

Analysis of an Incentive-Based Smartphone App for Young Drivers

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Acknowledgements

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Background

Teenage driving behavior is of great concern to traffic safety professionals and health advocates, as vehicle crashes are the leading cause of unintentional death and injury for young people aged 15 to 20 across the United States [1]. In 2014, 2,270 teens (16 to 19 years) were killed and 221,313 were treated in emergency rooms for injuries resulting from vehicle crashes [2]. Another report revealed that fatal crash rates per mile driven for drivers aged 16 to 19 were approximately three times higher than the rate for drivers 20 years and over [3]. Recently, statistics and rigorous research on teenage crash data have drawn attention to the alarming contribution of distracted driving to teen crashes. While various activities, including eating, drinking, adjusting the radio, putting on makeup, talking with passengers, etc., can divert a driver's attention from operating a vehicle, the most common form of distraction while driving is the use of portable electronic devices for talking, texting, or browsing [4]. Studies have also indicated that young drivers are significantly more likely to be involved in mobile phone related distracted driving crashes compared to both middle-aged and older drivers [5]. A recent survey of 1,243 high school students found that 83% of the respondents reported using an electronic device while driving at least once in the previous 30 days before the survey [6].

Moreover, young drivers have the highest risk of distraction-related crashes, partly because they are less efficient in anticipating driving demands on roads and properly assessing risks compared to experienced drivers [7,8]. In 2013, 10% of teen drivers (15 to 19 years) involved in fatal crashes, were reported to be distracted at the time of the crash [9]. To observe the trend in teen distracted driving, a study by Delgado et al. [10] analyzed the annual State Farm insurance company survey from 2009 to 2014, finding that the percentage of young drivers (18 to 29 years) who browsed social media websites while driving increased from 21% in 2009 to 41% in 2014. Drivers who posted on social media while driving increased from 20% to 30% during the same period. Conversely, texting while driving decreased from 71% in 2009 to 58% in 2014. Observations from other studies have made it evident that teens are not only distracted by texting and talking on mobile phones, but they are also using social media apps or even snapping selfies [11] while driving.

To formulate strategies for preventing and controlling distracted driving attitudes among teens, improved surveillance of the frequency and nature of distracted driving is essential. This analysis intends to further explore the nature and prevalence of distracted driving behaviors under real-world conditions by processing and investigating a unique data set derived from the Teens in the Driver Seat® (TDS) peer-to-peer safe driving program smartphone application (app), which was developed by the Texas Transportation Institute. Distracted driving, especially due to the use of mobile phones, has attracted broad research attention recently. The federal government's Healthy People 2020 objectives have identified mobile phone use while driving as the prominent cause of crashes and underscored the need to better understand trends, causes, and prevention strategies through research and monitoring [12].

Naturalistic, observational, and driving simulation studies have been used to illustrate the nature and prevalence of mobile phone distractions while driving. A study by Huisingsh et al. [13] observed 3,265 drivers at 11 intersections in the Birmingham, Alabama metro area to explore distracted driving behavior. The study found that among all distracted drivers, 31.4% were talking on the phone and 16.6% were texting or dialing. Females were observed talking on the phone more than males and young drivers (less than 30 years) were more frequently involved in distracted driving compared to older drivers (above 30 years). The same study also found that distracting behaviors occurred more frequently in stopped cars. A similar study [14] in Pennsylvania observed 2,000 passengers and found that texting and talking on the phone were more frequent among stopped drivers compared to drivers in motion. Another study [15] in Mexico observed 7,940 stopped vehicles and concluded that the factors significantly associated with the use of a mobile phone while driving included the number of passengers in the car, road type (3 to 5 lanes) and day of observation (weekdays). A report by Cooper et al. [16] compared 2011 through 2016 data collected in California to observe the trend in electronic device use while driving. A significant increase in mobile phone related distraction was observed during rush hour and in urban areas in 2016 compared to 2015. Although the study could not find significant difference in the distraction rate among males and females, young drivers (16 to 24 years) were significantly more often distracted compared to older drivers.

A number of large-scale, naturalistic driving studies using instruments, such as cameras, sensors, and radar, in participants' personal vehicles have been conducted to provide insights into distracted driving attitudes [17, 18], effects of distracted driving, [17, 19, 20] and related crash risk [21, 24]. One naturalistic study [5] observed drivers for 6 weeks during a wide variety of driving circumstances and found that participants used electronic devices 9% of the time. The study also revealed that drivers tended to start mobile phone conversations at lower speeds, especially below 5 mph. A similar study [25] indicated that drivers usually drove more slowly when using mobile phones compared to during distraction-free driving. The same study added that, while talking on the phone, drivers tend to drive more slowly at nighttime and in moderate traffic compared to daytime and in sparse traffic. On the other hand, a recent study analyzing driver data observed that 29% of distractions occurred at speeds exceeding 56 mph [26]. Although, to our knowledge, no studies have investigated the prevalence of distracted driving by route type, a Governor's Office of Highway Safety report on fatal crash by route type on Arizona roads in 2012 stated that the highest amount of mobile phone related distraction crashes occurred on Interstates or Highways [27].

To curtail the use of mobile phones on roads, a number of strategies have been promoted in various cities across the world. Among the studies investigating the insignificant impact that laws limiting mobile phone use while driving have had [28, 29], a study by Creaser et al. [30] ascertained that teenage drivers were aware of mobile phone ban laws and the risk associated with distracted driving, yet they continued to engage in this impulsive behavior.

Highlighting the need for technological intervention in promoting safe driving attitude, other studies have discussed the potential impact of an in-vehicle feedback system that comes with or without a parental notification option [31, 32]. Moreover, incorporating monetary incentives or some other stimuli, such as certification of safe traffic principles, connection to insurance premiums, etc., with a technological intervention, can encourage safe driving attitudes, especially among teens [33, 38]. With regard to preventing and monitoring mobile phone use, a National Highway Traffic Safety Administration project indicated that it is extremely difficult to accomplish either prevention or monitoring unless there is an app designed to do so on the mobile device [39].

Several available smartphone apps (e.g., TXTBlocker, IZUP, ZoomSafer, AT&T DriveMode, etc.) prevent and control mobile phone use while driving [40, 41]. A research study in Minnesota investigated the impact of mobile phone blocking software with teen drivers, concluding that although often teens find a way to get around the software, it has the potential to be effective for curtailing impulsive mobile phone use tendencies among teen drivers [30]. A recent study [26] conducted by Cambridge Mobile Telematics (CMT) analyzed data from a feedback based mobile app involving a sample of drivers. Observing a 35% reduction in phone related distraction among drivers in 1 month, the study indicated that risky driving behavior can be curtailed by using tools to analyze data after each drive and providing feedback to the user.

Following is a description of Texas A&M Transportation Institute's smartphone app, along with the results associated with its pilot project/field test, which provides incentives for drivers not to drive distracted.

Method

Smartphone Application, Phase 1 (2017)

Texas A&M Transportation Institute (TTI) developed a smartphone app as part of the peer-to-peer safe driving program known as Teens in the Driver Seat® (TDS). Similar to the fundamental philosophy of the TDS Program as a whole, the marketing slogan (and call to action) was “Responsibility has its Rewards.” Both iPhone (iOS) and Android versions were developed and made available for free download. Users were allowed to download and use the application on a voluntary basis. The student advisory boards (for the high school and college peer-to-peer program components) and top program/partner schools were engaged as users of the smartphone app for the purpose of this pilot project initiative.

To activate the app and earn points, users selected a green “Start Trip” icon at the beginning of each trip. The app would not activate while the car was in motion, so the vehicle would have to be parked (or not moving) to officially start a trip. Upon arriving at their destination, users selected a red “End Trip” icon, which would automatically appear once the vehicle came to a complete stop, to end a trip and initiate related point and mileage calculations. Users of the app received five

points for every distraction-free mile that was driven over the course of a trip. No partial credit was given, so if a distraction occurred at any point over the course of a given trip, zero points were earned.

If a distraction-free trip was completed, users received a “thank you note” for being a safe driver, and their total points earned for the trip were logged. If any interaction with the phone was detected while a trip was active, users received a note at the end of the trip indicating that no points were awarded and the trip was also logged, showing how many points were lost due to a distraction.

Users could also earn safe-driving levels (up to five) for achieving increasing point level benchmarks. Users who entered their school in the app profile could also earn bonus points for the annual TDS school competition. In this competition, points were awarded for a wide variety of education-outreach activities in users’ schools/communities. Summary metrics for each individual user were included in the app, and a monthly leaderboard was also provided, showing a users’ truncated identities (to keep their identity anonymous) in order to enhance the dynamics of competition.

Timelines and Incentives

Since April is National Distracted Driving Awareness Month, a system of rewards was put in place such that points accumulated during the month of April (2017) could be redeemed for gift cards (e.g., Amazon). There were also six grand prizes awarded to the users who accumulated the most points during April (2017). These included a variety of Samsung and Apple devices valued at over \$4,000, as well as “Whataburger for a Year” (from a popular statewide hamburger chain restaurant). Structured in this fashion, the month of April would represent a time period of significant incentives to promote usage of the app in order to assess the importance of app incentives user interest.

Pilot Project Approach, 2017

For the purposes of assessing the potential impact of app incentives on the reducing the frequency of distracted driving, the 2017 pilot project was conducted in four distinct time and condition phases. These four phases and their related timelines were: (1) pre-incentive conditions – March 1 to April 10, 2017; (2) incentives in place – April 10 to April 30, 2017; (3) post-incentives phase with school still in session – May 1 to May 31, 2017; and (4) post-incentives phase with school out of session – June 1 to June 30, 2017. The unequal timing of the first two stages was related to unexpected delays in deploying the “rewards redemption” app feature; this feature was not reliably functional until April 10, 2017, resulting in a slightly truncated “with incentives” phase of deployment. It is also worth noting that pre-incentive data going back any further than March 1, 2017, was not possible due to the need to acquire official Institutional Review Board (IRB) approval for Human Subjects Research.

Smartphone Application, Phase 2 (2018)

In 2018, TTI partnered with CMT to host the Safest Young Driver Contest. The contest took place from April to June, during which young drivers could use CMT's smartphone app (DriveWell), which provides feedback on driving habits.

The app runs in the background of the smartphone and automatically records trips when a user is in motion. It doesn't require internet connection to operate. To detect mode and driver status of a user, the app uses an algorithm to generate a driver label (driver or passenger) and trip mode labels, allowing researchers to separate out teen driver data. Users also indicated if they were a passenger during a trip. One of the distinct features of the app is that it only detected significant phone distraction, such as picking up the phone and talking, or the use of any other app by sensing the user moving the phone and tapping on it. The feedback and score did not penalize mounted use or hands-free use. The goal was to detect distraction that takes both the mind and the eye off the road. To detect aggressive driving events, the app used threshold values of 0.32 g for braking, 0.32 g for acceleration, and 0.45 g for cornering. Some aggregation and smoothing of events was carried out to compute the reported values.

Drivers of all ages were allowed to download and use the app; however, only users aged 15 to 24 were eligible for prizes like gift cards and electronic appliances, such as VR goggles and Amazon's Echo. When downloaded on a smartphone (both android and iPhone), the app detected use of phone while driving in conjunction with other aggressive driving behaviors (e.g., speeding, harsh acceleration, hard braking, and cornering) in real time using the phone sensors. Users received feedback on their driving performance for each trip in terms of a star rating. At the end of each trip, the app generated a star rating in five categories including braking, acceleration, cornering, speeding and phone distraction and suggested corrective action accordingly. The rating varied from 1 to 5, the higher rating indicating better driving."

Moreover, the app provided a periodic (typically 2 weeks) overall score and offered a number of features to engage users, such as personalized driving tips, a leaderboard to compare scores with family, friends, co-workers, etc., and the opportunity to earn a variety of badges. It was expected that users, even if not interested in winning prizes, would be encouraged to exercise safe driving behavior due to the app's real time feedback.

Data Collection

The app collected data for a 3-month period (April to June 2018) and created a large database with several thousand car trips, each with several trip attributes. The trip data were obtained in anonymized format without any personally identifiable information. Each trip identified its distinct driver along with their gender and age. Along with the daily trip reports that contained summary information for each drive occurring within the date range recorded by the phone, the developer provided drive reports (on request) that contained detailed information on each drive. The drive detail report included detailed 15 Hz data from each corresponding drive as well as information

about events data (e.g., phone motion, harsh braking, harsh cornering and harsh acceleration). The app recorded a total of 16,610 trips from 152 users during the 3 months of the study period.

Data Preparation

The large volume of raw data presented a challenge for researchers, as it required extensive data processing to extract user and trip level information with various trip attributes. The raw file contained detailed information for each trip. For example, if 200 trips occurred in a given day, the raw file generated 200 separate files in Json file format. Moreover, each file contained detailed information for every minute movement of the trips. For example, a 56-minute trip generated a file with 1,760 row entries. Researchers analyzed the raw files and extracted necessary information for each trip. The processed data set contained the following information about each trip.

- Trip start and end time
- Total distance
- Driving duration
- Mean speed
- User specific ID, age, and gender
- Number of aggressive braking events in a trip
- Number of aggressive acceleration events in a trip
- Number of aggressive cornering events in a trip
- Number of distractions from mobile phone use
- Distraction duration

During data processing, new attributes were created to assess the relationship with distraction occurrence in a trip. For example, morning peak variable represents trips starting from 7 a.m. to 9 a.m., and evening peak represents trips starting from 3 p.m. to 5 p.m. Binary variables were created from event data to identify trips that experienced at least one distraction.

The app collected data from 152 users of different ages and genders. As the focus of the study was young drivers, only trips from users under 25 years of age were used in the analysis. The initial analysis of the raw data identified several outlier values. For example, average speed of the trips was observed to range from 1.2 mph to 105 mph. This might be partly due to the app using its own algorithm to detect trip mode and driver status, which may have caused some discrepancy in detecting trip modes. For example, the app may have incorrectly detected walking and transit trips as private car trips. Based on the outlier analysis, trips below 25 mph and above 65 mph were removed from further analysis. The final (cleaned) dataset contained a total 8,111 trips from 138 users aged 15 to 24.

Data Analysis

Data analysis was split into three parts: (1) descriptive analysis to summarize the prevalence of distracted driving, (2) a paired test to observe the effectiveness of the feedback and incentive based app in reducing distracted driving, (3) and a mixed effect model to present the factors associated with the likelihood of phone related distraction in each trip

Descriptive Analysis

Data were investigated to determine how the users and trips were distributed in each gender and age group. Then an analysis was performed to determine the prevalence of distraction and harsh driving behavior. A comparative analysis revealed the differences in distraction frequency, duration, and percent of time spent distracted among all user groups.

Paired Test

One objective of this research was to determine if the incentives and real-time feedback from the app influenced young drivers' driving behavior. For this analysis, users who had taken at least 20 trips during the study period were taken into consideration. In this category, a total of 94 users were found who had 7,630 car trips from April to June. The researchers intended to investigate if users' distraction per mile driven in the first 10 trips was significantly higher than during the last 10 trips.

For the analysis, first, the normality of the data was tested using normal probability plots and a Shapiro-Wilk normality test, which showed that the data was not normally distributed. Hence, the pair comparison was conducted using a nonparametric method-Wilcoxon signed rank test.

The Wilcoxon signed-rank test is a nonparametric statistical hypothesis test that allows comparison between repeated measurements on a single sample to evaluate if the population mean ranks differ. It is comparable to the paired t-test but can be used when the normality assumption is violated. For this study, the hypothesis was that distraction rates in the last 10 trips would be lower compared to the first 10 trips among the young drivers due to the continued incentives and feedback from the app.

Mixed Effect Model

Generally, a binary logistic regression is used to predict the odds of an event occurring (such as probability of success) depending on some associated factors (independent variables). However, for this study, each user made multiple trips, and hence the observations were not independent. Therefore, to investigate the factor related to mobile phone distraction while driving, in each trip, a mixed binary logistic model was required to reflect unobserved heterogeneity among individual users. A mixed model is a statistical model that contains both fixed effects and random effects.

This study developed a mixed binary logistic model where the dependent variable was distraction occurrence due to mobile phone use while driving and the independent variables were the demographics, trips, and driving related attributes.

For this study, there was a binary outcome for each trip:

$$Y_{ij} = \begin{cases} 1, & \text{if subject } i \text{ has at least one distraction at trip } j \\ 0, & \text{if subject } i \text{ has no distraction at trip } j \end{cases}$$

The generic mixed model for y_{ij} is a mixed-effects logistic regression with the form:

$$\begin{cases} \log \frac{\pi_{ij}}{1-\pi_{ij}} = \mathbf{x}_{ij}^T \boldsymbol{\beta} + \mathbf{z}_{ij}^T \mathbf{b}_i \\ \mathbf{b}_i \sim \mathcal{N}(0, \mathbf{D}) \end{cases}$$

where $\pi_{ij} = \Pr(y_{ij} = 1)$ is the probability of a positive response

\mathbf{x}_{ij} is a vector of fixed-effects covariates, with corresponding regression coefficients $\boldsymbol{\beta}$

\mathbf{z}_{ij} is a vector of random-effects covariates, with corresponding regression coefficients \mathbf{b}_i

Results (Phase 1, 2017)

Trip and Distraction Characteristics

Included in Table 1 (below) is a summary of app user metrics and their related trip characteristics over the various phases of the pilot project. As noted therein, the number of users increased to nearly 200 once incentives were added to the pilot. There was also a noteworthy drop in the percentage of distracted trips once incentives were put in place. Once the major incentives ceased (May 1, 2017, and thereafter) there was a decrease in users, although the percentage of distracted trips remained lower than the pre-incentive conditions.

Table 1. Summary of App Users and Trip Characteristics

Phase	Time-span (2017)	Total Users	Total Trips	Total Distance Traveled km (miles)	No. of Distr. Trips	Distracted Distance km (miles)	% of Distracted Trips	Average Distraction Start time (Minutes)
Pre Incentive	March 01–April 10	123	649	9,589 (5,960)	147	1,722 (1,070)	24%	6.4
Incentive	April 11–April 30	181	1934	31,195 (19,388)	328	3,495 (2,172)	17%	11.1
Post-Incentive w/School	May 01–May 31	96	881	16,654 (10,351)	127	1192 (741)	14%	9.2
Post-Incentive no School	June 01–June 30	35	639	15,483 (9,623)	90	645 (401)	14%	11.8
Total			4103	72,923 (45,322)	692	7,054 (4,384)		9.6

A breakdown of app users who manipulated their phone while the vehicle was in motion (by age and gender) is provided in Figure 1. Those app users who drove while distracted most frequently were males between the ages of 19 and 24. In general, those aged 25 or older tended to drive distracted less frequently than younger drivers. As noted in Figure 2 and Figure 3 respectively,

distractions occurred most frequently on Friday and Saturday, while the most common time of day for a distraction to occur was between the hours of 4 and 5 p.m.

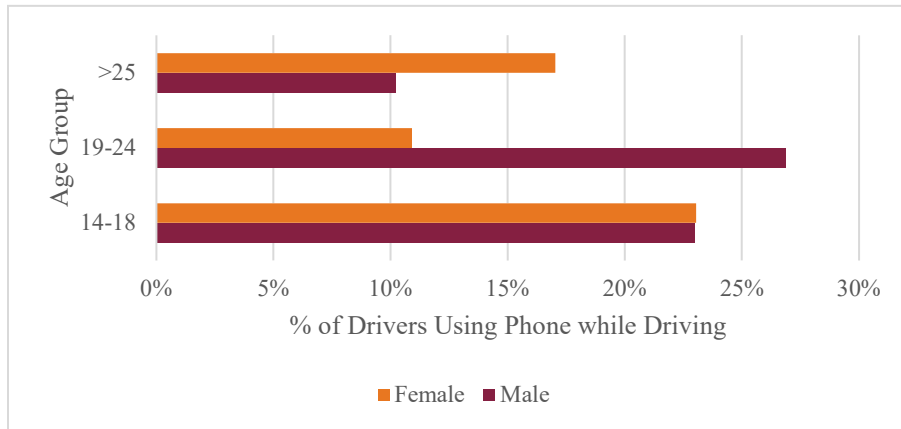


Figure 1. Percentage of drivers using phone while driving male vs female by age group.

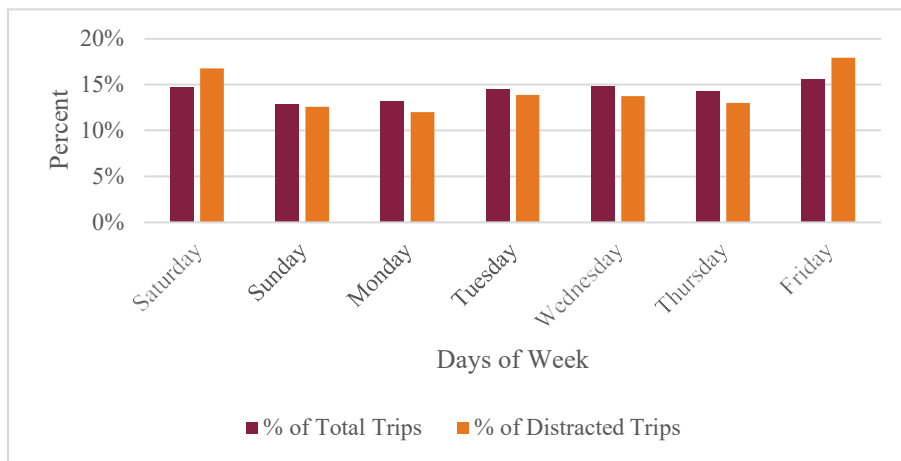


Figure 2. Distribution of trips by day of week.

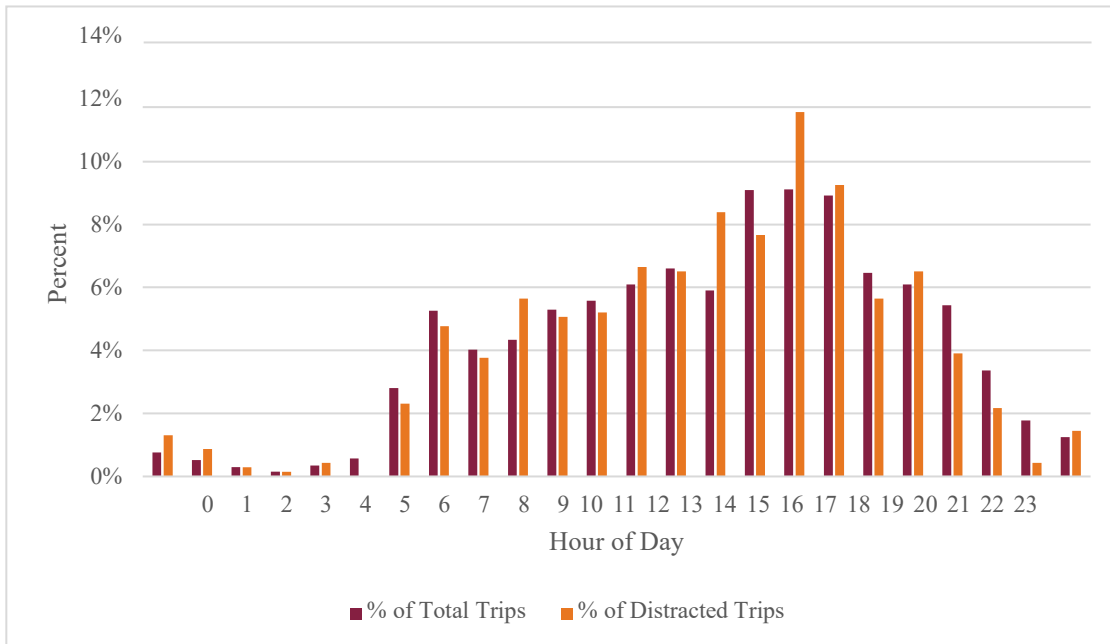


Figure 3. Trip and distraction distribution by hour of day.

Distractions most commonly occurred within the first 5 minutes of the trip (see Figure 4). Distractions also occurred most frequently at lower speeds (< 5 mph, see Figure 5), while distractions detected at speeds greater than 50 mph were relatively rare. This finding is consistent with results from a number of previous studies [5, 25] but does not conform to the CMT study [26], which observed around 29% distraction at speeds exceeding 56 mph. To investigate the distraction pattern in different road types, road inventory data from Highway Performance Monitoring System (HPMS) were used. As illustrated in Figure 6, the locations at which distractions were most commonly detected with the app were either on local streets and private driveways (outside HPMS database) or at minor arterials. Given the fact that distractions were mainly detected at relatively low speed, the finding is logical and intuitive, as average speed on local streets and minor arterials is much lower than on expressways and highways.

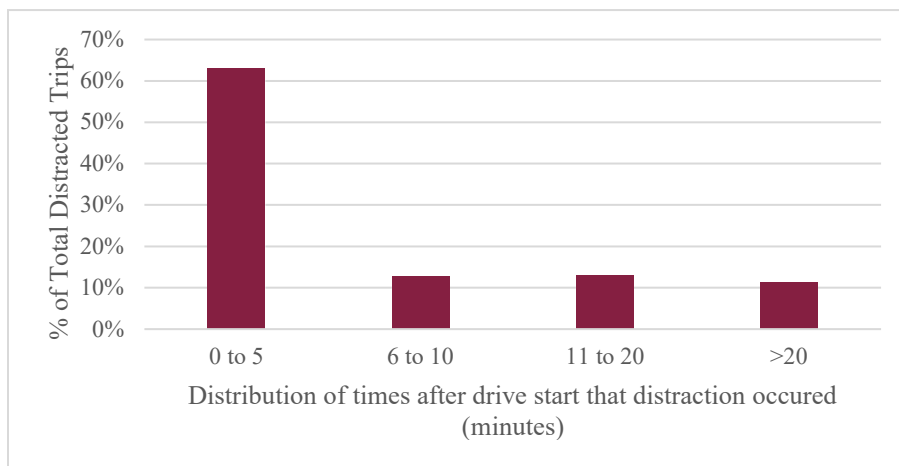


Figure 4. Percent of distracted trips by the distribution of times after start that a distraction occurred.

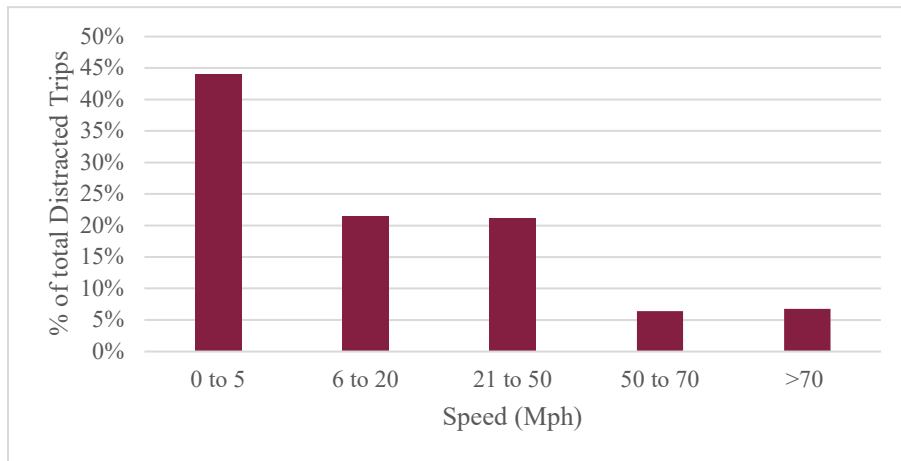


Figure 5. Speed distribution of distraction.

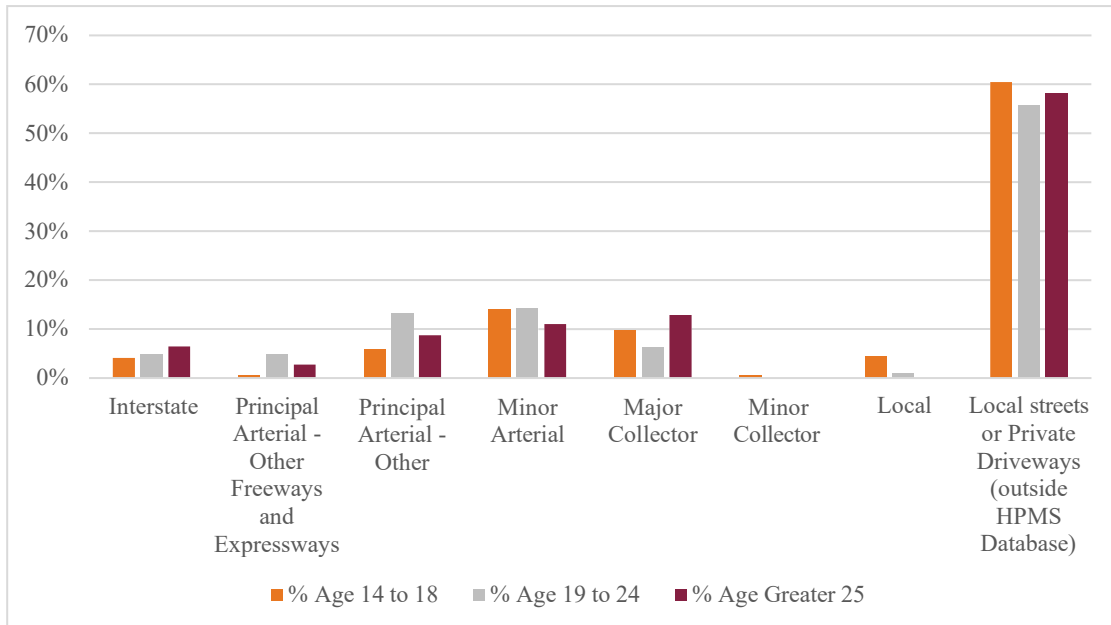


Figure 6. Distraction by age and road type

Statistical Analysis

A chi-square test was conducted on the data to assess the statistical significance of the impact that incentives had on the frequency of distracted trips. Highlights of that analysis are given in Table 2 and include some of the variables that were shown to be different at a 95% confidence level. In summary, the reduction in the percentage of distracted trips due to the introduction of incentives was (in general, for the entire user group) statistically significant. In taking a closer look at subcomponents of the user group demographics, the influence of incentives was strongest (and statistically significant) among females and those over the age of 18.

Table 2. Summary of Statistical Analysis

Time Period/Phase	Variable/Demographic	P value
Pre Incentive vs Incentive	Entire User Group	< 0.05
Pre Incentive vs Incentive	Females	< 0.05
Pre Incentive vs Incentive	19–24 Years	< 0.05
Pre Incentive vs Incentive	≥ 25 Years or Greater	< 0.05

Results (Phase 2, 2018)

Prevalence of Distracted Driving

It is imperative to explore the demographic and sample size of the users whose trip characteristics are to be investigated further. The data collection period was April to June, 2018. A total of 8,111 trips from 138 young drivers were analyzed. Table 3 presents the number of users across different ages and genders along with the total number of trips. This study categorized the users into two age groups: adolescents (ages 15 to 17) and young adults (ages 18 to 24). The table shows that female young adults make up the largest user group with the highest total number of trips for this study. Overall, number of users and total trips were higher for female users compared to male users.

Table 3. User Demographics and Trips

Age	Gender	Number of Users	Total Trips
15 to 17 (Adolescents)	Female	34	1674
15 to 17 (Adolescents)	Male	24	1579
18 to 24 (Young adults)	Female	56	3736
18 to 24 (Young adults)	Male	24	1122
Total		138	8111

With regard to the prevalence of distracted driving, 42% of the trips included significant phone motion. Half of the total distracted trips had two or less distractions. Figure 7 presents distraction and trip characteristics of the four different user groups. While 43% of the trips made by female drivers had at least one distraction, only 38% of the total trips by male drivers included any

distraction. Trips made by female adolescents had the highest percentage of distraction. Young adults had fewer distracted trips compared to adolescents.

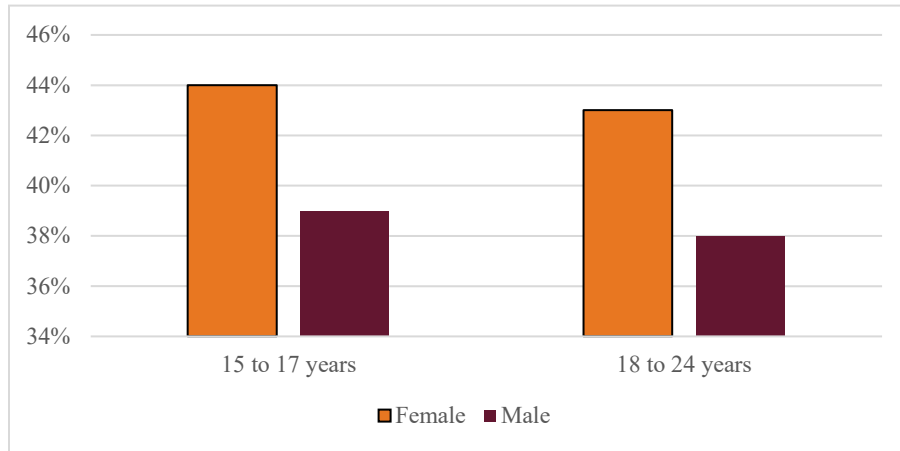


Figure 7. Percentage of distracted trips by age and gender.

Figure 8 presents aggressive driving event rates per 100 driven miles across different demographics. Harsh event (acceleration, braking and cornering) rates were higher among male drivers compared to female drivers. Moreover, male adolescents had the highest harsh event rate during the study period. It is notable that the distribution of harsh event rates across different groups is different from the distribution of distraction, where female made up the largest demographic segment. This is probably because harsh driving events can be attributed more to other, non-distraction, driver characteristics. Simons-Morton et al. [31] investigated hard braking events among teenage drivers and found that the majority (around 80%) of the hard-braking events were due to driver misjudgment and only 4.8% were due to distraction.

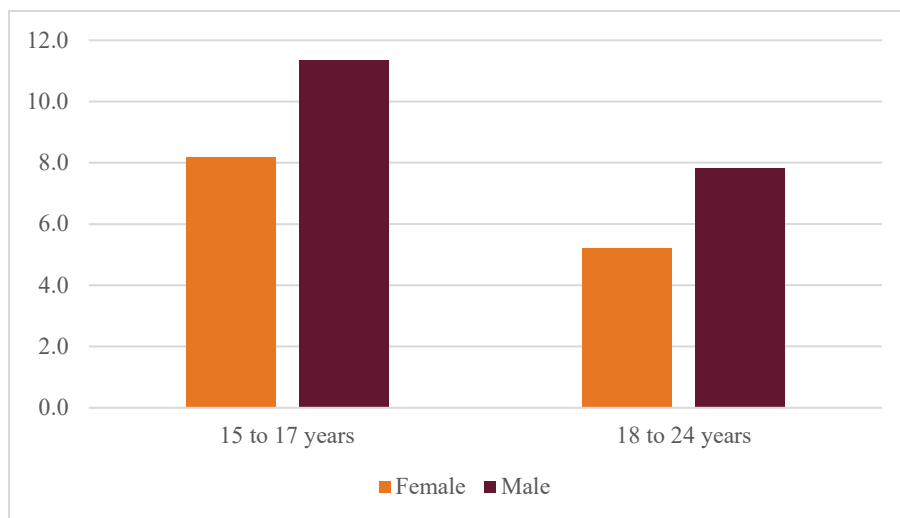


Figure 8. total aggressive events per 100 driven miles by age and gender.

Figure 9 compares the frequency and duration of distraction across the four user groups. On average, all drivers used their smartphones around 7% of the time while driving. Length of distraction per trip averaged 5.9 seconds per mile.

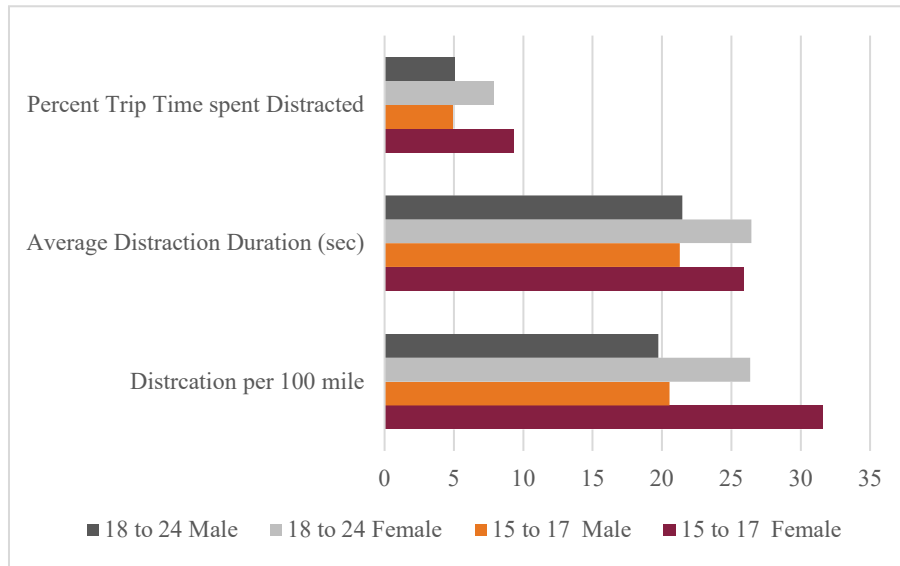


Figure 9. Distraction frequency and duration by age and gender.

After investigating age and gender variation across distraction characteristics, the current project explored how different trip attributes were related to the proportion of distracted trips as well as distractions per trip.

The data in Table 4 reveals that the percentage of distracted trips as well as distractions per trip increased with trip distance and trip duration. The finding is not surprising, as long distance trips can be tedious, and drivers are more likely to succumb to the temptation of picking up a phone.

Table 4. Relationship between Trip Attributes and Distraction Characteristics

Trip Attribute	Category	Total Trips	Distracted Trip Percentage	Distraction Per Trip
Trip Distance	Less than 8 km (5 miles)	2427	29	1.76
Trip Distance	8 to 16 km (5 to 10 miles)	2648	39	2.60
Trip Distance	16 to 32 km (10 to 20 miles)	2068	49	3.57
Trip Distance	Greater than 32 km (20 miles)	968	69	6.94
Trip Duration	Less than 20 min	5990	37	2.46
Trip Duration	20 to 45min	1774	53	4.43
Trip Duration	Greater than 45 min	347	75	9.65
Trip Time and Day of and Week	12 a.m. to 6 a.m. – Weekdays	180	34	3.35
Trip Time of Day and Week	12 a.m. to 6 a.m. – Weekend	135	49	3.64

Trip Attribute	Category	Total Trips	Distracted Trip Percentage	Distraction Per Trip
Trip Time of Day and Week	7 a.m. to 10 a.m. – Weekdays	1172	36	3.21
Trip Time of Day and Week	7 a.m. to 10 a.m. – Weekend	332	38	3.84
Trip Time of Day and Week	11 a.m. to 3 p.m. – Weekdays	1686	41	3.52
Trip Time of Day and Week	11 a.m. to 3 p.m. – Weekend	858	46	3.51
Trip Time of Day and Week	4 p.m. to 7 p.m. – Weekdays	1632	43	3.54
Trip Time of Day and Week	4 p.m. to 7 p.m. – Weekend	642	44	3.70
Trip Time of Day and Week	8 p.m. to 11 p.m. – Weekdays	1051	44	3.56
Trip Time of Day and Week	8 p.m. to 11 pm – Weekend	423	50	4.10

Additional insight was gained by examining the relationship between trip start time and the proportion of distracted trips. On average, weekend trips had more distractions compared to weekday trips. Evening peak trips (4 p.m. to 7 p.m.) experienced more distraction compared to morning peak trips (7 a.m. to 10 a.m.) for both weekdays and weekends trips. For the weekday trips, the highest percentage of distracted trips were found from 4 p.m. to 11 p.m.. Moreover, almost half of the trips between 8 p.m. to 11 p.m. exhibited distraction during the weekends. We can likely conclude from these results that the probability of distraction was high when teens were coming home from school, events, social activities, and work.

Paired Test

A Wilcoxon signed rank test was conducted to evaluate app users who had taken at least 20 trips during the study period. The hypothesis was that distraction rates in the last 10 trips would be lower compared to the first 10 trips due to the continued usage of the incentive and feedback-based app. Table 5 below presents the result of the test for all users of different demographics.

As the data in Table 5 shows, use of the app was associated with significant changes (90% confidence level) in phone use frequency while driving. Both female drivers and drivers aged 15 to 17 (in general) exhibited a significant decrease in phone use frequency in their last 10 trips compared to their first 10 trips. However, male drivers and drivers aged 18 to 24 didn't exhibit any significant change in terms of phone use while driving.

The finding is encouraging, as female drivers aged 15 to 17 were found to be the most probable group to use a phone while driving. The results suggest that the real-time feedback from the app coupled with the likelihood of getting a reward have the potential to reduce the frequency and/or habit of phone use while driving among this high-risk driver group.

Table 5. Wilcoxon Signed Rank Test Result Comparing Distraction Per Mile of First and Last 10 Trips

Alt Hypothesis: First 10 > Last 10	First 10 Trips: Median	First 10 Trips: Standard Dev	Last 10 Trips: Median	Last 10 Trips: Standard Dev	P value	N
Female	0.070	0.081	0.051	0.087	0.1*	62
Male	0.039	0.042	0.055	0.046	0.9	32
15 to 17	0.064	0.085	0.052	0.069	0.1*	36
Age 18 to 24	0.049	0.064	0.061	0.081	0.8	58

*Significant at 0.1 level

Mixed Effects Logistic Regression

Table 6 presents the results of the mixed effect logistic regression model. Insignificant explanatory variables are retained in the models, as the primary objective of this research was not to predict or forecast the distraction occurrence but to identify factors associated with it.

Table 6. Mixed Binary Logistic Models

Fixed effects	Estimate	Std Error	P Value
(Intercept)	-1.92	1.40	0.17
Log (distance in mile)	1.02	0.05	0.00***
Gender (male)	-0.13	0.25	0.60
Log (mean speed in mph)	-0.50	0.16	0.00***
Morning peak (7 a.m. to 9 a.m.)	-0.39	0.08	0.00***
Age	0.07	0.07	0.35
Total event	-0.06	0.02	0.00***
Weekend trips	0.18	0.06	0.00***
Random effect (variance of random intercept) 1.594			
Number of trips: 8111			
Groups: User 138			

***Significant at 0.001 level

A number of factors were found to significantly influence the likelihood of engaging in mobile phone distracted driving. The result suggests that five variables were significantly (0.001 level) associated with distraction occurrence probability. Intuitively, the risk of distraction increases with increasing trip distance. Distraction probability was less if the mean speed of the trip was high. Morning peak trips exhibited less distraction, but weekend trips exhibited high distraction. Although not significant, males seemed to exhibit less distraction and distraction likelihood was positively associated with age. The relationship between aggressive event occurrence and

distracted trip was interesting, as it appears that trips with aggressive events had a lower proportion of distractions compared to trips with no such events.

Discussion

The data accumulated in this project are more thorough and insightful (in terms of breadth and detail) in comparison to data readily available from other sources (e.g., police crash reports, localized field observations, etc.). As such, these data should add valuable insights into the scope and characteristics of distracted drivers (youth and adults), related roadway safety challenges that the transportation profession continues to address, and insights into prospective solutions to mitigate distracted driving. This study is one of the first to directly measure the impact of feedback and incentive-based smartphone apps among teenage drivers, and how these events are associated with several aspects of young drivers and trip attributes.

Challenges were encountered with the two different private sector vendors used during this project in terms of costs and timeline/deadline adherence. As such, TTI is re-developing a smartphone app of this nature internally to better control costs, scope, and timelines in the future.

Conclusions and Recommendations

Although the two smartphone apps that were deployed were somewhat different, the results of applying them with multiple incentives and means of feedback were fairly similar. In summary, statistically significant improvements in driving behavior—particularly a reduction in distracted driving—was accomplished in both cases. The analyses conducted in this project yielded substantial evidence that this fundamental approach of an incentive-based smartphone app can have a positive influence on this high-risk (i.e., young driver) group of road users. Implementing and sustaining such an intervention is therefore valuable and warranted.

Additional Products

The Education and Workforce Development (EWD) and Technology Transfer (T2) products created as part of this project are described below and are listed on the Safe-D website [here](#). The final project dataset is located on the [Safe-D Dataverse](#).

Education and Workforce Development Products

The results of this project indicate that there may be potential value in leveraging the findings of this research and integrating them into educational tools/elements for teenagers—both adolescents who may be thinking about or soon be driving (i.e., junior high and middle school students) and young drivers (those who are already licensed).

Technology Transfer Products

The smartphone apps that were deployed during this project are no longer functional or available. The working relationships with the two private sector vendors were terminated due to escalating costs and repeated delays in product enhancement and delivery. TTI is currently developing a replacement smartphone app of this nature. The iOS version of the app is planned for public launch in late August 2020, while the Android version is scheduled for public release in late October 2020. The app can be shared as needed as a byproduct of this project moving forward from those dates. For more information about the app can be found on the project site [here](#).

Data Products

The dataset contains trip data obtained from an incentive-based smartphone application (app) developed by the Texas A&M Transportation Institute as part of the peer-to-peer safe driving program, Teens in the Driver Seat®. The dataset contains 8111 trip level observations from 138 young drivers (under 25 years). The drivers can be identified by their unique (anonymized) numbers. The dataset includes the demographic characteristics of the drivers and trip-related information, such as the occurrence of phone motion-related distraction and harsh driving events. The dataset can be accessed <https://doi.org/10.15787/VTT1/QNLEDZ>.

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