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# The Effect on Teenage Risky Driving of Feedback From a Safety Monitoring System: A Randomized Controlled Trial

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## Abstract

**Purpose—**Teenage risky driving may be due to teenagers not knowing what is risky, preferring risk, or the lack of consequences. Elevated gravitational-force (*g*-force) events, caused mainly by hard braking and sharp turns, provide a valid measure of risky driving and are the target of interventions using in-vehicle data recording and feedback devices. The effect of two forms of feedback about risky driving events to teenagers only or to teenagers and their parents was tested in a randomized controlled trial.

**Methods—**Ninety parent-teen dyads were randomized to one of two groups: (1) immediate feedback to teens (Lights Only); or (2) immediate feedback to teens plus family access to event videos and ranking of the teen relative to other teenage drivers (Lights Plus). Participants' vehicles were instrumented with data recording devices and events exceeding 0.5 *g* were assessed for two weeks of baseline and 13 weeks of feedback.

**Results—**Growth analysis with random slopes yielded a significant decrease in event rates for the Lights Plus group (slope = −.11, $p < 0.01$), but no change for the Lights Only group (slope = 0.05, $p = 0.67$) across the 15 weeks. A large effect size of 1.67 favored the Lights Plus group.

**Conclusions—**Provision of feedback with possible consequences associated with parents being informed reduced risky driving, while immediate feedback only to teenagers did not.

**Implications and Contribution—**Reducing elevated *g*-force events due to hard stops and sharp turns could reduce crash rates among novice teenage drivers. Using materials from the DriveCam For Families Program we found that feedback to both teens and parents significantly reduced rates, while feedback only to teens did not.



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Teenage drivers have higher crash rates than older drivers [1–3]. The typical pattern among novice drivers of highly elevated crash risk during the early months of licensure, rapid decline for a period of months, and then slow decline over a period of years appears to be exacerbated by early age at licensure [4,5]. In addition to young age, high teenage crash rates are generally attributed to inexperience and risk taking [2,3,6]. Relative to older drivers, young drivers engage in high levels of risky driving, including excessive speed [2,7], close following [7], and elevated gravitational-force (*g*-force) events [3].

Advances in accelerometer technology have made elevated *g*-force event rates a popular measure of risky driving and focus of crash reduction efforts. Elevated *g*-force events are largely the result of poor speed management practices such as accelerating rapidly, decelerating late and abruptly, sharp cornering, and over-correcting after a turn [8]. Higher rates of elevated *g*-force events are associated with the likelihood of a crash in the near future among teenage [8], adult [9], and bus drivers [10]. Relative to experienced adults novice teenage drivers have five times higher rates of elevated *g*-force events [3]. High rates of events among young drivers could be due to inexperience or intentional risk taking. Notably, feedback about elevated *g*-force events can be provided to drivers by devices connected to accelerometers and records of events can be made available to supervisors or parents. These technologies are commonly employed to reduce crash risk among commercial fleet drivers, with notable success, and novice teenage drivers [11].

In general, feedback can provide information about performance, increase attention to discrepant behavior, reduce uncertainty, establish and reinforce expectations for behavior, and serve as a source of social comparison [12]. Feedback is available in a wide range of vehicle devices important to driver performance and a common element of driver training, traffic safety efforts, and research on driver behavior [13–15] .

While personalized feedback is essential to behavioral self-regulation to the extent it provides information about one’s approximation to the standards of a task, its effect on behavior can be complicated and may depend on individual motivation and perceived or actual consequences [12,15,16]. Accordingly, elevated *g*-force event rates could be expected to decrease if the driver receives feedback that an event has just occurred, learns from this feedback how to avoid similar events in the future, is motivated to improve performance, and associates the feedback to meaningful consequences. If the high rate of elevated *g*-force events among teenage drivers is due primarily to inexperience, lack of knowledge about the types of maneuvers that cause events, deficiencies in vehicle management skills, and unsafe driving judgment, then immediate feedback to the driver about what constitutes an event would be expected to reduce event rates, assuming the driver is intrinsically motivated to improve their driving performance in this regard. However, if high rates of risky driving among teenage drivers are due to other factors, such as a preference for risky driving, feedback to the driver would not dampen rates unless it were linked to meaningful consequences, for example, from concerned parents alerted to the teen’s risky driving.

A few studies have reported declines in elevated *g*-force events among teenage drivers whose events were signaled by a blinking light and information about them was posted to a website for the teens and their parents to view [17–20]. Three of these studies used single-group, pre-post study designs that tested the combined effect of immediate feedback to the driver (two in the form of a blinking light and one in the form of audio) plus delayed feedback to the teenage drivers and their parents [17–19]. The one previous randomized trial that compared the effect of immediate feedback to the driver only to immediate feedback to the teen plus delayed feedback to the family used a device with an accelerometer, audio alerts, but no camera. Results for elevated *g*-force events showed non-significant declines for the treatment conditions that received in-vehicle alerts plus web-based feedback to parents, and significant reductions in speeding and safety belt non-use [19]. Devices with video may have the advantage of providing visual context for interpreting the riskiness of *g*-force events. The efficacy of devices with video was not yet demonstrated in a randomized controlled trial.

In this evaluation of the DriveCam For Families Program we sought to determine the extent to which two forms of feedback altered elevated *g*-force event rates among novice teenage drivers. The research question of interest was, "what is the effect on elevated *g*-force event rates of immediate feedback of these events to teenage drivers compared with immediate feedback plus delayed feedback to teen-parent dyads in the form of a weekly report card, video footage of events, coaching tips, and a comparison to other teenage drivers?" We hypothesized that the decline over time in elevated *g*-force event rates would be greater among teenage drivers who received immediate plus family feedback and access to event videos.

## Methods

### Participants

Parent-teen dyads were recruited from high schools in Ann Arbor, Michigan and screened. Inclusion requirements were as follows: a Level 2 Michigan driver license (allows independent, unsupervised driving) issued in the prior 30 days; regular access to a vehicle that could be instrumented for the 15-week study period; access to the Internet; living at home with at least one parent; not older than age 18; and able to speak and read English. Incentives of $100 to the parent and teenager at pre-test and $150 each at the end of the study were provided. Study participants provided signed consent (parent) and assent (teen) according to the protocol approved by the University of Michigan Institutional Review Board. Participants' privacy and data were protected by a certificate of confidentiality.

### Study Design

Separate randomization lists were prepared for male and female participants and then assigned at random by a computer program to one of the two study conditions within fixed blocks of 4 such that each block contained two males and two females. Survey administrators, data coders, and statistician for preliminary analyses were blind to group assignment. During the first two weeks the data recording devices were set to record *g*-force events, but no feedback was provided. Thereafter, feedback was provided according to the assigned conditions.

**Treatment Group 1: Lights Only (LO)—**From weeks 3 to 15, the LO condition provided participating teenage drivers with immediate feedback in the form of a green light in the absence of a *g*-force event, a red and green flashing light following an event, and then a red light indicating that the video footage of the event had been saved.

**Treatment Group 2: Lights Plus (L+)—**During weeks 3 to 15, the L+ condition received immediate feedback about events as described in the LO condition plus delayed feedback sent to the parent-teen dyad in a weekly email containing a report card indicating the teen's events and risk score for the week, and a graph of the teen's weekly risk score relative to other teenage drivers. In addition, the dyads had access to a secure website that allowed them to view reports and video footage of a few seconds before and after each event. Parents were encouraged to view and discuss the videos together with their teen and the website included tips for parents on coaching their teen to be a safer driver.

Families in the L+ group were sent an email that included a welcome to the DriveCam for Families Program, a link to the login page, and username and password. In addition parents received a copy of the Parent Resource Guide (a one-page introduction to the Program), Website Guide (information on using the website), and the contact information of the study coordinator. Parents were encouraged to visit the website once a week and told “Your participation in the DriveCam for Families Program starts TODAY.” Parents could log in, view the videos, and mark them as resolved.

## Data Collection

At pretest participants met a study representative at a national electronics department store, Best Buy, where DriveCam event recorders were installed in their personal vehicles. Survey data were collected during installation and 15 weeks later during de-installation.

**Data Recording Device and Feedback—**Study vehicles were instrumented with accelerometer-activated data recorders from DriveCam, Inc., a commercial technology originally designed for fleet vehicle operators and adapted for and marketed as a feedback and monitoring device for teenage drivers and their parents. The device is attached to the windshield behind the rear view mirror of the vehicle and records video of the occupant compartment and forward and rearward of the vehicle. The device continuously records data but saves only data for events recorded six seconds before and four seconds after the pre-set threshold of 0.5 *g* is exceeded, a force that is noticeable to the vehicle occupants and uncomfortable for most passengers. The device can be set so that an indicator light on the front surface alerts the driver that an event threshold has been exceeded or be operated in “stealth mode”, recording acceleration events but with the indicator light turned off. Data were uploaded from the device remotely via cellular connection and saved on a secure server.

By arrangement with DriveCam, Inc., trained coders employed by the company, blinded to study condition, viewed and evaluated each elevated *g*-force event according to the company’s standard procedures. Each event was coded according to the following: primary cause, including acceleration, braking, cornering, or other; and driver behaviors observed at the time of the event, including aggressive driving, distractions, and seatbelt usage. Crashes, defined as “vehicle makes contact with or is contacted by another object, leaves the roadway unexpectedly, or driver loses control of the vehicle”; and near crashes, defined as “collision narrowly avoided”, were coded. Each event was assigned a number of *risk points* based on the driver behaviors associated with the event.

At the end of each week, 3 to 15, the parent-teen dyads in the L+ group were sent an email with the week’s risk score for the teenager and a link to a secure website where they could view the report cards and the teen’s events. The report cards were customized for each teen and listed each event with its date and time of occurrence and coaching feedback provided by the data coder (e.g., “slow down”, “reduce speed before entering a turn”, “increase your following distance”). Each event’s video footage could be viewed on the website. The report cards included a chart with the teenage driver’s risk score for each week of participation and the weekly scores of other adolescents who previously participated in the program and the program goal of a risk score of 5 or lower.

## Survey Measures

At installation teenage participants completed a survey that asked their sex, age, grade, race/ethnicity and included measures of sensation seeking and parent-teen relations.

The Brief Sensation Seeking Scale [21] included eight items derived from the Zuckerman Sensation Seeking Scale [22] and adapted to adolescents, with two items each on thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility. Response options were 1 = strongly disagree to 5 = strongly agree.

Parental trust, knowledge, monitoring and communication were assessed using four measures from Kerr and colleagues [23,24]. Six items measured trust (1 = not at all to 4 = a lot). An example of the items is "How much do your parents trust that you will not hang out with bad people?" Parental knowledge about the teen was assessed using an eight-item measure (1 = always to 5 = never), with items such as "How often do your parents know what you do during your free time?" Parental monitoring of the teen was measured using five items (1 = always to 5 = never), with items such as "How much do your parents trust you to not do anything dumb during your free time?" The measure of parent communication (called "solicitation"), contains six items (1 = always to 5 = never), with questions such as "How often do your parents talk with your friends when they come over?"

### Exposure Data

Mileage was collected so that event rates could be calculated. Odometer readings were taken at the beginning and end of the study and participants reported the percent of time they drove the vehicle during the study period.

### Analyses

Each event above 0.5 *g* was counted and rates were calculated by dividing the number of events by 100 miles of driving. For 5 participants, odometer readings were not available, two due to odometer malfunction and two due to recording errors, for whom exposure was imputed based on the median for the other study participants (both treatment groups). Group differences were tested in two ways. First, the effect size was calculated by Cohen's d, which compared the differences in event rates between groups during the last month minus the group's event rate during the first two weeks (no feedback). Second, growth curve analysis with random slopes [25] was used to compare the change in rates of elevated *g*-force events over the entire period of the study. The unconditional model included study week as the only predictor to compare the linear changes in rates of the LO and L+ groups. Next, teens' demographic and psychosocial measures from the surveys were added to the unconditional model as potential predictors or covariates in a multilevel regression analysis. The final growth curve was adjusted for baseline event rates and the survey covariates. Analyses were run without the 5 participants for whom mileage was imputed and the results did not change, so we report here the analyses with all participants with otherwise complete data.

## RESULTS

The flow of participants through the study is shown in Figure 1. Of 197 respondents 90 were enrolled and final analyses were conducted using the data from 88 of the 90 participants, which were mostly white and included 46 males and 42 females with an average age of 16.4 years. There were no treatment group differences in psycho-social measures.

Event rates were not significantly different in the LO and L+ groups during the 2-week baseline period. Table 2 shows that the weekly means and standard deviations of the observed event rates were higher for the L+ group compared to the LO group in weeks 3–15. Over the 15 week study period, the L+ group was involved in significantly fewer events than the LO group ($M = 23.42$, $SD = 28.14$ vs. $M = 50.49$, $SD = 70.32$; $t(86) = 2.39$, $p < 0.05$)

(data not shown), with an effect size of 1.67. The results did not vary by age or time of licensure.

Figure 2 shows the observed and predicted event rates and 95% confidence intervals (in the shaded areas) resulting from growth curve analysis with random slopes. Group differences in the weekly, observed rates began in week 3 and were maintained throughout. Analyses of the slopes for each group indicated a significant decreasing rate across the 15 weeks for the L+ group (slope = −.11, $p < 0.01$), but no decrease for the LO group (slope = 0.05, $p = 0.67$).

Table 2 shows the results of the growth curve analyses, adjusted for baseline event rates, time of licensure, and all variables in the model, and indicating significant group, week, and group-by-week interaction effects. However, these analyses provided no evidence of association between event rates and participant sex, age, sensation seeking, or parent-teen relationship variables.

### Event Characteristics and Crash/Near Crash Outcomes

Evaluation of the recorded events indicated that events for the LO group were mostly sharp cornering (74%) and hard braking (10%). There were seven near-crash and three at-fault crash events for the L+ group, and 10 near-crash and 11 at-fault crash events for the LO group (none resulting in air-bag deployment or injury). Between-group differences were not significant.

### Exposure to the Lights Plus Intervention

In the L+ group, 41 of 45 parents logged in at least once to the website where families could view reports and videos of events. The average weekly number of logins over the course of the 13 weeks was 0.78 and the average number of log-ins per dyad for the entire study period was 10.2, with a range of 0–46. As shown in Figure 3, the average number of log-ins per week per family declined from just under 2 the first week of the intervention to less than 0.5 the last week of the intervention, consistent with the decrease in event rates.

## Discussion

This is the first randomized trial with novice teenage drivers to evaluate the effects on elevated *g*-force event rates of different forms of feedback from event-activated data recorders equipped with cameras. Our data show significant group differences in *g*-force event rates, with declines over time in the L+ but not in the LO group, with a large effect size of 1.67 [26]. If devices of this sort could prevent risky driving, even for a few months after licensing, they might help reducing the teenage driver problem which is particularly high during the first months of licensure.

Observational studies have shown that on average novice teenage drivers experience much higher rates of elevated *g*-force events than adult drivers [3,27], but it is unclear the extent to which this is due to inexperience and poor judgment or intentional risk taking. Inexperienced drivers may not realize when they drive erratically, stopping, starting, and turning rapidly and dangerously. Objective feedback about elevated *g*-force events has potential for reducing this sort of risky driving among novice drivers [12,16, 17–20]. However, our data for the LO group provided no evidence that immediate feedback about events had a significant effect on subsequent event rates, which could suggest that teenage drivers did not learn from the visual feedback provided (which could possibly be less powerful than audio feedback) and/or were not motivated to change the way they drove.

The significant reduction in rates in the L+ group suggests that the combination of immediate and delayed feedback to parents was effective, as demonstrated for braking in a recent simulation study [288]. Our findings suggest the importance of contingent feedback. Because parents could access the video footage of their teens' events, the possible consequences of risky driving would have been greater than for immediate feedback to the teen only. On average families logged onto the website nearly twice weekly initially and on average once a week overall, where they could view video of events and presumably parents would provide instruction and apply consequences, such as expressing displeasure and exerting sanctions. However, login rates declined over time, possibly due to the reduction in teen events or to a decline in interest among families, consistent with other studies [18,19].

Effects of feedback did not vary by demographic characteristics, sensation seeking, or parenting practices, suggesting that the findings are not due to these particular teen characteristics. Curiously, we found no differences in event rates among teenage boys and girls. Studies evaluating fatal crash rates have generally shown that males have higher rates, but studies of non-fatal crashes have not shown consistent effects of driver sex [6]. Surprisingly, the effects did not vary by the parenting practices measured. While interest among parents in using feedback systems is not high [299], our families were reasonably highly involved and parental involvement appears to be important to the success of such systems. Previous research has reported that treatment effects vary according to parental involvement [17,18].

### Limitations

The study is limited by the small sample and short measurement period term. Also, there was no untreated control group, mileage was estimated, and speeding was not assessed. Families in the L+ group received the intact DriveCam for Families Program, not specifically adapted for study purposes. Also, we measured participation by parents but not the extent to which they utilized the information they were provided to coach their teenage children.

### Conclusion

The data support the hypothesis that risky driving, as measured by elevated *g*-force event rates, declined when immediate feedback in the form of a blinking light, plus web access to the video of these events, and weekly reports made available to teenage drivers and their parents, but not when feedback only was provided to the teenage drivers. If confirmed in future studies, the implications for policy are that parent involvement is essential to the prevention of novice teenage risky driving.

## Acknowledgments

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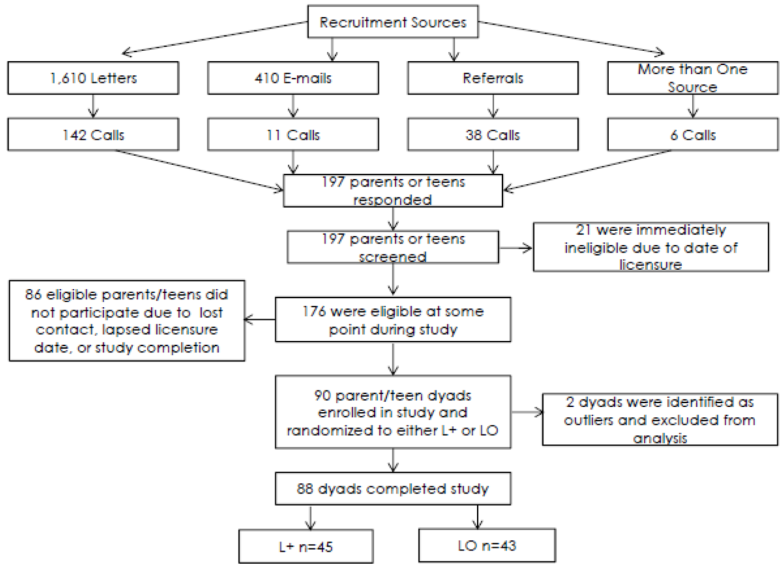


**Figure 1.**
Participants flow through the study.

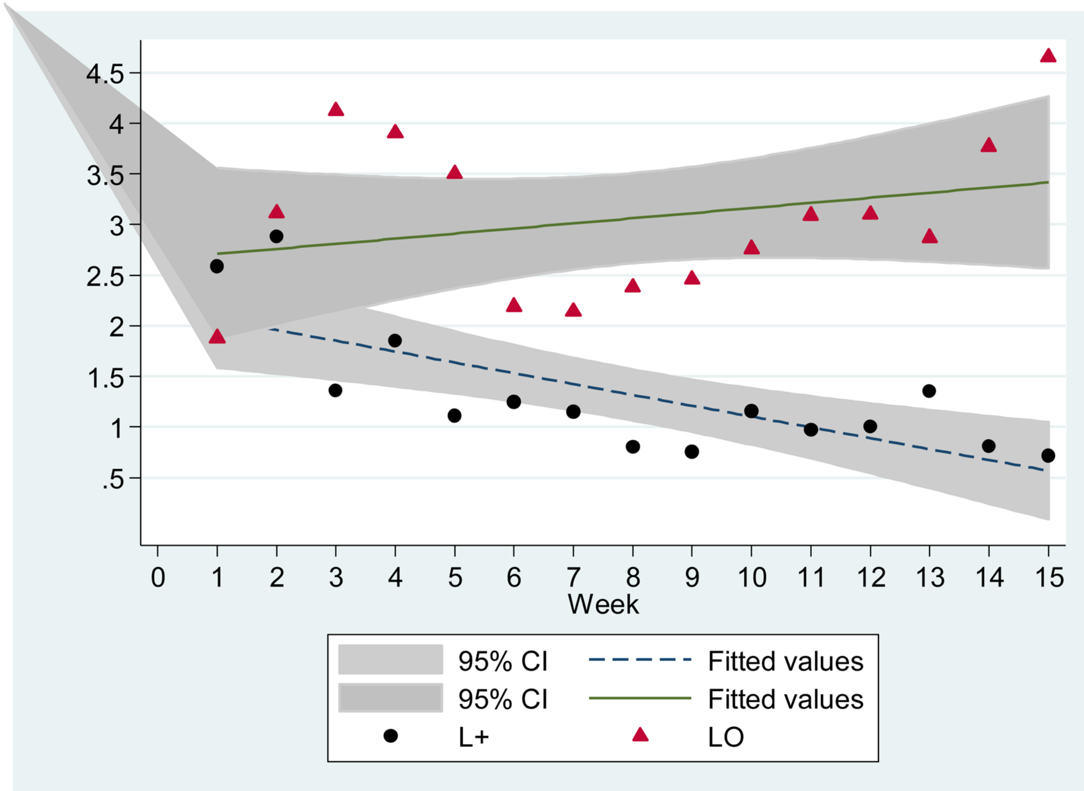


**Figure 2.**
Weekly observed rates of events / 100 miles (shown as point prevalence) and predicted rates (shown as best fit lines) with 95% CIs (shaded area) for lights only (LO; n = 43) and lights plus delayed feedback to family (L+; n = 45)

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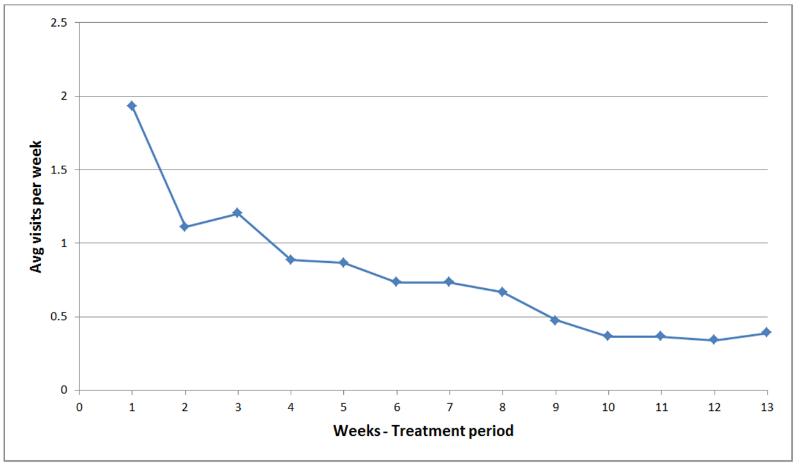


**Figure 3.**
Average logins per week per dyad in L+ group (n = 45)

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**Table 1**

Means and standard deviations (SD) for g-force event rates per 100 miles and results of t-tests comparing lights only (LO; n = 43) and lights plus delayed feedback to families (L+; n = 45) groups by week; effect size =1.67.

| Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LO | | | | | | | | | | | | | | | |
| Mean | 1.88 | 3.11 | 4.12 | 3.90 | 3.50 | 2.19 | 2.14 | 2.38 | 2.46 | 2.76 | 3.09 | 3.10 | 2.87 | 3.77 | 4.65 |
| SD | 3.07 | 4.77 | 6.16 | 5.88 | 5.00 | 2.71 | 3.96 | 3.09 | 5.42 | 6.60 | 6.53 | 8.20 | 7.19 | 11.72 | 15.43 |
| L+ | | | | | | | | | | | | | | | |
| Mean | 2.59 | 2.88 | 1.36 | 1.85 | 1.11 | 1.25 | 1.15 | 0.80 | 0.76 | 1.16 | 0.97 | 1.00 | 1.35 | 0.81 | 0.72 |
| SD | 6.33 | 4.39 | 2.47 | 3.16 | 2.20 | 2.87 | 1.91 | 1.43 | 1.27 | 1.98 | 2.97 | 2.25 | 3.61 | 1.82 | 1.39 |

**Table 2**

Growth curve analysis predicting teens' event rates per 100 miles, adjusted for baseline event rates, time of licensure, and all variables in the model

| Measures (# items; alpha) | % or Mean (SD) | B | SE | z | p |
|---|---|---|---|---|---|
| Group[a] | | −1.94 | 0.76 | −2.54 | 0.011 |
| Week | | 0.24 | 0.09 | 2.63 | 0.009 |
| Group*Week | | −0.17 | 0.06 | −3.08 | 0.002 |
| Male Sex | 52.3% | 0.07 | 0.78 | 0.09 | 0.927 |
| Age | 16.4 (0.48) | −0.60 | 0.78 | −0.77 | 0.439 |
| Sensation Seeking (8; 0.80) | 2.81 (0.71) | 0.66 | 0.61 | 1.08 | 0.278 |
| Parent Trust (6; 0.78) | 3.59 (0.42) | −0.14 | 1.02 | −0.14 | 0.889 |
| Parent Knowledge (8; 0.82) | 1.80 (0.54) | −1.04 | 0.78 | −1.34 | 0.180 |
| Parent Monitoring (5; 0.60) | 2.79 (0.44) | −0.49 | 0.78 | −0.63 | 0.528 |
| Parent Trust (6; 0.77) | 3.02(0.42) | 1.27 | 1.03 | 1.23 | 0.217 |

Note:

[a]Coding for group was 1 or L+ and 0 for LO.