence of distractions). Finally, research suggests many key areas of the brain are still developing during adolescence, including areas involved in regulatory competence, forming judgments and decision making (Keating, 2007), all of which have important implications for driving. For these reasons, teenage drivers may have greater difficulty than experienced adult drivers in effectively managing potentially distracting behaviors and situations while driving.

Most research on distracted driving among teenagers has focused on one of two issues: the effects of carrying teen passengers and driver cell phone use. A number of studies have shown that passengers substantially increase the risk of a crash for young, novice drivers (Chen et al., 2000; Doherty, Andrey, & MacGregor, 1998; Ouimet et al., 2010; Preusser, Ferguson, & Williams, 1998). However, little is known about the mechanisms behind this heightened crash risk. It is widely assumed that risk taking behavior by teen drivers is more common when same-age passengers are present. Whether passengers actively encourage the driver to take risks, whether drivers simply behave differently in the presence of teen passengers, or whether more risky drivers are more likely to carry passengers, has not been determined. In a naturalistic study of 52 teenage drivers using in-vehicle cameras, Goodwin, Foss and O'Brien (2012) found risky driving behaviors were indeed more common in the presence of passengers. For example, drivers carrying multiple teenage peers were three times as likely as those with no passengers to engage in one or more potentially risky behaviors such as speeding, following too closely, or goofing/showing off with the vehicle. However, passengers encouraged the driver to take risks in only 1% of the video clips when passengers were present. This suggests the mere presence of peers may have been the more important influence on risky driving behaviors than passengers actively encouraging the driver to take risks (Goodwin, Foss, & O'Brien, 2012). However, it is also plausible that "riskier" drivers are more likely to carry multiple peers.

Somewhat different findings were obtained in another recent study also involving instrumented vehicles. Simons-Morton et al. (2011) equipped the vehicles of 42 newly licensed teenage drivers with recording systems that monitored driving performance and vehicle occupants. Teens engaged in *less* risky driving – defined as g-force events high enough to make the passengers uncomfortable – when carrying teenage passengers. However, having friends who tend to be risky (i.e., who smoke, drink alcohol, use marijuana, do not use seat belts, etc.) was associated with rougher driving as well as crash/near crash incidents. The authors conjectured that injunctive norms – the perceived expectations of others – may play a key role in teenage driving risk (Simons-Morton et al., 2011).

Beyond the effects of passengers on risky driving behavior, carrying passengers also has the potential to increase distractions for novice drivers. In self-report surveys, teenagers often acknowledge that passengers can be distracting (Ginsburg et al., 2008; Heck & Carlos, 2008). For example, in a survey of California high school seniors, the most commonly mentioned distractions while driving included talking/yelling among passengers, horseplay and music/dancing (Heck & Carlos, 2008). In the naturalistic study of teenage drivers mentioned previously, Goodwin, Foss and O'Brien (2012) found several potential distractions were more common in the presence of teenage passengers than when a parent/adult was present. Loud conversation was five times more likely when teens were carrying multiple teenage peers, and horseplay was nine times more common. In all, loud conversation and horseplay were observed in 26% and 14%, respectively, of video clips involving multiple teenage peers.

Cell phone use among teenage drivers is another issue that has received considerable attention. Self-report surveys suggest many teens use cell phones at least occasionally while driving (Foss et al., 2009; O'Brien, Goodwin & Foss, 2010; Madden & Lenhart, 2009). In a survey of 320 licensed teen drivers, O'Brien, Goodwin and Foss (2010) found that 45% reported using their phone in some capacity during their most recent trip. Only 12% said they "often" talk on a cell phone while driving, and most reported keeping their conversations short because they were driving. However, 23% of teen drivers said they "often" read text messages while driving. Lerner, Singer and Huey (2008) conducted focus groups with drivers of different ages. In comparison to older drivers, teenagers perceived in-vehicle tasks such as cell phone use to involve less risk, and they had higher opinions of their ability to multitask. In fact, some teens reported enjoying the challenge of multitasking and testing limits.

A few observational studies have examined cell phone use among young drivers. In NHTSA's nationwide observational survey, 8% of drivers judged to be age 16-24 were observed using a hand-held cell phone, compared to 5% of drivers 25-69 and just 1% of drivers 70 and older (NHTSA, 2010c). Foss et al. (2009) conducted observations of more than 15,000 teenage drivers departing from high schools in two states. Approximately 11% of teenage drivers in North Carolina and 13% in South Carolina were observed using a cell phone. Cell phone use was twice as common among drivers who were alone compared to drivers carrying passengers. Also, females were 70% more likely to be using a cell phone than males.

Project Objectives

Although distracted driving among teenagers is of great concern to traffic safety professionals and has received considerable media attention in recent years, rigorous research on this issue has been limited. Most of the research to date has concentrated on the risks associated with teen passengers and driver cell phone use. Almost no research has examined the many other potential driving distractions often believed to be common and problematic among teenage drivers.

In an ongoing study with the AAA Foundation, we collected a sizeable dataset of video data on teen drivers during the provisional licensing stage of GDL. This in-vehicle data provided a unique opportunity to study distracted driver behaviors and potentially distracting conditions among young, beginning drivers. For the present analysis, we sampled and coded video data with the specific purpose of studying the nature and prevalence of distracted driving among teenagers. The study addressed a number of questions:

- Which distracted driver behaviors are most common among teenage drivers?
- Do males and females differ in how often they engage in distracted behaviors, or the kinds of distractions they experience?
- Do distracted driver behaviors vary based on the number of passengers and the characteristics of those passengers (e.g., teens vs. adults vs. young siblings)?
- Are distracted driver behaviors more common during certain times of day or week (e.g., weekday vs. weekend), and do these behaviors bear any relation to the amount of traffic or other characteristics of the driving environment?
- Do drivers who engage in distracted behaviors spend more time looking away from the roadway than drivers who are not distracted?
- Are distracted driver behaviors associated with serious incidents such as near collisions, or events involving hard braking or swerving?

By gaining a better understanding of the frequency and nature of distracted driver behaviors and distracting conditions, more effective interventions can be developed. Beyond restricting passengers and cell phone use by young drivers, interventions to address distracted driving have been largely non-existent. Even those pertaining to cell phones and passengers are based only on evidence of their contribution to increased crash risk and reflect virtually no understanding of how these situations create risk, how commonly they occur, and how they are distributed across the teenage driving population. Vehicle-based interventions, such as lane-departure and forward-collision warning systems, that may help to prevent many distracted driving crashes are now being developed. However, behavioral and policy interventions to address distracted driving remain limited.

Methods

To examine distracted driver behaviors and distracting conditions among teenage drivers, we used data collected during an earlier, naturalistic study of teen driving behavior (Goodwin, Foss, Margolis & Waller, 2010; Goodwin, Foss & O'Brien, 2011). Event-based data recorders were placed in the vehicles of participating families at the outset of the learner stage so parent and teen behaviors during practice sessions could be directly observed. The data recorders were returned to family's vehicles during the initial 6 months of unsupervised driving, a very high risk time for new drivers (Foss, Martell, Goodwin, & O'Brien, 2011; Lewis-Evans, 2010; Masten & Foss 2010). The data reported in the present study are from this initial period of independent driving. Because these vehicles were sometimes shared, we also have data on some more experienced teen drivers – the siblings of the original target teen. It is important to note this was a "naturalistic" study of teen driving behavior. No interventions were conducted with participating families. All aspects of the study were approved by the University of North Carolina Institutional Review Board.

Sample of Teenage Drivers

Fifty families were recruited through two Division of Motor Vehicles (DMV) offices in central North Carolina at the time teens applied for a learner's permit.[1] Of these, 38 families agreed to continue participating when the teen obtained an intermediate (restricted) license. In 14 of the 38 families, an older high-school aged sibling shared the vehicle with the original "target teen." Driving data for these siblings were included in the present analyses, raising the total sample to 52 teenage drivers.

The 38 "target" teens were paid $200 for participating in this second phase of the study. This incentive was distributed in four graduated payments to encourage teen participation for the full six months. Siblings did not receive compensation.

Event-Based Data Recorders

Event-based data recorders were installed in the family vehicle most often driven by the new teen driver, usually within one week of the date of licensure. They remained in the vehicle for six months. The event-based data recorders were obtained from DriveCam. The DriveCam recorder is a palm-sized camera that captures video, audio and g-force information that describes vehicle movements. The camera is mounted on the windshield behind the rearview mirror and has two lenses – one is forward facing to capture the scene in front of the vehicle, and the second faces rearward to record activity inside and behind the vehicle. Although the recorder runs continuously, it only saves information when a triggering "event" such as sudden braking or an abrupt turn occurs. Once triggered, it saves the 10 seconds preceding and 10 seconds following the event. Thus, the nature of the triggering event, as well as occupants' responses, can be viewed. The sensitivity of the data recorder (i.e., the change in g-force required to trigger the unit to record) is adjustable. The thresholds employed for the present study were 0.40 for longitudinal (forward/rearward) g-forces and 0.45 for lateral (sideways) g-forces. These matched the sensitivity settings employed during the initial phase of the study when teens were driving under supervision.

[1] See Goodwin et al. (2010) for a detailed description of the recruitment procedures.

Generally, these thresholds are more sensitive than other studies employing similar event-based data recorders. For example, another recent study of newly licensed teen drivers used threshold settings of .50 and .55 for longitudinal and lateral g-forces, respectively (McGehee, Raby, Carney, Lee, & Reyes, 2007). Highly sensitive settings were used in the present study to capture more normal or routine moments of driving as well as serious incidents. At these settings, it is unlikely passengers would feel uncomfortable or notice anything unusual had occurred for most recorded events. In fact, in the initial phase of the study two-thirds (67%) of all recorded events appeared to go unnoticed by parents and teens (Goodwin et al., 2010).

Selection of Video Clips for Full Coding

During the 228 total months data recorders were installed in vehicles during the intermediate license stage (6 months x 38 vehicles), 29,920 individual driving clips were recorded. Because vehicles were sometimes shared with other family members, each driving clip was screened to identify the driver and passengers.[2] In total, 24,085 driving clips were recorded for the 52 teens in the study (19,384 from target teens; 4,701 from high school age siblings). In the remaining clips, the driver was a parent, other adult, friend, older sibling, or someone else. On average, there were 463 clips per teen driver, ranging from 17 to 1,028. The average number of clips recorded by target teens (510) was noticeably higher than the number of clips recorded by siblings (336).

Because coding clips is a labor-intensive, time-consuming process, a sample of teen driver clips from the intermediate license stage was selected for coding. To ensure the findings were not biased toward the teens who recorded the most clips, a cap was set on the total number of clips selected for each of the participating drivers. Table 1 shows the maximum number of clips selected from any driver, based on the combination of passengers in the vehicle. Initial screening of clips to identify the driver and passengers revealed that teens carried passengers in a minority of clips. Consequently, clips with passengers were oversampled to ensure a sufficient sample size for comparisons between different combinations of passengers (e.g., driving with teenage peers versus siblings or parents).

Table 1

Maximum Number of Driving Clips per Driver
Selected for Coding by Passenger Combination

Passenger combination	Max clips
No passengers	60
One teenage peer	50
Two or more teenage peers	100
One sibling	50
Two or more siblings	70
Teenage peer(s) & sibling(s)	50
Adults†	35

† Adult(s) includes any clip where an adult passenger was present.

[2] Because we had tracked families from the beginning of the learner stage, we were able to identify whether the vehicle occupants were "target teens," siblings, parents, or non-family members.

Driving clips were randomly selected within each passenger combination for each participating teen driver up to the pre-determined maximum number of cases. If a driver had fewer than the maximum number of clips for a certain passenger combination, all clips with that combination were selected. The median number of clips selected per teen was 151 (ranging from 17 to 315). In total, 7,858 driving clips from the 52 teen drivers were selected for full coding.

Coding Scheme

A coding scheme was developed to analyze the selected video clips. For each clip, we coded several background details including:

- Month, day and year
- Hour and minute
- Max forward g-force
- Max lateral g-force
- Total number of vehicle occupants

When passengers were present, we coded the sex, age, relation, and belt use of each passenger. For passenger age and relation, the following categories were used: teenage sibling, teenage non-sibling, child sibling, child non-sibling, parent, other adult, can't determine. "Teenagers" were defined as passengers between the age of 13 and 20; "child" included anyone younger than 13. In many cases, the exact age of siblings was known. With peers, however, judgment was occasionally required in making age determinations.[3] Finally, because it was sometimes difficult to determine the identity of a passenger due to darkness or other circumstances, a "can't determine" category was included for each of the passenger variables.

We also coded a number of distractions and distracted driver behaviors. Table 2 shows potential distractions that were coded in all driving clips. For each of the coded variables, a definition or description of the variable is provided, along with the coded categories. The behavior was coded if it occurred at any point during the clip, unless otherwise noted. Each variable was coded separately so multiple distractions could be coded within each clip.

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[3] The same passengers often appeared multiple times in clips. The repeated exposures, along with the conversation between driver and passengers, often helped to clarify the approximate age of passengers.

Table 2

Distracted Driver Behaviors Coded in All Driving Clips

Variable name	Definition or description	Categories
Communicates with someone outside vehicle (driver)	Driver communicates with or toward someone outside vehicle.	No Yes
Reading (driver)	Reading or looking at papers or maps. Only coded if done while moving.	No Yes
Reaching for object in vehicle (driver)	Moving body, not just arm. Only coded if done while moving.	No Yes
Adjusting controls (driver)	Moving body, not just arm. Only coded if done while moving.	No Yes
Eating or drinking (driver)	Handling food or drink. Not chewing gum. Only coded if done while moving.	No Yes
Personal hygiene (driver)	Combing hair, looking at self in mirror, etc. Only coded if done while moving.	No Yes
Turning around (driver)	Turns more than head. Only coded if done while moving and not driving related (for example, would not include backing up or checking traffic).	No Yes
Electronic device use (driver)	Electronic device use. Only coded if done while vehicle is moving.	No Holding cell phone to ear Talking on a hands-free phone Observed operating an electronic device (e.g., dialing, texting, GPS) Suspected operating an electronic device

Note that many of the potentially distracting behaviors were only coded *while the vehicle was moving.* A distraction or distracting behavior could not be expected to influence driving behavior (or increase crash risk) when the vehicle is stopped at a red light or otherwise not moving.

Table 3 shows additional distracting conditions that were coded only when a passenger was present in the vehicle (peer, sibling, parent, etc.).

Table 3

Distracting Conditions Coded Only When a Passenger Was Present

Variable name	Definition or description	Categories
Loudness of conversation	Includes singing.	No conversation Normal Loud
Horseplay	Rowdy, rough or boisterous behavior by vehicle occupants.	None Mild Rough
Horseplay – persons involved	Who is involved in the horseplay.	Driver is active Driver is passive (recipient) Passengers only
Communicates with someone outside vehicle (passenger)	Passenger communicates with or toward someone outside vehicle.	No Yes
Dancing (passenger)	Passenger is dancing at any point during clip. Only coded if done while vehicle is moving.	No Yes
Physical contact	Contact involving the driver (kissing, handholding, pushing, etc.).	None Affectionate – driver is active Affectionate – driver is passive (recipient) Non-affectionate – driver is active Non-affectionate – driver is passive (recipient)

Finally, two variables concerning the characteristics of the driving setting were coded for each clip. These are described in Table 4.

Table 4

Characteristics of the Driving Setting

Variable name	Definition or description	Categories
Amount of traffic	Amount of traffic prior to the event.	None Light Moderate Heavy N/A (e.g., parking lot)
Pavement condition		Dry Wet (no wipers) Raining (wipers on)

Data Weighting and Analysis

Odds ratios (OR) were estimated using univariate logistic regression. Ninety-five percent confidence intervals (95% CIs) are provided for each OR. In addition, the ratio of the upper to lower 95% confidence interval – the Confidence Limit Ratio (CLR; Poole, 2001) – is reported to give an indication of the precision of the point estimate (OR) and to provide a convenient way to compare the relative precision of ORs. Because the present study is both non-experimental and largely exploratory, tests of statistical significance are rarely reported. In recent years, there has been a movement away from using null-hypotheses significance testing for studies that do not involve true experimentation (Goodman, 1999; Poole, 2001; Savitz, 2003; Schwab et al., 2011; Stang, Poole, & Kuss, 2010).[4]

Clips with teen passengers were oversampled; hence, it was necessary to weight the final dataset of coded clips. The case weights are simply the inverse of the probability of selection based on the known passenger distributions of the full sample of teen driver clips (N=24,085). Because multiple clips were coded for each driver, all analyses took this clustering of measures within driver into account to ensure that standard errors (hence, confidence intervals) were correctly estimated. Finally, in some cases data are missing due to darkness of the clip or other circumstances that prevented clear determination of passenger presence or characteristics, so the counts in the tables do not always total 7,858.

[4] By referring to the ORs and confidence intervals, readers can conduct their own significance tests, testing against a range of possible alternate hypotheses in addition to the conventional – but often substantively meaningless – hypothesis of "no relationship/no difference" (the latter is accomplished by simply looking at whether the confidence interval includes 1.00).

Results

Characteristics of Participating Teenage Drivers

All of the 52 participating teenage drivers were high school students. Sixty-three percent (63%) were age 16 when we began recording their driving behaviors, 17% were age 17, and 19% were age 18. Participants were predominantly female (69%). A majority of the sample drove a passenger car (56%). Fewer drove an SUV (17%), minivan (15%) or pickup truck (12%).

Frequency of Distracted Driver Behaviors

In this section, we first examine the frequency of electronic device use among drivers. We then examine the frequency of a variety of other distracted driver behaviors such as reaching for objects, adjusting controls, eating/drinking, and turning around.

<u>Electronic Device Use</u>
Information on the frequency of electronic device use among drivers is presented in Table 5. Because previous studies suggest electronic device use may be more common among females than males (Foss et al., 2009; NHTSA, 2010c), findings are shown separately by sex.

In total, teenage drivers were observed using an electronic device in 6.7% of all driving clips. Nearly twice as many were operating (or suspected of operating) an electronic device than were observed holding a cell phone to their ear (4.3% versus 2.3% of clips). There were noticeable differences in electronic device use by sex. Females were twice as likely as males to be using an electronic device. The difference between males and females was observed for each type of electronic device use.

Table 5

Percent of Recorded Teenage Driving Clips in Which Electronic Device Use by Drivers and Other Distracted Driver Behaviors Were Observed, by Sex of Driver

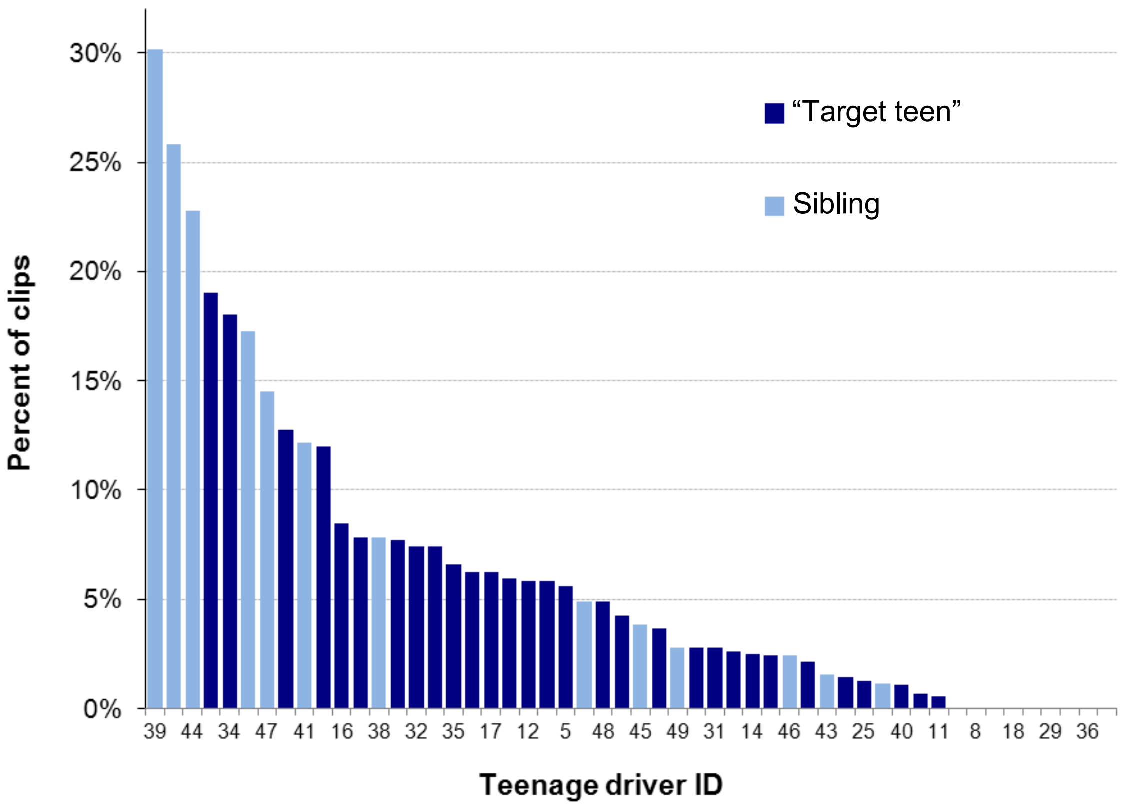
	Overall (N=7,858 clips)		Female driver (N=5,434 clips)		Male driver (N=2,424 clips)		Female/male comparison	
	N	% of clips	N	% of clips	N	% of clips	Odds Ratio (95% CI)	CLR
Electronic device use by drivers								
Holding cell phone to ear	178	2.3%	157	2.9%	21	0.9%	3.30 (2.10, 5.18)	2.47
Talking on hands-free phone	4	0.1%	4	0.1%	0	0.0%	---	
Operating an electronic device (e.g., texting)	97	1.2%	82	1.5%	15	0.6%	2.42 (1.39, 4.18)	3.01
Suspected operating an electronic device	244	3.1%	184	3.4%	60	2.5%	1.36 (1.02, 1.81)	1.77
Any electronic device use	**523**	**6.7%**	**427**	**7.9%**	**96**	**4.0%**	**1.96 (1.58, 2.44)**	**1.54**
Other distracted driver behaviors								
Adjusting controls	471	6.2%	352	6.7%	119	5.0%	1.33 (1.09, 1.63)	1.50
Personal hygiene	287	3.8%	207	4.0%	80	3.4%	1.16 (0.90, 1.50)	1.67
Eating or drinking	211	2.8%	154	2.9%	57	2.4%	1.22 (0.90, 1.64)	1.82
Reaching for object in vehicle	191	2.5%	146	2.8%	45	1.9%	1.47 (1.05, 2.04)	1.94
Communicates with someone outside vehicle	113	1.5%	71	1.3%	42	1.7%	0.77 (0.53, 1.12)	2.11
Turning around	71	0.9%	36	0.7%	35	1.5%	0.47 (0.29, 0.74)	2.55
Reading	8	0.1%	6	0.1%	2	0.1%	1.35 (0.27, 6.71)	24.85
Any distracted behavior†	**1,186**	**15.1%**	**848**	**15.6%**	**338**	**13.9%**	**1.12 (1.00, 1.26)**	**1.26**

† Drivers could engage in more than one potentially distracting behavior during a clip. Consequently, the total N for “Any distracted behavior” does not equal the sum of the individual distracted behaviors.

Note. In some cases data are missing due to darkness of the clip or other circumstances that prevented clear determination of electronic device use or other distracted driver behaviors. CLR = upper-to-lower confidence limit ratio.

The frequency of electronic device use varied considerably by driver, as shown in Figure 1. Nine drivers (17%) did not use an electronic device in any of their driving clips. By comparison, six drivers (12%) were observed using an electronic device in over 15% of their clips. The median use was 4% of clips.

Figure 1. Percent of Clips with Any Electronic Device Use, by Teenage Driver



Electronic device use was twice as high among the slightly older and more experienced high school age siblings than among "target teens" (11.2% versus 5.1%; OR=2.19, 95% CI=1.86, 2.58, CLR = 1.37). All but one of the 14 siblings were observed using an electronic device in at least one driving clip. By comparison, eight of the 38 target teens did not use an electronic device in any of their clips.

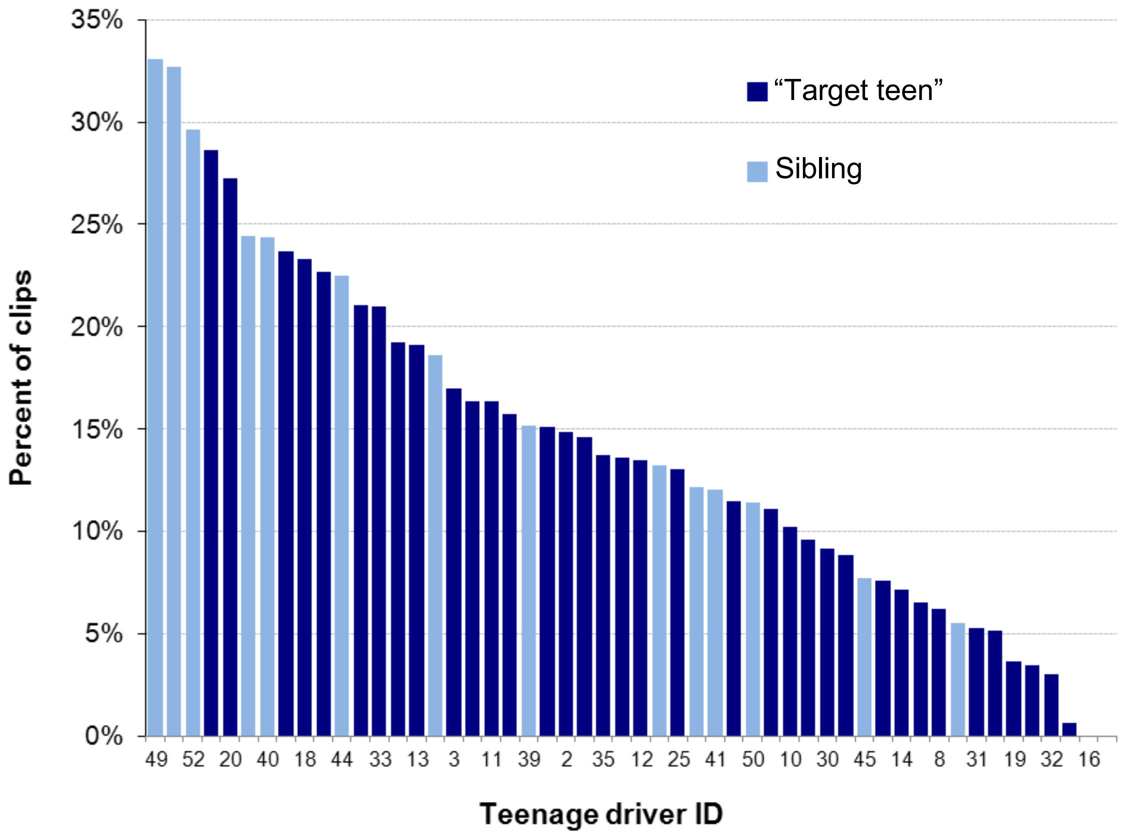
<u>Other Distracted Driver Behaviors</u>

Information on the frequency of distracted driver behaviors, other than using electronic devices, is also shown in Table 5. All of the behaviors we examined were relatively rare. Adjusting controls in the vehicle was the most common behavior; reading was the least common. Females were more likely than males to be observed adjusting controls or reaching for objects in the vehicle. Males were approximately twice as likely as females to turn around while driving. Altogether, excluding use of electronic devices, teenage drivers engaged in at least one of the distracted driver behaviors in 15.1% of all driving clips (see Table 5). When all distracted driver behaviors were combined, the percent of driving clips involving one of these behaviors was slightly higher among females than males (15.6%

versus 13.9%; OR=1.12, 95% CI=1.00, 1.26, CLR = 1.26), and higher among high school age siblings than “target teens” (17.6% versus 14.2%; OR=1.24, 95% CI=1.11, 1.39, CLR = 1.25).

Once again, the frequency of distracted behaviors varied considerably by driver, but the incidence was not concentrated so heavily among a small subset of drivers as was the case with use of an electronic device. Figure 2 shows the percent of clips in which each of the 52 teenage drivers were engaged in at least one potentially distracting behavior.

Figure 2. Percent of Clips with at Least One Distracted Driver Behavior (Excluding Electronic Devices), by Teenage Driver



As illustrated, two teens were not observed engaging in a distracted driver behavior during any of their recorded clips. By contrast, five drivers engaged in a distracted driver behavior in more than 25% of their clips. This suggests substantial individual differences in the frequency of these behaviors. The median percent of clips involving a distracted driver behavior was 13.5%.

Passengers and Distractions

Research shows carrying passengers is associated with higher crash risk for young, novice drivers. In this section, we first examine how often drivers were observed carrying passengers. We then consider the frequency of potentially distracting conditions, such as loud conversation and horseplay, which can only occur when passengers are present.

Finally, we examine how potentially distracting conditions are related to various combinations of passengers (teens vs. siblings vs. adults).

Frequency of Carrying Passengers

Information about the presence and combination of passengers is presented in Table 6. In almost two-thirds of all clips, there were no passengers. A teenage peer was present in about 20% of clips, and siblings were present in almost 15% of clips. Adults were present in only 3% of clips. The vast majority (90%) of adults in these clips were parents. Note that clips with an adult present may have also included various combinations of peers, siblings and other adults.

Table 6 also shows the distribution of passengers based on the sex of the driver. Females were somewhat more likely to have passengers in general. However, males were noticeably more likely to carry multiple peers.

Frequency of Distracting Conditions Involving Passengers

Passengers can distract young drivers, or create a potentially distracting environment, in many different ways. The observed frequency of potentially distracting conditions involving passengers is presented in Table 7. Since none of these is possible in the absence of a passenger, they were coded only for clips in which passengers were present.

Loud conversations were evident in 12.2% of driving clips when passengers were present. Horseplay was less common, at 6.3% of clips. When horseplay was observed, the driver was an active participant just over half the time (3.7% of clips). Other potentially distracting conditions, such as dancing by passengers or physical contact between the driver and passengers, were quite rare. There were few, if any, notable differences for male and female drivers in distractions involving passengers.

Table 6

Passenger Combination by Driver Sex

	Overall (N=7,858 clips)		Female driver (N=5,434 clips)		Male driver (N=2,424 clips)		Female/male comparison	
	N	% of clips	N	% of clips	N	% of clips	Odds ratio (95% CI)	CLR
No passengers	5,142	65.4%	3,508	64.6%	1,634	67.4%	1.04 (1.01, 1.08)	1.07
One teenage peer	1,027	13.1%	743	13.7%	284	11.7%	1.17 (1.03, 1.33)	1.29
Two or more teenage peers	322	4.1%	175	3.2%	147	6.1%	0.53 (0.43, 0.66)	1.53
One sibling	885	11.3%	638	11.7%	247	10.2%	1.15 (1.00, 1.32)	1.32
Two or more siblings	53	0.7%	38	0.7%	15	0.6%	1.13 (0.62, 2.05)	3.31
Teenage peer(s) & sibling(s)	160	2.0%	137	2.5%	23	0.9%	2.66 (1.71, 4.12)	2.41
Parent or other adult present	269	3.4%	195	3.6%	74	3.1%	1.18 (0.90, 1.53)	1.70

Abbreviations: CLR = upper-to-lower confidence limit ratio.

Table 7

Percent of Recorded Teenage Driving Clips in Which Potentially Distracting Conditions Involving Passengers Were Observed, by Sex of Driver

	Overall (N=7,858 clips)		Female driver (N=5,434 clips)		Male driver (N=2,424 clips)		Female/male comparison	
	N	% of clips	N	% of clips	N	% of clips	Odds Ratio (95% CI)	CLR
Loud conversation	406	12.2%	309	12.8%	97	10.6%	1.21 (0.98, 1.51)	1.54
Horseplay (mild or rough)	170	6.3%	111	5.8%	59	7.6%	0.77 (0.56, 1.04)	1.86
Passenger communicates with someone outside vehicle	30	1.1%	17	0.9%	13	1.7%	0.53 (0.26, 1.09)	4.19
Passenger dancing	40	1.5%	32	1.7%	8	1.0%	1.61 (0.75, 3.48)	4.64
Physical contact – affectionate	17	0.6%	9	0.5%	8	1.0%	0.46 (0.18, 1.18)	6.56
Physical contact – non-affectionate	7	0.3%	4	0.2%	3	0.4%	0.54 (0.12, 2.41)	20.08

Note. In some cases data are missing due to darkness of the clip or other circumstances that prevented clear determination of passenger behaviors. CLR = upper-to-lower confidence limit ratio.

Distracting Conditions and Passenger Combination

In all likelihood, the frequency of potentially distracting conditions depends not only on the presence of passengers, but also on *who* those passengers are. Hence, we examined how the frequency of driver electronic device use and other distracted driver behaviors was related to the combination of passengers. The findings are presented in Table 8. The variable "other distracted driver behavior" counts whether any of the seven distracted behaviors described previously (adjusting controls, personal hygiene, etc.) were observed in the clip. Most of the individual distracted driver behaviors were too rare to examine their separate association with different combinations of passengers. Table 8 also provides odds ratios showing how much more likely – or less likely – distracted behaviors are with certain passenger combinations. For these comparisons, the reference group is driving clips with no passengers.

Table 8

Association of Driver Electronic Device Use and Other Distracted Driver Behaviors with Passenger Combination

	%	Odds Ratio (95% CI)	CLR
Driver electronic device use			
No passengers	8.1%	1.00 (reference)	
One teenage peer	3.5%	0.40 (0.29, 0.55)	1.90
Two or more teenage peers	5.3%	0.66 (0.44, 0.99)	2.25
One sibling	5.0%	0.60 (0.38, 0.96)	2.53
Two or more siblings	9.4%	1.11 (0.33, 3.77)	11.42
Teenage peer(s) & Sibling(s)	3.8%	0.48 (0.30, 0.77)	2.57
Parent or other adult present	1.1%	0.12 (0.06, 0.25)	4.17
Other distracted driver behavior†			
No passengers	16.9%	1.00 (reference)	
One teenage peer	12.3%	0.69 (0.56, 0.85)	1.52
Two or more teenage peers	19.0%	1.15 (0.84, 1.57)	1.87
One sibling	10.9%	0.60 (0.47, 0.77)	1.64
Two or more siblings	8.9%	0.48 (0.34, 0.67)	1.97
Teenage peer(s) & Sibling(s)	9.3%	0.50 (0.34, 0.75)	2.21
Parent or other adult present	4.2%	0.21 (0.14, 0.34)	2.43

† Other distracted driver behavior includes any of the following: adjusting controls, personal hygiene, eating or drinking, reaching for object in vehicle, communicates with someone outside vehicle, turning around or reading.

Note. N = 7,858 clips. However, in some cases data are missing due to darkness of the clip or other circumstances that prevented clear determination of electronic device use or other distracted driver behaviors. CLR = upper-to-lower confidence limit ratio.

Generally speaking, electronic device use and other distracted driver behaviors were most common when teens were carrying *no* passengers. Teen drivers used an electronic device in 8.1% of clips and engaged in other distracted behaviors in 16.9% of clips when driving alone. Not surprisingly, these behaviors were least common when a parent or other adult was in the vehicle. It is also noteworthy that the use of an electronic device was particularly low in the presence of a single teenage peer (60% less likely than when a driver was alone).

Table 9 examines the association of loud conversation and horseplay with various combinations of passengers. Because loud conversation and horseplay could only occur when passengers were present, we used cases with one teenage peer as the reference group.

Table 9

Association of Loud Conversation and Horseplay with Passenger Combination

	%	Odds Ratio (95% CI)	CLR
Loud conversation			
One teenage peer	15.0%	1.00 (reference)	
Two or more teenage peers	27.1%	2.11 (1.62, 2.75)	1.69
One sibling	5.5%	0.33 (0.21, 0.52)	2.48
Two or more siblings	8.9%	0.55 (0.23, 1.33)	5.87
Teenage peer(s) & Sibling(s)	18.5%	1.29 (0.82, 2.02)	2.46
Parent or other adult present	6.7%	0.41 (0.26, 0.63)	2.42
Horseplay (mild or rough)			
One teenage peer	7.1%	1.00 (reference)	
Two or more teenage peers	16.3%	2.53 (1.73, 3.69)	2.13
One sibling	2.3%	0.30 (0.16, 0.57)	3.56
Two or more siblings	7.4%	1.04 (0.29, 3.71)	12.79
Teenage peer(s) & Sibling(s)	10.5%	1.53 (0.93, 2.52)	2.71
Parent or other adult present	1.8%	0.24 (0.08, 0.71)	8.88

Note. Loud conversation and horseplay were only coded when passengers were present, so a "no passenger" comparison was not possible. N = 2,717 clips. CLR = upper-to-lower confidence limit ratio.

Compared to when only one teenage peer was in the vehicle, loud conversation and horseplay were more than twice as likely when teens were carrying multiple teenage peers. Conversely, the likelihood of loud conversation and horseplay were markedly less likely with one sibling passenger or when a parent/adult was present.

Distractions and Characteristics of the Driving Setting

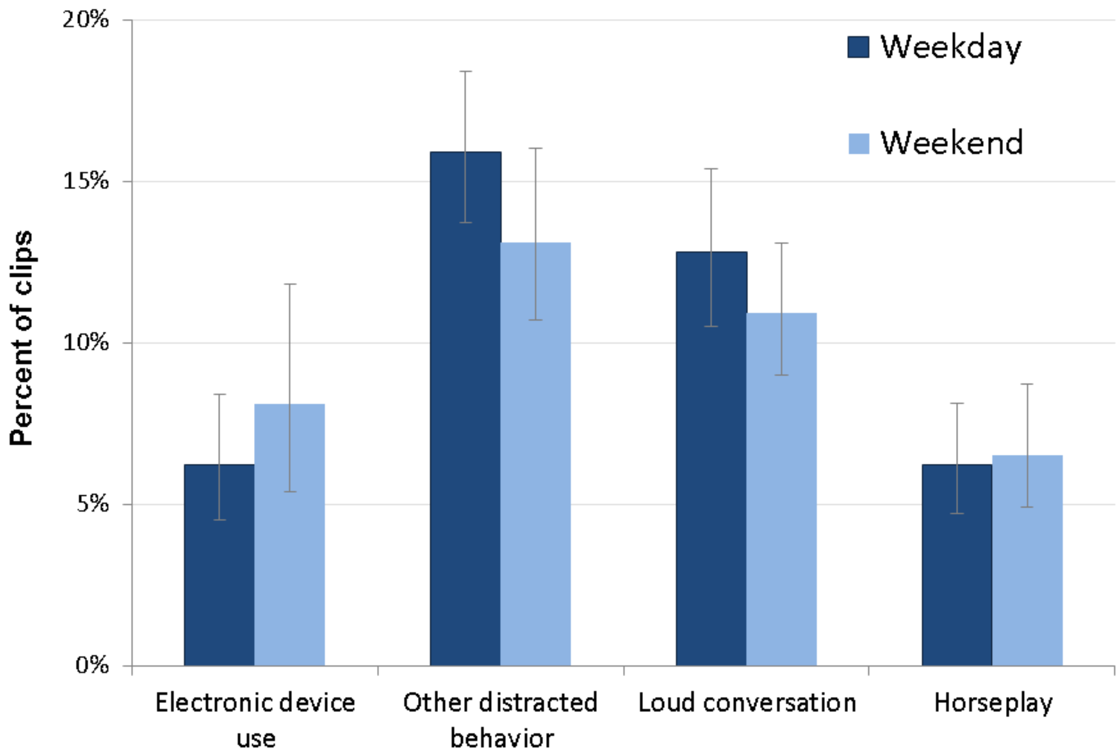
In this section, we investigate how the frequency of distracted driver behaviors and distracting conditions vary as a function of the driving environment. As mentioned previously, many distracted driver behaviors are quite rare. To ensure an adequate sample size for the analyses, only the following variables were examined: electronic device use, other distracted driver behavior (adjusting controls, eating/drinking, etc.), loud conversation and horseplay.

Day of Week and Time of Day

Research shows that fatal crash risk is higher at night for teenage drivers (Williams, 2003). Moreover, crash risks are particularly high when teenagers combine nighttime driving with passengers on weekends (Doherty, Andrey, & MacGregor, 1998). Although distractions are believed to be common in this setting, this assumption has not previously been examined.

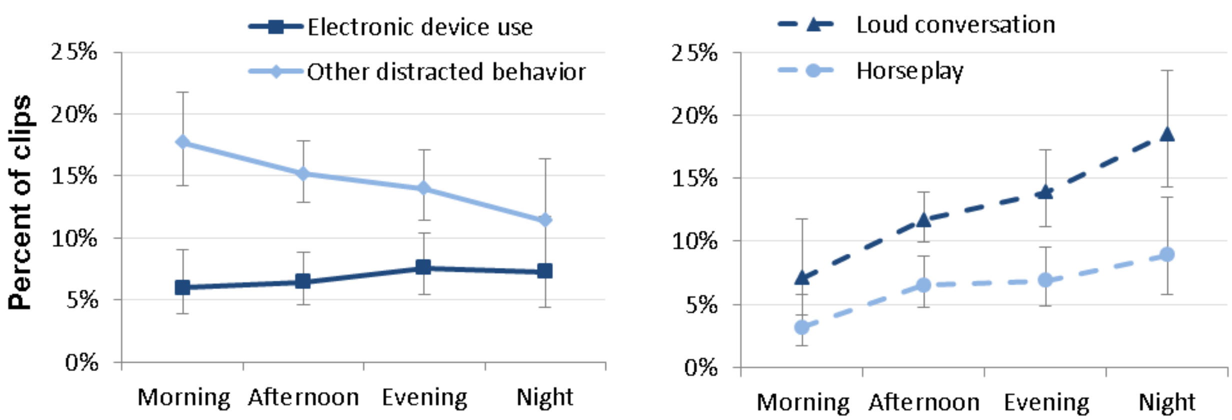
Figure 3 shows the frequency of various distracted driver behaviors and distracting conditions on weekdays and weekends. For this analysis, "weekend" was defined as 6 p.m. Friday through 5:59 p.m. Sunday. Error bars in the figure represent the 95% confidence interval.

Figure 3. Distracted Driver Behaviors and Distracting Conditions by Time of Week



There was no clear pattern of distractions, with some slightly more common on weekends, others more frequent on weekdays. All the differences are quite small. Information about the frequency of distracted behaviors and distracting conditions by time of day is displayed in Figure 4. "Morning" was defined as 6 a.m. to 11:59 a.m., "afternoon" as 12 p.m. to 5:59 p.m., "evening" as 6:00 p.m. to 8:59 p.m., and "night" as 9:00 p.m. to 5:59 a.m.

Figure 4. Distracted Driver Behaviors and Distracting Conditions by Time of Day



Electronic device use by teenage drivers changed little over the course of the day, whereas other distracted driver behaviors (adjusting controls, eating/drinking, etc.) showed a small, gradual decline. By contrast, loud conversation and horseplay seemed to increase, especially at night. Finally, in the specific setting of driving at night on weekends with one or more teenage peers (and no adults or siblings), loud conversation was observed in 20.2% of clips and horseplay was observed in 11.2% of clips.

Amount of Traffic and Inclement Weather

A few studies suggest drivers may be more likely to engage in potentially distracting activities when the driving environment seems "safer" (Atchley, Atwood, & Boulton, 2011; O'Brien, Goodwin, & Foss, 2010; Stutts et al., 2005). Consequently, we examined whether distracted behavior was less common in more challenging conditions such as busy traffic or rain.

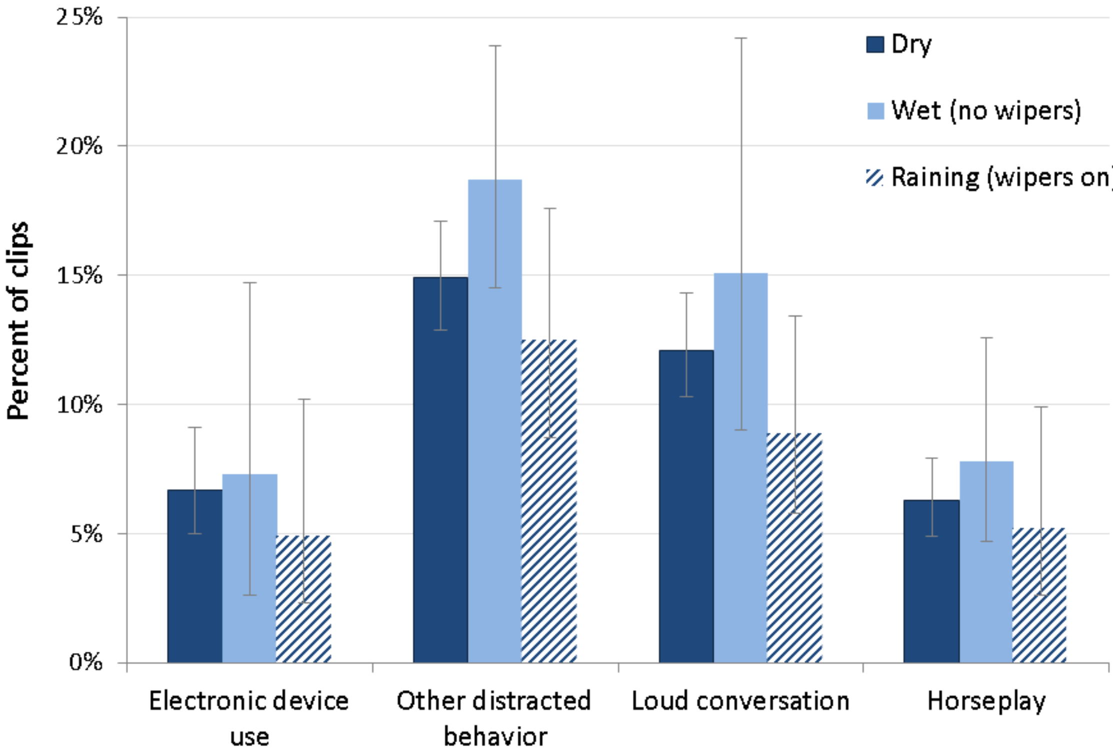
The amount of traffic on the roadway was coded for every driving clip. Twenty-nine percent (29%) of clips were judged to have no traffic,[5] 50% to have light traffic, 15% moderate traffic, and 0.3% heavy traffic. Another 6% of clips occurred in parking lots, driveways, or other roads without free flowing traffic (these were excluded from the following analysis). Because clips with heavy traffic were so rare, clips with heavy and moderate traffic were combined.

Overall, there was no clear relationship between the frequency of distracted driver behaviors or distracting conditions and the amount of traffic. The frequency of distractions was relatively similar in light or moderate/heavy traffic, or when there was no traffic. This suggests drivers did not modulate their electronic device use or other distracted behaviors based on the amount of traffic, at least in light to moderate traffic.

The pavement condition was also coded in all driving clips. The pavement was judged to be dry in 89% of clips. In 7% of clips, the pavement was wet (no wipers), and it was raining (wipers on) in 4% of clips. Distracted driver behaviors and distracting conditions by pavement condition are shown in Figure 5.

[5] "No traffic" denotes clips where no vehicles were visible in front of, or behind, the driver. Although the camera did not show vehicles directly to the side, it is unlikely that vehicles were hidden from the camera for the entire 20 second clip.

Figure 5. Distracted Driver Behaviors and Distracting Conditions by Pavement Condition



The frequency of all distracted driver behaviors and distracting conditions was slightly lower during rain. However, the differences are relatively small and the confidence intervals are quite large.

Distractions and Looking Away from the Roadway

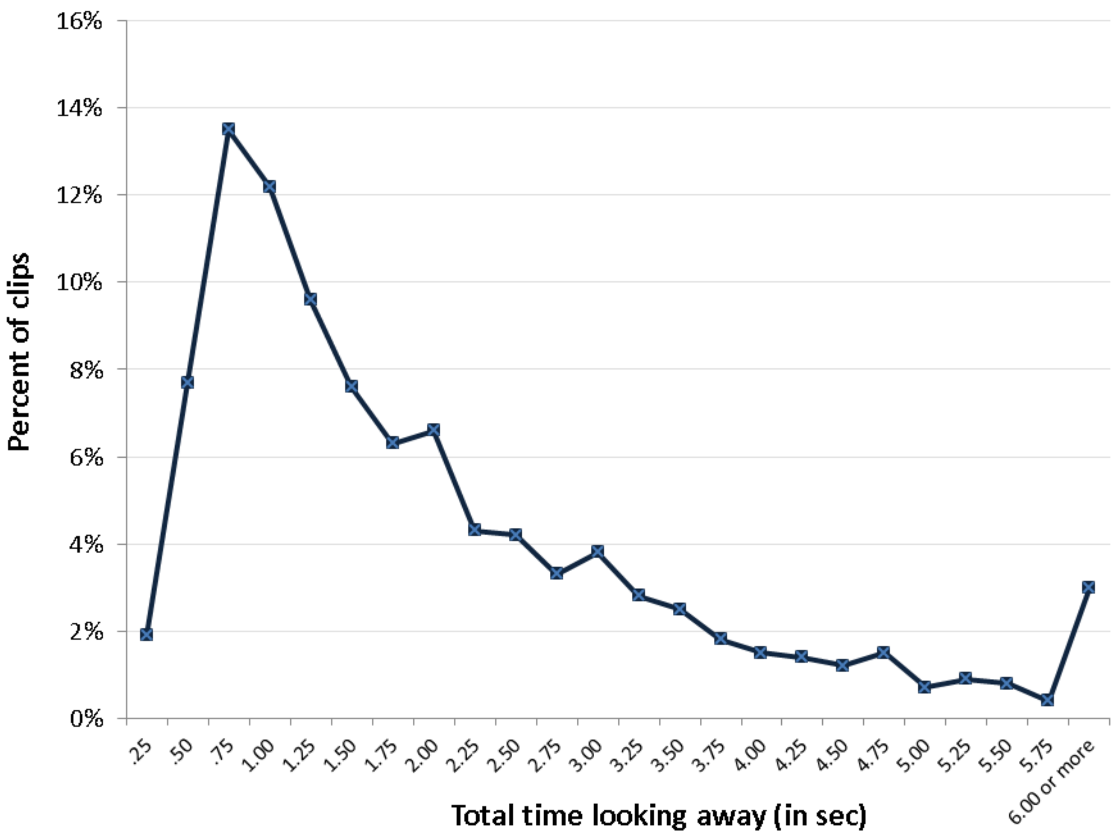
Stutts et al. (2005) found that distractions such as dialing/answering a cell phone, manipulating audio controls and grooming were associated with (adult) drivers not looking at the roadway. In the present study, we also examined the relationship between distractions and inattention to the roadway.

We first coded whether the driver looked away from the roadway at any point during the 10 seconds preceding the vehicle movement that triggered the camera to record. "Looks away" included any unnecessary look downward, at a passenger, or elsewhere apparently unrelated to driving. Hence, glances in the rearview mirror or looking in the direction of a turn did not qualify as looking away. Clips recorded during a pause in driving (e.g., sitting at a stop light) were excluded from the analysis. In addition, 14% of clips were excluded due to darkness of the clip, drivers wearing sunglasses, or other circumstances that prevented clear determination of where the driver was looking.

Drivers looked away from the roadway, at least briefly, in 45% of the driving clips where the vehicle was moving and a clear determination could be made of where the driver was looking. Females were somewhat more likely to look away from the roadway than males (45.8% versus 42.8%; OR=1.07, 95% CI=1.01, 1.14, CLR = 1.13). Looking away was also more common among the slightly older and more experienced high school age siblings than among "target teens" (51.1% versus 42.7%; OR=1.20, 95% CI=1.13, 1.27, CLR = 1.12).

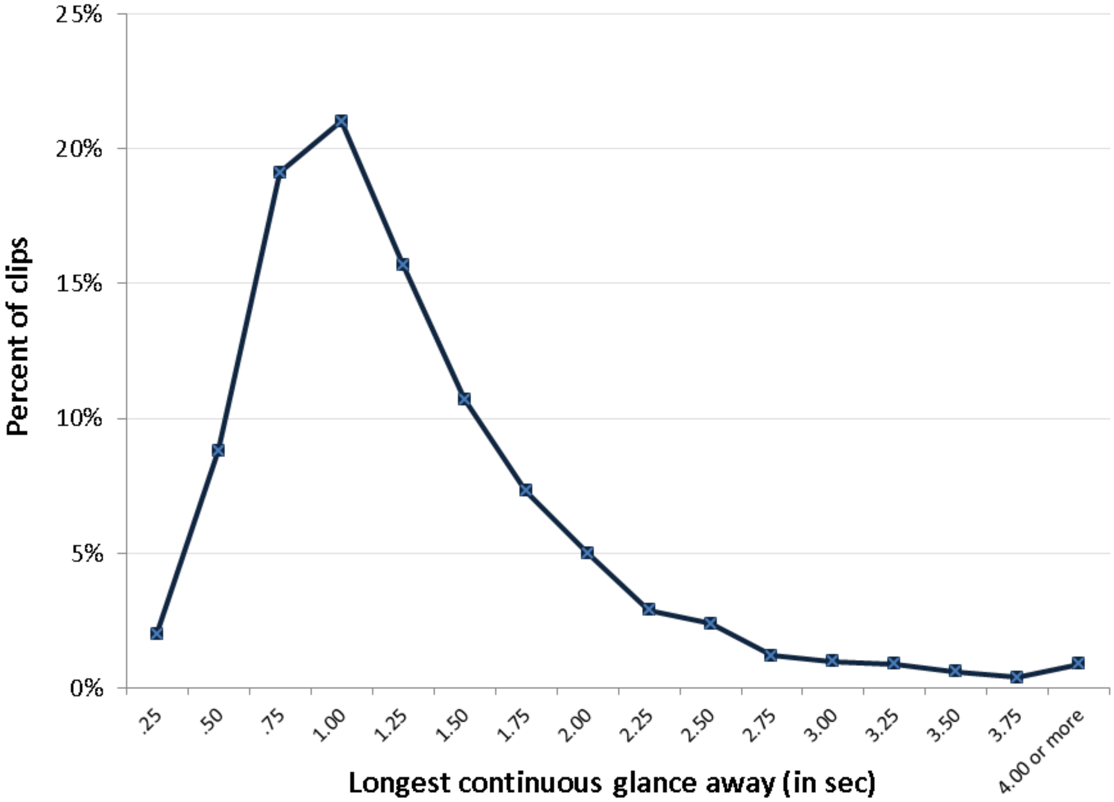
We next calculated the total amount of time that drivers looked away from the roadway during the 10 seconds preceding the event (see Figure 6). Because the event-data recorders capture a still image four times per second, the total time looking away was coded in .25 second intervals. Most drivers who looked away from the roadway did so only briefly. A third (35%) of drivers who looked away did so for one second or less. A similar proportion (31%) looked away for 1.25 to 2 seconds. However, it is noteworthy that 12% of drivers looked away from the roadway for at least four seconds during the 10 second period prior to the event. The median amount of time that drivers looked away was 1.50 seconds.

Figure 6. Distribution of Total Amount of Time Drivers Looked Away from the Roadway During 10 Seconds Prior to Event (Among Drivers Who Looked Away)



We also examined the longest continuous glance away from the roadway among drivers who looked away. Findings are shown in Figure 7. In clips where drivers looked away from the roadway, half the time (51%) the longest glance was one second or less. In 39% of clips, the longest glance away was 1.25 to 2.0 seconds, and in 10% of clips the longest glance was more than 2 seconds.

Figure 7. Longest Continuous Glance Away from the Roadway During 10 Seconds Prior to Event (Among Drivers Who Looked Away†)



† Drivers looked away from the roadway in 45% of driving clips.

Table 10 shows the relationship between distractions and looking away from the roadway. Once again, we excluded clips where there was a pause in driving or it could not be determined where the driver was looking. Drivers were three times as likely to look away from the roadway when using an electronic device, and two and a half times as likely to look away when engaging in some other distracted driver behavior (adjusting controls, personal hygiene, etc.). They were also more likely to look away when there was loud conversation or horseplay in the vehicle. The right side of Table 10 shows how long drivers looked away from the roadway (among those who looked away). Because the distributions are skewed, the median is reported and a non-parametric test of the difference in amount of time looking away is presented. When using an electronic device, drivers spent a full second longer looking away during the 10 seconds preceding the event that triggered the camera to record than drivers who were not using an electronic device. Although loud conversation and horseplay were also associated with a greater likelihood of looking away from the roadway, the amount of time doing so was only a quarter of a second more when these distractions were present.

Table 10

Association of Driver Electronic Device Use, Other Distracted Driver Behaviors, Loud Conversation and Horseplay with Looking Away from the Roadway

	% of clips driver looked away	Odds Ratio (95% CI)	Median seconds looking away (among those who looked away)	Mann-Whitney U Test
Driver electronic device use				
No	29.3%	1.00 (reference)	1.50	*p* < .001
Yes	70.7%	2.97 (2.43, 3.62)	2.52	
Other distracted driver behavior†				
No	32.5%	1.00 (reference)	1.50	*p* < .001
Yes	67.5%	2.56 (2.27, 2.88)	2.25	
Loud conversation				
No	44.6%	1.00 (reference)	1.50	*p* < .01
Yes	55.4%	1.42 (1.15, 1.75)	1.75	
Horseplay (mild or rough)				
No	36.7%	1.00 (reference)	1.50	*p* = .058
Yes	63.3%	1.98 (1.40, 2.82)	1.75	

† Other distracted driver behavior includes any of the following: adjusting controls, personal hygiene, eating or drinking, reaching for object in vehicle, communicates with someone outside vehicle, turning around or reading.
Note. Looking away from the roadway was only coded when the vehicle was moving. N = 2,853. In some cases data are missing due to darkness of the clip or other circumstances that prevented clear determination of where the driver was looking.

Distractions and Potentially Serious Events

This final section examines the association between distractions and potentially serious events, such as near collisions or events involving high g-forces (indicating hard braking or turning).

Driving Incidents
For the present study, serious incidents were defined as events involving one of the following:

- Collision (n = 3 clips)
- Near collision – evasive maneuver by teen (n = 22)
- Near collision – other driver avoids crash (n = 8)
- Other serious incident, such as losing control or leaving the roadway (n = 19)

Of the 7,858 driving clips, only 52 (0.7%) involved a serious incident. Serious incidents were equally common among males and females (0.6% versus 0.7%; OR=0.91, 95% CI=0.50, 1.66). Similarly, the difference between high school age siblings and "target teens" in the frequency of serious incidents was small (0.8% versus 0.6%; OR=1.29, 95% CI=0.72, 2.32).

Twenty-seven of the 52 teenage drivers had no serious incidents during the six month period the event data recorder was installed. By contrast, seven teens accounted for 58% of the serious incidents, with three teens having five incidents each.

Table 11 shows the relationship of incidents to distracted driver behaviors and distracting conditions. Drivers were approximately six times more likely to have a serious incident when there was loud conversation in the vehicle. Although driver electronic device use and horseplay were also associated with driving incidents, the confidence intervals are too wide (CLRs of 5.48 and 8.24, respectively) for these associations to be considered meaningful.

Table 11

Association of Driver Electronic Device Use, Other Distracted Driver Behaviors, Loud Conversation and Horseplay with Serious Incidents

	% of clips with a serious incident	Odds Ratio (95% CI)	CLR
Driver electronic device use			
No	0.6%	1.00 (reference)	
Yes	1.2%	1.85 (0.79, 4.33)	5.48
Other distracted driver behavior†			
No	0.7%	1.00 (reference)	
Yes	0.7%	1.00 (0.47, 2.12)	4.51
Loud conversation			
No	0.6%	1.00 (reference)	
Yes	4.0%	6.41 (3.29, 12.50)	3.80
Horseplay (mild or rough)			
No	0.9%	1.00 (reference)	
Yes	2.4%	2.71 (0.94, 7.75)	8.24

† Other distracted driver behavior includes any of the following: adjusting controls, personal hygiene, eating or drinking, reaching for object in vehicle, communicates with someone outside vehicle, turning around or reading.
Note. N = 7,858 clips. CLR = upper-to-lower confidence limit ratio.

High G-force Events

Another potential indicator of the seriousness of an event is the g-forces that were involved. Specifically, we examined whether distracted driver behaviors and distracting conditions were associated with higher g-force events. For this analysis, we examined events triggered by acceleration, deceleration, left and right turns separately. High g-force events were defined as those in the top 10% of the g-force distribution[6] and included the following:

- Events triggered by acceleration – longitudinal g-forces of .49 or higher (n = 86 clips)
- Events triggered by deceleration – longitudinal g-forces of -.55 or higher (n = 166)
- Events triggered by left turns – lateral g-forces of .59 or higher (n = 214)
- Events triggered by right turns – lateral g-forces of .59 or higher (n = 226)

There was considerable, though not complete, correspondence between serious incidents and high g-force events. Of the 52 serious incidents, half (26) involved high g-forces. Unlike serious incidents, high g-force events were widely distributed across drivers – all but three teens recorded at least one high g-force event. High g-force events were almost twice as common among males as females (13.1% of clips versus 6.9%; OR=1.89, 95% CI=1.64, 2.18). The difference in high g-force events between high school age siblings and "target teens" was relatively small (7.9% versus 9.1%; OR=0.88, 95% CI=0.74, 1.03).

The relation between high g-force events and distracted driver behaviors and distracting conditions is shown in Table 12. Horseplay was consistently associated with high g-force events, whether the events were triggered by acceleration, deceleration, left or right turns. High g-force decelerations and left turns were also more common when loud conversation was present. Driver electronic device use and other distracted driver behaviors were not strongly related to high g-forces. In fact, the general trend was for high g-force events to be *less* common when drivers were using electronic devices or engaging in other distracted behaviors. In some cases the confidence intervals are fairly wide, suggesting the need for caution to avoid over-interpreting relatively unstable point estimates.

[6] Selection of the top 10% represents a somewhat arbitrary cutoff. However, the cutoffs we set to identify high g-force events are similar to the cutoffs used in other studies to identify "safety relevant" events. For example, researchers at the University of Iowa have employed threshold settings of .50 for longitudinal g-forces and .55 for lateral g-forces as part of an intervention to reduce safety-relevant driving errors among teen drivers (Carney et al., 2010; McGehee et al., 2007).

Table 12

Association of Driver Electronic Device Use, Other Distracted Driver Behavior, Loud Conversation and Horseplay with Events Involving High G-Forces

	Events triggered by acceleration (N = 727)			Events triggered by deceleration (N = 1,565)			Events triggered by left turns (N = 2,151)			Events triggered by right turns (N = 1,966)		
	% of clips with high g-forces	OR (95% CI)	CLR	% of clips with high g-forces	OR (95% CI)	CLR	% of clips with high g-forces	OR (95% CI)	CLR	% of clips with high g-forces	OR (95% CI)	CLR
Driver electronic device use												
No	11.9%	1.00 (reference)		10.8%	1.00 (reference)		10.0%	1.00 (reference)		11.8%	1.00 (reference)	
Yes	9.8%	0.83 (0.35, 1.95)	5.57	7.9%	0.73 (0.40, 1.35)	3.38	10.6%	1.06 (0.62, 1.80)	2.90	7.1%	0.60 (0.31, 1.19)	3.83
Other distracted driver behavior†												
No	11.2%	1.00 (reference)		10.7%	1.00 (reference)		10.0%	1.00 (reference)		11.6%	1.00 (reference)	
Yes	15.2%	1.36 (0.83, 2.21)	2.66	9.6%	0.89 (0.59, 1.36)	2.31	9.6%	0.95 (0.66, 1.37)	2.08	10.9%	0.94 (0.64, 1.36)	2.13
Loud conversation												
No	12.6%	1.00 (reference)		9.5%	1.00 (reference)		8.6%	1.00 (reference)		11.1%	1.00 (reference)	
Yes	14.6%	1.16 (0.54, 2.48)	4.59	20.7%	2.18 (1.41, 3.38)	2.40	15.6%	2.18 (1.07, 3.10)	2.90	14.3%	1.29 (0.72, 2.31)	3.21
Horseplay (mild or rough)												
No	11.6%	1.00 (reference)		10.6%	1.00 (reference)		8.7%	1.00 (reference)		10.2%	1.00 (reference)	
Yes	29.6%	2.55 (1.27, 5.13)	4.04	22.6%	2.13 (1.22, 3.73)	3.06	19.5%	2.24 (1.15, 4.37)	3.80	23.3%	2.29 (1.15, 4.57)	3.97

† Other distracted driver behavior includes any of the following: adjusting controls, personal hygiene, eating or drinking, reaching for object in vehicle, communicates with someone outside vehicle, turning around or reading.

Note. OR = odds ratio; CLR = upper-to-lower confidence limit ratio.

Discussion

This study is one of the first to directly measure the occurrence of distracted driver behaviors and distracting conditions among teenage drivers, and how these activities are associated with several aspects of driving performance. Although distracted driving has received a great deal of media attention in recent years, relatively little is known about the nature and prevalence of distracted driving among teenagers. The few existing studies have relied mostly on self-report or roadside observation. In an ongoing study with the AAA Foundation, we collected a sizeable dataset of video data on teen drivers during the provisional licensing stage of GDL. For the present analysis, we sampled and coded video data with the specific purpose of studying how often teenage drivers engaged in various distracted driver behaviors, how often they were exposed to potentially distracting conditions resulting from passengers, and whether distracted driver behaviors and distracting conditions were related to looking away from the roadway and serious incidents.

Incidence of distracted driver behaviors was estimated from the proportion of video clips in which these behaviors were observed. When considering the findings, it is important to keep in mind the video data collected in this study may not be representative of all teen driving. The event-data recorders employed had to be triggered for data to be saved. Triggers include a stop, start, turn or any other shock (e.g., a collision) that exceeded pre-determined thresholds. In an effort to capture an essentially random sample of driving, we set these thresholds very low – far lower than previous studies where similar recorders have been used to monitor teen driver behavior. Consequently, most clips in the present study consist of fairly routine moments of driving, rather than true “events.” This is underscored by the fact that our cutoffs to identify high g-force events – i.e., those events in the top 10% of the g-force distribution – were similar to the thresholds used in other studies to identify safety relevant events (Carney et al., 2010; McGehee et al., 2007). In other words, 90% of our driving clips would not have been captured by previous studies that sought to identify and minimize driving actions considered to be risky. Nonetheless, to the extent the recorded clips were not truly random moments of driving, the findings reported here may not represent teenage driving more generally. Because the recorders were triggered by changes in the vehicle’s motion, it is likely that driving in or near intersections – where turning, stopping and starting are more common – is over-represented in the clips.

Frequency of Distracted Behaviors Among Teenage Drivers

Teenage drivers were using (or suspected of using) an electronic device in 6.7% of all clips. This is similar to observed rates of cell phone use in previous studies of young drivers (Foss et al., 2009; NHTSA, 2010c). A somewhat greater proportion was operating an electronic device (e.g., dialing or texting) than was observed holding a cell phone to the ear. A growing body of research now suggests texting may be as common among young drivers, if not more so, than talking on a handheld phone (Madden & Lenhart, 2009; O’Brien et al., 2010). This is a worrisome trend. Although the crash risk associated with talking on a cell phone is uncertain (Farmer, Braitman, & Lund, 2010; Young, 2012), the limited available research points to substantially heightened risk associated with texting while driving (Olson, Hanowski, Hickman, & Bocanegra, 2009).

In addition to electronic device use, we examined the frequency of seven driver behaviors that indicate varying degrees of distraction: adjusting controls, eating/drinking, attending to personal hygiene, reaching for objects, reading, turning around, and communicating with someone outside the vehicle. All these behaviors were relatively rare, and none of them occurred in more than 6% of clips. Adjusting controls was the most frequently observed behavior. Another naturalistic driving study – using adult drivers rather than teens – also found that manipulating vehicle or music/audio controls was among the most common distracted behaviors (Stutts et al., 2005). Adjusting controls can sometimes be important for safety reasons, for example, when turning on the windshield wipers or the defroster in inclement weather. However, much of this behavior is clearly discretionary (e.g., inserting a CD). Adjusting controls often takes just a few moments and can sometimes be done without taking one's eyes off the road (e.g., when using controls on the steering wheel). Perhaps for these reasons, adjusting controls is generally associated with only small increases in the risk of a crash or near-crash (Klauer et al., 2006). Personal hygiene, eating/drinking and reaching for objects were the next most common behaviors among teenage drivers, with each observed in roughly 3% of clips. Although infrequent, reaching for a moving object and applying makeup have been shown to substantially increase the likelihood of involvement in crashes or near-crashes (Klauer et al., 2006). Attending to personal hygiene can be a prolonged activity, and may involve substantial amounts of time looking away from the roadway. Other distracted behaviors that entail high risk, such as turning around or reading, were quite rare among teenage drivers.

Substantial individual differences were found in the frequency of distracted driver behaviors. For example, although 8 of the 52 teens (15%) accounted for half of the instances of electronic device use, 9 teens (17%) were never observed using an electronic device. This pattern – wherein a small subset of drivers accounts for a disproportionate share of problems – is routinely found in traffic safety issues. This is the case with young drivers (Carney et al., 2010; McGehee et al., 2007), truck drivers (Hanowski, Perez & Dingus, 2005), drinking drivers (Simpson et al., 2004), and others (Klauer, Sudweeks, Hickman & Neale, 2006).

A number of differences were also observed between males and females in distracted driver behaviors. Consistent with previous research (Foss et al., 2009), females were twice as likely as males to use an electronic device and slightly more likely than males to engage in other distracted behaviors. Age/experience of drivers was also related to the frequency of distracted behaviors. Electronic device use was approximately twice as high among older siblings than among the 38 original "target teens." The target teens, who had just received their intermediate license, may have felt a greater need to comply with the restriction. However, there has been no concerted effort to enforce the teen driver cell phone restriction in North Carolina, which teens may realize after several months of driving. According to data from the North Carolina Administrative Office of the Courts, less than 50 citations were issued for violations of the teen driver cell phone restriction in 2010. In any event, only a handful of studies have investigated cell phone use among teen drivers, and no study has examined cell phone use for such narrow age/experience groups. The present findings do suggest rapid changes in cell phone use may occur during the first several months of driving. Several other driver behaviors appear to evolve rapidly during the first 18-24 months of driving – most of these are for the better, but there are some deleterious changes as well (Foss et al., 2011).

Passengers and Distractions

Passengers have long been associated with higher crash rates among young drivers (Chen et al., 2000; Doherty et al., 1998; Preusser et al., 1998). However, the mechanisms behind this heightened crash risk are not well understood. It is widely assumed at least some of this risk can be attributed to distractions that young passengers create and which are more difficult for novice drivers to handle. A few self-report studies have asked teenagers whether, and how, passengers can be distracting (Ginsburg et al., 2008; Heck & Carlos, 2008). The present study is among the first to directly observe the behavior of passengers riding with young drivers.

Carrying passengers, especially multiple teenage peers, was clearly associated with higher rates of several potential distractions. Loud conversation and horseplay were more than twice as likely when teens were carrying multiple teenage peers compared to carrying only one peer. These potential distractions were not rare: loud conversation was observed in 27% of clips and horseplay in 16% when multiple teenage peers were present. Both of these indicate a degree of rowdiness, disorder or chaos in the vehicle. It is not difficult to see how this could add to a driver's overall cognitive load, which in turn increases the susceptibility of less experienced drivers to a distraction-related crash, since they have less spare attentional capacity than more experienced drivers (Lee, 2007). On the other hand, a number of other potential distractions were quite rare, including several that are sometimes cited to explain increased crash rates among young drivers when teenage passengers are present. These include physical contact between the driver and passengers, "dancing" by passengers, and communicating with (yelling at) someone outside the vehicle, each of which occurred in about 1% of all clips with passengers. Moreover, electronic device use and other distracted driver behaviors (adjusting controls, eating/drinking, etc.) were most common when teens carried *no* passengers. In sum, although teenage peers may create or increase the likelihood of certain types of distracting conditions for drivers (e.g., rowdiness in the vehicle), it appears they decrease other types of distracted driver behaviors.

Not surprisingly, the presence of parents reduced or eliminated most distracting conditions. Electronic device use, other distracted driver behaviors, loud conversation and horseplay were all substantially less common when parents were present than with any other combination of passengers (or no passengers). This is consistent with previous research showing undesirable or risky driving behaviors as well as crashes are less common when parents or other adults are in the vehicle (Goodwin, Foss, & O'Brien, 2012; Lewis-Evans, 2010; Simons-Morton et al., 2011). In the present study, sibling passengers represented a middle ground. The frequency of distracting conditions was higher when siblings – but no adult – were present, but lower than when drivers carried teenage peers.

Distractions and Characteristics of the Driving Setting

A few previous studies have examined the context in which driving distractions occur (Klauer et al., 2005; Stutts et al., 2001). With teenage drivers, there is a particular concern that distractions are more common at night, especially on weekends with passengers (often called "recreational" driving). In the present study, there was a clear trend for loud conversation and horseplay to increase over the course of the day. Moreover, the combination of weekend, night driving (9 p.m. to 5:59 a.m.), with one or more teenage peers, entailed particularly high incidence of distracting conditions. Graduated driver licensing (GDL) systems commonly include nighttime and passenger restrictions that are designed to reduce exposure to this high risk setting for the initial 6-12 months of unsupervised driving. Unfortunately, the nighttime restriction in 23 states currently begins at midnight or later (IIHS, 2011) which is too late to reduce much of the high risk period. The present findings clearly indicate that distractions increase well before midnight and that most driving by young novices occurs before midnight as well, helping to explain the nearly 3-fold increase in risk of a driver death from 10 p.m. to midnight (Chen et al., 2000). State passenger restrictions are more uniform, and may do more to protect novice drivers from the added risk associated with having multiple passengers. Presently, 45 states have some form of passenger restriction in place, and only two of these have provisions allowing teens to carry more than one teenage peer (IIHS, 2011).

We also examined whether the frequency of distracted driver behaviors was related to potentially challenging driving environments or circumstances. Teens engaged in somewhat fewer distracted behaviors when it was raining. This is encouraging given crash rates increase 71% in rain, and injury rates increase by 49% (Qiu & Nixon, 2008). Differences were small, however, and drivers did not engage in fewer distracted behaviors when roads were wet, but it was not raining. Although the amount of traffic on the roadway was unrelated to the frequency of distracted behaviors, heavy traffic was too rare to examine this issue adequately. Overall, this study provides only limited evidence that young drivers avoid potentially distracting activities in more challenging driving conditions.

Distractions and Driving Performance

Finally, we examined the association between distractions and several measures of driving performance, including looking away from the roadway, serious incidents and high g-force events. Electronic device use and other distracted driver behaviors were strongly associated with looking away from the roadway. Drivers were three times as likely to look away from the roadway when using an electronic device, and 2.5 times as likely to look away when engaging in some other distracted driver behavior. Moreover, drivers who were engaged in a distracted behavior spent almost a full second longer than non-distracted drivers looking away from the road during the 10 seconds preceding the event that triggered the camera to record. This finding is not surprising given that many distracted behaviors, such as texting or changing a CD, include a visual component. Stutts et al. (2005) also found that distractions such as dialing/answering a cell phone, manipulating audio controls and grooming are associated with (adult) drivers not looking at the roadway.

Electronic device use was only weakly related to the occurrence of serious incidents. There has been disagreement over the degree to which talking on a handheld cell phone increases crash risk. Two case-crossover studies suggest a fourfold increase in crash risk associated with cell phone use by adult drivers (McEvoy et al., 2005; Redelmeier & Tibshirani, 1997), but others have noted that crash trends in the United States are inconsistent with the observed prevalence of phone use and this degree of risk (Farmer, Braitman & Lund, 2010). Young (2012) provides a possible explanation, showing how crash risk associated with phone use may have been overestimated in the case-crossover studies. Research suggests manipulating a phone (e.g., dialing, texting) entails greater risk than talking on a hand-held phone (Klauer et al., 2006; Olson et al., 2009); however, we did not have a large enough sample to examine these various types of phone use separately.

In addition to the weak relationship between electronic device use and serious incidents, we also found drivers were less likely to experience high g-force events when using electronic devices. A few studies using driving simulators have suggested drivers may slow down or increase following distances when using a cell phone, perhaps to compensate for delayed reaction times (Pachiaudi & Chapon, 1994; Rakauskas et al., 2004; Strayer & Drews, 2004). Although the event data recorders in the present study were not capable of recording speed, the general pattern of results do suggest drivers may have changed their driving "style" when using a cell phone. This may explain, in part, the puzzling pattern noted by Farmer et al. (2010). Perhaps crashes have not increased in the U.S. – despite the rise in cell phone use – because at least some of the "clueless" behavior exhibited by drivers using cell phones may reflect cautiousness.

Potentially distracting conditions that are not so completely within the driver's control as phone use, such as loud conversation and horseplay, were strongly associated with serious incidents and high g-force events. Drivers were approximately six times more likely to have a serious incident when there was loud conversation in the vehicle, and more than twice as likely to record high g-force events when horseplay was occurring. It is tempting to conclude these distracting conditions diverted the driver's attention or overloaded their cognitive capacity, thereby leading to a serious event, but causation cannot be assumed. An equally plausible alternative explanation is that teens who tend to drive in a risky manner (i.e., higher speeds and g-forces) are also more likely to have "rowdy" friends, to carry more passengers, or both. In any event, it is apparent potentially distracting conditions and serious events frequently co-occur. Further research is needed to disaggregate spurious and causal effects. Both seem likely to contribute to the association of passengers with increased risk of crashes and other serious incidents.

Strengths and Limitations

Naturalistic driving studies, in which driver behavior is unobtrusively monitored using in-vehicle technology, represent just one approach for studying driver distraction. It is not necessarily the ideal method, but when combined with other methodologies it allows us to triangulate measurement of distracted behaviors and distracting conditions. Consequently, both the strengths and limitations of this approach should be considered.

A major advantage of naturalistic driving studies is that they allow researchers to directly observe (see and hear) driver and passenger behaviors in a level of detail which was previously not possible. In the present study, this included measurement of a variety of distracted driver behaviors, as well as a precise quantitative measure of eye glances, all while driving in real (not simulated) conditions. None of these can be accurately recalled or precisely reported in surveys. In-vehicle technologies also provide quantitative measures of vehicle action, including g-forces involved in hard turns or stops.

Although naturalistic driving studies provide a rich source of data on distracted driver behaviors and potentially distracting conditions, there are drawbacks to this type of study. Such studies invariably involve small samples because instrumenting vehicles is logistically complex and costly. As a consequence, parameter estimates are less stable and confidence intervals are wider than would be desired. Although the present study involved just 52 teenage drivers, it is larger than any other U.S. study of teenage drivers to date that uses in-vehicle technology to observe or measure behaviors. For example, studies in Virginia, Iowa and Minnesota have involved samples between 18 and 42 drivers (e.g., McGehee et al., 2007; Carney et al., 2010). Several larger naturalistic studies of young drivers are currently under way.

There are also concerns about the representativeness of drivers who participate in naturalistic driving studies. Recruiting participants for these studies can be particularly challenging. Some families are reluctant to allow cameras or other instrumentation in their vehicle. The need to overcome logistic hurdles requires substantial commitment by participants, which further limits the size and perhaps the representativeness of the sample. The present study included a disproportionate percent of females and families with higher education and incomes (see Goodwin et al., 2010). Many of the findings in this report are presented separately for males and females. Nonetheless, such self-selection raises concerns about the representativeness of the sample, hence the generalizability of the findings. Neither a low response rate, nor a demographically atypical sample is, of itself, necessarily an indicator of sample bias as is often assumed (Groves, 2006). However, the key issue is whether teenagers who participated in the study are more (or less) likely to engage in distracted driver behaviors than the general teenage driving population. It is somewhat reassuring that the frequency of electronic device use in the present study was similar to what has been found previously. However, additional research on distracted driving among teenagers is needed both to expand the present findings and to ensure they characterize teens more generally.

Another concern is whether the presence of a camera may have influenced the behavior of participants. Participant reactivity is an issue when an individual is aware that his or her behavior is being observed by researchers (Adair, 1984). Although participant reactivity cannot be ruled out in the present study, there are several factors that reduce this concern. First, families had previously had a camera installed for a four month period during the learner permit stage, so teenage drivers and their siblings had an opportunity to become acclimated to the camera. Also, there was no indication when, or whether, the cameras were recording. (All lights on the cameras which signal camera activity were disabled.) Perhaps most importantly, neither teens nor their parents received any feedback based on the recorded information. If teens had concerns that misbehavior might be shared with parents, these concerns should have been allayed quickly when they realized no feedback was provided. The most likely influence of a camera in a teen’s vehicle would be avoidance of certain kinds of trips (e.g., driving in violation of a limit on multiple passengers), rather than an effect on specific behaviors while in the vehicle (e.g., answering a phone call, reading a text message, or engaging in horseplay). The latter are likely more responsive to the salient behavior-inducing cues than to the presence of a camera. Finally, it is noteworthy that other studies employing instrumented vehicles to monitor driver behavior have generally shown that drivers acclimate to the devices relatively quickly and begin driving “normally” within a few days (e.g., Dingus et al., 2006).

Lastly, there are several additional concerns specific to the measurement of driver distraction. It is important to note we could not capture cognitive distraction, only observable driver behaviors. Moreover, it can be challenging to operationalize distracted behaviors. We were as specific as possible in measuring (coding) various items of interest.

For example, "turning around" was only coded if: 1) the driver turned his body in addition to turning his head, 2) the vehicle was moving, and 3) the look to the rear was not driving related (e.g., backing up or checking traffic). There were also limitations with the camera itself that presented difficulties in observing distractions. In nighttime clips the behavior of the driver and passengers was sometimes difficult to observe, depending on the amount of ambient light. Also, the camera view was limited to chest level or higher. Behaviors below chest level, such as texting, sometimes had to be inferred based on other driver behaviors (e.g., one arm below the wheel, repeated downward glances), or other contextual clues (e.g., the telltale "glow" of the phone at night).

Conclusions

This study is among the first to directly measure the occurrence of distracted driver behaviors and distracting conditions among teenage drivers. It also describes how distractions vary based on the presence of passengers, time of day, sex of the driver, and other potentially important factors. Finally, it documents how distracting activities were related to several aspects of driving performance, including serious incidents. Similar to adults, teenagers engage in a wide variety of distracted behaviors while driving. However, substantial individual differences were observed between teenagers in the frequency of distracted behaviors, and there was some evidence teenagers tempered these behaviors in a setting that places greater demands on the driver (rainy conditions). The study also provides insight into the increased crash risk for teenage drivers when carrying passengers. The presence of teenage peers – especially multiple peers – sometimes resulted in horseplay and loud conversation in the vehicle. Both horseplay and loud conversation were particularly common after 9 p.m. on weekends, a time when much of teen driving may be "recreational." By contrast, carrying parents – and to a lesser degree siblings – was associated with a substantially lower likelihood of horseplay and loud conversation. Potentially distracting conditions in the vehicle such as horseplay went hand-in-hand with serious incidents and high g-forces. However, causality cannot be inferred. Carrying multiple passengers may have caused these incidents, but it is also possible that riskier drivers are simply more likely to carry multiple, rowdy passengers. Finally, electronic device use and other distracted driver behaviors were strongly associated with looking away from the roadway, although electronic device use was only weakly related to serious incidents.

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