Can providing feedback on driving behavior and training on parental vigilant care affect male teen drivers and their parents?

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Abstract

This study focuses on investigating the driving behavior of young novice male drivers during the first year of driving (three months of accompanied driving and the following nine months of solo driving). The study's objective is to examine the potential of various feedback forms on driving to affect young drivers' behavior and to mitigate the transition from accompanied to solo driving. The study examines also the utility of providing parents with guidance on how to exercise vigilant care regarding their teens' driving. Driving behavior was evaluated using data collected by In-Vehicle Data Recorders (IVDR), which document events of extreme g-forces measured in the vehicles.

IVDR systems were installed in 242 cars of the families of young male drivers, however, only 217 families of young drivers aged 17-22 (M=17.5; SD =0.8) completed the one year period. The families were randomly allocated into 4 groups: (1) *Family Feedback*, in which all the members of the family were exposed to feedback on their own driving and on that of the other family members; (2) *Parental Training*, in which in addition to the family feedback, parents received personal guidance on ways to enhance vigilant care regarding their sons' driving; (3) *Individual Feedback*, in which family members received feedback only on their own

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driving behavior (and were not exposed to the data on other family members); (4) *Control* group that received no feedback at all.

The feedback was provided to the different groups starting from the solo period, thus, the feedback was not provided during the supervised period.

The data collected by the IVDRs was first analyzed using analysis of variance in order to compare the groups with respect to their monthly event rates. Events' rates are defined as the number of events in a trip divided by its duration. This was followed by the development and estimation of random effect negative binomial models that explain the monthly event rates of young drivers and their parents. The study showed that: (1) the *Parental Training* group recorded significantly lower events rates (-29%) compared to the *Control* group during the solo period; (2) although directed mainly at the novice drivers, the intervention positively affected also the behavior of parents, with both fathers and mothers in the *Parental Training* group improving their driving (by -23% for both fathers and mothers) and mothers improving it also in the *Family Feedback* group (by -30%). Thus, the intervention has broader impact effect beside the targeted population.

It can be concluded that providing feedback on driving behavior and parental training in vigilant care significantly improves the driving behavior of young novice male drivers.

Future research directions could include applying the intervention to a broader population, with larger diversity with respect to their driving records, culture, and behaviors. The challenge is to reach wide dissemination of IVDR for young drivers accompanied by parents' involvement, and to find the suitable incentives for its sustainability.

Keywords

Young novice drivers, driving behavior, Parental Training, in-vehicle data recorders

1. Introduction

Young drivers in Israel, as in many other countries all over the world, experience higher road crash rates than any other age group. The over-representation in crashes is especially substantial in severe and fatal crashes (ICBS 2011). This problem received considerable public and media attention which led, among other efforts, to modifications in the Israeli driver licensing process. Starting in July 2013, newly licensed young drivers are required to drive only when accompanied by an experienced driver for the first three month after receiving their driving license, and are not allowed to drive at night unaccompanied for the first six months. The accompanying driver must be over the age of 24 and have at least five years of driving experience, or be over the age of 30 with at least three years of driving experience. During the first two years after licensure, the new driver is restricted to drive with no more than two passengers, unless when accompanied by an experienced driver (zero blood alcohol content (BAC) for all drivers under 24 years old, compared to 0.05% for other drivers). The graduation from the accompanied to the solo period is automatic, based only on the passage of time. This study was completed before July, 2013, when there was no restriction on night driving nor minimal amount of driving within the accompanied driving period.

A previous study (Lotan and Toledo 2007) showed that throughout the accompanied driving period the involvement of novice drivers in Israel in crashes is extremely low. However, as the solo un-supervised driving phase begins, crash rates rise drastically. Afterwards, crash rates gradually decline. Similar trends in crash involvement statistics were observed elsewhere (Mayhew et al., 2003; McCartt et al. 2003). At the individual level, Simons-Morton et al. (2011) equipped vehicles driven by teens with an advanced data acquisition system. They observed a general decrease in crash and near-crash involvement along the first 18 months of driving. They also found changes in specific behaviors over time (a decline in rapid starts and an increase in hard turns). The results of these studies indicate that the problem of novice drivers' crash involvement is most acute immediately after the transition from supervised to independent driving.

The literature shows substantial differences between young males and females with respect to involvement in road crashes. Male drivers, and in particular drivers in the 16-18 years age group, are significantly more involved in fatal crashes per miles driven (Lewis-Evans, 2010; NHTSA, 2009; OECD 2006). This difference may be partly explained by more aggressive driving behaviors, stronger inclination towards risk taking, sensation seeking and anti-social behaviors, a higher tendency to over-estimate their driving abilities and higher susceptibility to the influence of peers of young male drivers compared to females (Farah, 2011; OECD, 2006; Prato et al.

2010). The higher crash involvement rates for young males led us to include only male teen drivers in this study.

In recent years significant advances have been made in measuring and communication technologies. These led to considerable growth in development and use of in-vehicle data recorders (IVDR) to monitor and influence drivers' behavior, not only in the context of post-crash data, but also as tools to assist in crash prevention. As a measurement tool, IVDR facilitate observing naturalistic driving behavior. As a tool for intervention, it supports reducing risky behaviors by providing feedback to drivers or to those that are responsible for their driving. The "100 cars naturalistic study" (Dingus et al., 2006; Neale et al., 2002) was a major research effort in this direction that used elaborate and expensive monitoring equipment. It involved equipping vehicles with IVDRs that continuously measured and recorded the location, speed and acceleration of the vehicles using GPS and accelerometers. In the DriveAtlanta experiment (Ogle 2005) 172 vehicles were instrumented with IVDRs that included a GPS and connected to the vehicle's on-board computer. The data collected in this experiment included high resolution vehicle locations, speeds and accelerations and parameters of the engine and vehicle systems, such as the use of seatbelts, emissions, and the positions of the gas and brake pedals.

At the same time, more affordable commercial IVDR systems have also been introduced. Lotan et al. (2010) used a g-forces based IVDR system in various experiments. This system analyses the raw measurements to identify various maneuver events that the vehicle has undertaken, such as hard braking and acceleration, turns and lane changes. Toledo and Lotan (2007) and Toledo et al. (2008) showed that the rates of these events can be used as indicators of the risk to be involved in road crashes. Lerner et al. (2010) also found a connection between aggressive driving maneuvers and involvement in crashes and near-crashes. Prato et al. (2010) and Toledo and Lotan (2007) used these g-based events to study the driving behavior of novice drivers within the Graduate Driving Licensing (GDL) system.

As noted above, IVDRs may be used not only for measurement, but also as tools to provide feedback to drivers and others (e.g. parents, fleet managers) about their driving. Several studies provide empirical evidence to the positive effect of monitoring through IVDR systems on driving behavior and safety (Musicant et al. 2007). In the context of young drivers, Carney et al. (2010) used a one group (18 drivers) pretest–posttest quasi-experimental design to compare the rate of coachable error events per 1000 miles. In this study video recordings were triggered by safety-relevant events. Teen drivers and their parents reviewed these videos together weekly. It was found that the review process and parental feedback resulted in significant decrease in the number of events that the young drivers generated. McGehee et al.

(2007) also used a quasi-experimental design and equipped 26 vehicles of young drivers with an event-triggered video device. Data collection took place in three phases over the course of 1 year, baseline (no feedback from device or parents), intervention, and second baseline. It was found that feedback from the device combined with parental weekly review of safety-relevant incidents resulted in a significant decrease in events for the more at-risk teen drivers. Farmer et al. (2010) and Prato et al. (2010) also reported that providing young drivers and their parents with IVDR-generated feedback can reduce the incidence of risky behaviors. However, previous studies suffer from some methodological limitations. For example, the studies by Carney et al. (2010) and McGehee et al. (2007) did not include a control group in the study design and used relatively small samples. The study by McGehee et al. (2007) also could not address the critical first months of driving. The study by Farmer et al. (2010), on the other hand, randomly assigned participants to four study groups, including a control group, and monitored young drivers' behaviors over a baseline, intervention, and post-intervention periods. Additionally, the sample of participants was larger, consisting of 85 participants.

A large body of literature links various aspects of parental monitoring and family safety climate to the prevention of risky behaviors among young drivers (Simons-Morton et al., 2002; Taubman Ben-Ari and Katz-Ben-Ami, 2012; 2013). These studies showed that young drivers of families that are committed to safety and with more authoritative parenting adopt more careful driving style, while those with less authoritative parenting and less commitment to safety adopt more risky driving style. Young drivers are also influenced by their parents' driving behavior through imitation (Taubman Ben-Ari et al., 2005). However, many parents that were offered the opportunity to monitor the young drivers' driving behavior using IVDRs did not make full use of it, or even rejected it completely (Farmer et al., 2010; Guttman and Gesser-Edelsburg, 2010; Guttman, 2013). In Farmer et al. (2010), parents tended to check the young driver driving record through their website a few times at the beginning, but then lost interest. The authors suggest that this might have happened due to various possible reasons such as: the reports sent by mail were either sufficient or too brief to induce interest, other higher priority tasks, parents received the monitoring device for free so they felt no need to get their moneys' worth, or because parents trusted that they would be informed of any serious problems by the researchers who monitored the young driver behavior. In Guttman and Gesser-Edelsburg, (2010) and Guttman, (2013) parents explained these choices by saying that they trusted the young driver or were concerned about damaging their relationship with them. Parents in these studies also said that they needed guidance on how to motivate the young driver to use the feedback effectively and on how to avoid conflicts with them around the feedback.

Vigilant care refers to an authoritative approach to parenting that emphasizes increased parental presence and involvement in areas of potential risk (e.g., driving, computer misuse, alcohol, drugs, unsafe sex, bad company, delinquency, etc.). The parents are trained to monitor the child's activities flexibly, increasing their involvement according to the signs of alarm they detect. Thus, when the child does not evince signs of dangerous behavior, the parents remain at a relatively low level of monitoring, termed "open attention" (this is characterized by open dialogue, trust and open interest in the child's doings); when alarm signs become evident they move over to "focused attention" (this is characterized by direct questions regarding the "when", "what" and "with whom" of the child's activities); when the risk signs persist or denote actual danger, the parents go over to "protective action" (this is characterized by actual steps to prevent further risk behavior). In addition, parents are trained on how to prevent that these steps deteriorate into escalating interactions in which screaming, threats and aggression come to rule the parent-child relationship (Omer, 2004; 2011). Parental counseling based on this model has been shown effective in reducing aggressive and risk behaviors, as well as in reducing parental helplessness, preventing parental outbursts and increasing positive interactions (Levavi, Shahar and Omer, in press; Ollefs et al. 2009, Weinblatt and Omer, 2008). This counseling program has also been shown to be helpful for the parents of highly demanding and dysfunctional young adults (Lebowitz et al. 2012). Those findings suggest that enhancing vigilant care might help parents reduce risk driving by teens and increase their ability to make use of IVDR feedback.

2. Methodology

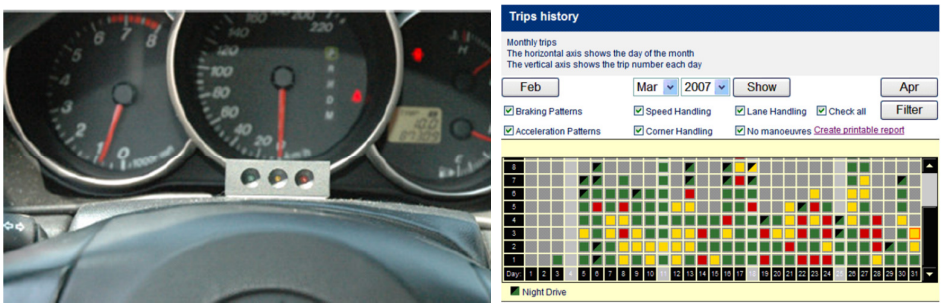
2.1. The IVDR

The IVDR system used in this study was the GreenRoad technology. It is a g-force based system which tracks all trips made by the vehicle and records the following information:

1. Trip start and end times
2. Driver identification. Drivers were requested to identify themselves at the beginning of each trip using Dallas keys (personal magnetic identification keys).
3. Vehicle location.
4. Events of excessive maneuvers defined by patterns of g-forces measured in the vehicle. These events are classified into severity groups, according to the intensity of the g-forces. The system can identify 20 different types of excessive maneuvers in the raw measurements. These maneuvers are classified

into five categories – braking, accelerating, turn handling, lane handling and speeding.

Feedback from the IVDR can be provided in multiple ways. In the current study, participants in the experiment groups that received feedback got it through a specialized web-based application and through an in-vehicle display as shown in Figure 1.



(a) (b)

Figure 1: Feedback media: (a) In-vehicle display; (b) web-based application.

The real-time feedback unit shown in Figure 1(a) provides drivers with continuous feedback on their driving aggressiveness level (measured through g-based events) which is color coded by green, yellow and red lights for moderate, intermediate and high aggressiveness levels, respectively. The web-based application provides drivers with reports that summarize trip information and events. An example of a monthly driver report is presented in Figure 1(b). The chart shows the various trips that the driver undertook during the month, where each square represents a trip. The X-axis indicates the day of the month and the Y-axis indicates the trips undertaken during each day. Trips are color-coded according to their aggressiveness classification, which is based on the rate of IVDR events that were recorded in the trip. Drivers are classified as moderate, intermediate or aggressive drivers if they record less than 2, 2 to 5 or more than 5 events per one driving hour, respectively. Black triangles indicate night-time trips. For a more detailed description of the system and previous studies that have used it see Prato et al. (2010) and Toledo et al. (2008).

2.2. Participants and recruitment

The very specific characterization of the sample required a great effort to reach the target population within the desired time schedule. In order to maximize the recruitment effort, it was divided into several channels both in-house and outsourcing, using push and pull "marketing" strategies. The main channel was "Or-Yarok for Life", which is a program run by Or Yarok (Association for Safer Driving in Israel) –

participants were contacted by phone and were offered to take part in the study. Other channels included: distributing flyers during Or Yarok activities among relevant populations, publication at the Or-Yarok homepage, publicizing information in relevant broadcasted items, operating driving instructors as "agents" among their driving learners. Also a special effort was made to spread the information via social media. Eventually, the most effective method was using "Or-Yarok for Life" lists.

A rolling recruitment procedure was used where recruitment continued for several months after starting data collection. The entire process took place between July 2009 and November 2010. In total 6290 phone calls were made to potential candidates. A potential candidate was defined as a young male driver who was newly licensed. 2380 candidates expressed their interest to participate and were asked to fill a web questionnaire, that served as screening in order to evaluate their relevance to the study (it included questions regarding access to e-mails of both the teen and his parents, holding a car, age, driving experience and so forth). 872 of those who received the questionnaires completed it. Candidates who expressed an interest to participate in the study were screened based on the following criteria:

1. Male young drivers.
2. Licensed as drivers less than 1.5 months prior to enrollment, which means that they were still within the accompanied driving period.
3. Their parents have access to the internet.
4. Live in the central part of Israel (between Haifa in the north and Ashdod in the south).
5. Drive the family car (i.e. do not have their own car).
6. Do not have untreated ADHD (Attention Deficit Hyperactivity Disorder).

242 families started participation in the experiment. Of these, 217 completed the one year period. This represents an attrition rate of 10.3%. The young participants were between 17 and 22 years old (M=17.5, SD= 0.8). Participants received an incentive of 1000 NIS (approximately $250). In the study 194 fathers between 39 and 62 years old (M=50.2, SD=5.4), and 207 mothers between 37 and 59 years old (M=47.6, SD=4.9) participated. More than half of the fathers (54%) and mothers (52%) are with an academic degree. Parent participation means that the parent had a personal magnetic identification key and drove the family car. Moreover, they were requested to fill the questionnaires. Parents in the parental training group were also requested to participate in the training on vigilant care meeting. Training in vigilant care was administered through a ninety-minute meeting at the family's home.

2.3. Training on vigilant care

The goal of the present training was to help parents exercise vigilant care over their child's driving behavior. To this end parents were supported in checking routinely the driving record on the IVDR website and were trained on how to react effectively and in a non-provocative manner to information about the driver's driving style. When the young driver drives moderately (very low levels of risk-events), the parents display vigilant care at the level of "open attention", relating to him as a member of the "community of drivers" in the family, engaging with him in "drivers' talks" and conveying to him that he is deservedly earning the privileges of independent driving. When the young driver is classified as intermediate (middle rate of risk-events), the parents intensify their vigilant care to the level of "focused alertness". At this level, the parents are trained to sit with the child to examine the feedback and to set specific goals for improvement for the coming week. If these goals are not met (that is, risk-events are not reduced), the parents are encouraged to go over to the highest level of vigilant care, namely, "protective action". At this level, they are coached on how to apply restrictions in a decisive manner (e.g., limiting night or weekend driving), but systematically avoiding fruitless arguments, scolding and screaming, while at the same time learning how to withstand the child's anger without giving in or lashing back.

Training in vigilant care was administered in a ninety-minute meeting at the family's home. Both parents and the young driver were invited to attend. In most cases both parents attended. Throughout the study these sessions were conducted by five different trained counselors. Approximately two thirds of the sessions were conducted by three psychologists, while the remaining sessions were conducted by two third-year psychology students. All counselors have extensive experience in vigilant care treatment.

The parents were also given written material with instructions on how to implement the guidelines in ways that increase effectiveness and minimize clashes.

During the experiment three to four phone calls (about once every three weeks), initiated by the counselors, were made to the parents. These phone conversations were mini-bolster sessions, devised to help the parents to cope with the difficulties they faced in implementing vigilant care. An e-mail was sent after each contact, summarizing the main messages of the conversation to the parents. The parents were also given the option of calling the counselors if they felt they needed to get immediate support. Only a small number of parents utilized this option.

2.4. The study design

The families that participated in the experiment were randomly allocated into one of four groups. The participants were not aware of the various study groups that existed within the study. The four groups were defined based on the type of feedback that the family members received from the IVDR and on the guidance that parents received on ways to enhance their involvement and monitoring of their child's driving:

Individual Feedback: In this group the feedback to family members was on their own driving, but not on that of other family members. Thus, parents did not have direct access to the driving records of their teens and vice versa.

Family Feedback: In this group all family members were exposed to the driving records of all the drivers in the family. Thus, parents had access to the driving records of their teens and vice versa.

Parental Training: Family members had access to the driving data for all other family member, as in the previous group. In addition, parents received training on how to exercise vigilant care regarding their son's driving.

Control: None of the drivers (both parents and teens) in this group received any feedback or guidance throughout the duration of the study.

Family members in the three experiment groups received feedback starting from the end of the accompanied driving period. Thus, the feedback was not provided during the supervised period.

According to the study design groups, this paper will attempt to answer the following questions: (1) what are the effects of different forms of feedback and of adding training on parental vigilant care upon the driving behavior of male teens? (2) Do the interventions impact also the driving behaviors of parents?

3. Data

The data collected in the experiment covered 45,295 driving hours in 144,367 trips that were made by 217 young drivers. It also included 37,255 driving hours in 95,798 trips that were made by young drivers' fathers, and 40,846 driving hours in 124,853 trips that were made by young drivers' mothers. Table 1 presents summary statistics for the four groups of young drivers and their parents in the accompanied and solo driving periods. Numbers in parentheses are standard deviations. Events' rates are defined as the number of events in a trip divided by its duration.

Table 1: Summary Statistics for the Four Experiment Groups

	Research Group			
	Family Feedback	*Parental Training*	*Individual Feedback*	*Control*
Number of families	55	54	53	55
Young Drivers				
Age (Std.)	17.5(0.8)	17.5(0.8)	17.5(0.8)	17.4(0.6)
Events rates – Accompanied trips (events/hour)	0.99(1.38)	1.42(1.89)	1.05(1.15)	1.38(2.03)
Events rates – Solo trips (events/hour)	2.48(2.69)	2.10(2.29)	2.61(1.94)	3.83(4.74)
Number of trip – Accompanied	2491	2513	2680	3196
Number trips – Solo	33846	32623	33146	33872
Driving time – Accompanied (hours)	945.7	907.2	993.2	1072.5
Driving time – Solo (hours)	10655.0	10612.2	9860.9	10248.4
Fathers				
Number of trip – Accompanied	3329	4091	3671	3450
Number trips – Solo	22299	21300	21331	16328
Driving time – Accompanied (hours)	1109.2	1551.5	1575.1	1184.6
Driving time – Solo (hours)	7872.7	8179.0	9513.1	6269.6
Mothers				
Number of trip – Accompanied	4480	4877	3546	4494
Number trips – Solo	23451	30443	25811	27749
Driving time – Accompanied (hours)	1553.9	1556.0	1143.5	1355.2
Driving time – Solo (hours)	8161.7	10185.9	8366.0	8524.1

The four groups are roughly balanced in terms of the number of participating families and the distribution of the ages of the young drivers. The amount of driving that young drivers and their parents undertook in the experiment vehicle, in both the accompanied and solo driving periods, are also similar. Furthermore, there are no significant differences among the young drivers in the four groups with respect to their events' rates during the accompanied driving period, in which there were no interventions for any of the four groups. Thus, differences in the driving behavior among the groups in the solo period may be attributed to the intervention. Detailed

analysis of young drivers' exposure in the accompanied and solo periods can be found in Farah et al. (2013).

4. Analysis Approach

The approach adopted in this study uses the data collected by the In Vehicle Data Recorders (IVDR), which document events of extreme g-forces measured in the vehicles, to analyze the driving behavior of young drivers and their parents. The various types of events occurring in a certain month were summed up in order to calculate the monthly event rate by dividing the total number of events with the total number of driving hours in that month.

In order to examine whether there are any significant differences among the four treatment groups with respect to their average event rates, One-way ANOVA analysis was conducted for the accompanied period and for the solo period, separately. Following this analysis, negative binomial regression models were developed. The negative binomial regression model explains the number of drivers' monthly risky events. Events counts are converted to rates using the monthly driving duration as an offset variable. A random effects structure was used in order to capture the correlations among the various measurements for the same driver over time. The resulting model is given by:

$$\ln\left[\frac{E(N_{it})}{D_{it}}\right] = \beta_0 + \beta_j \cdot X_j + b_{0i} \qquad \textbf{(1)}$$

Where, N_{it} and D_{it} are the number of events and the driving time in hours for driver i in month t, respectively. β_0 is the free fixed parameter, β_j is the vector of fixed effect parameters corresponding to the explanatory variables X_j. b_{0i} is a random effect parameter for the intercept which is assumed to follow a normal distribution with mean 0 and standard deviation of σ_{b0}.

The model parameters were estimated with the R statistical program using the glmmADMB package (Bolker et al. 2012).

The analysis approach described above was adopted for analyzing young drivers' driving behavior as well as the driving behavior of their parents.

5. Results and Analysis

5.1. Direct assessment of the intervention

Before analyzing the impact of the intervention by looking at differences among groups with respect to their driving behavior, the extent to which parents in the intervention group (*Parental Training*) employed the tools of Vigilant Care was assessed. It was assumed that if no differences would be found between the *family*

feedback and *Parental Training* groups in this stage, it would be less likely to expect differences in driving behavior of the teens in these two groups. Assessment was made by comparing the number of entries to the website of the IVDR system. It was assumed that parents in the *Parental Training* group would enter the website more frequently than parents in the *family feedback* group. In figure 2 we present the number of families in each group that entered the web site at least once a month.

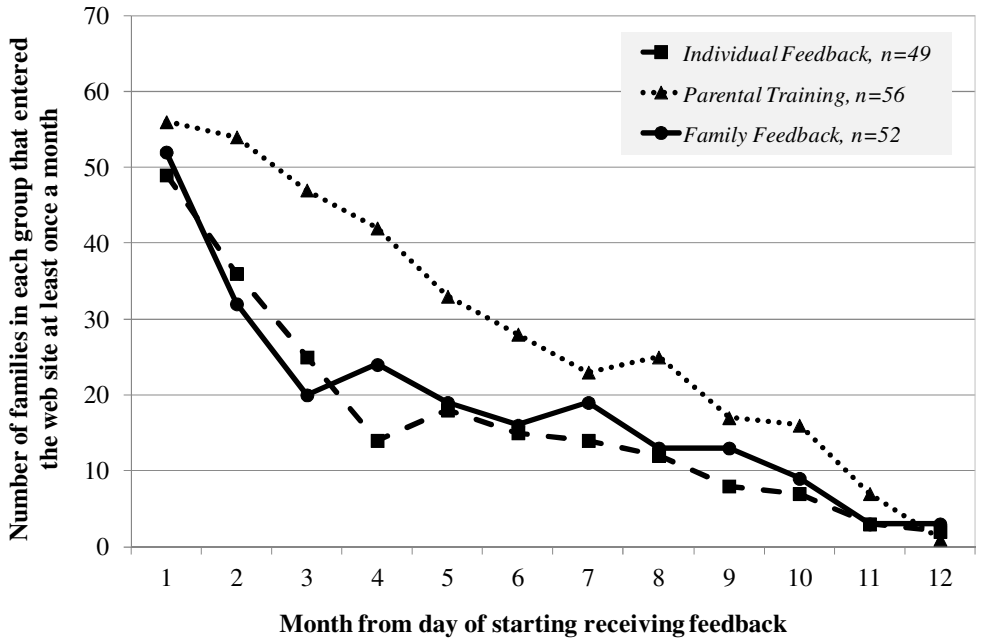


Figure 2: Number of families that entered the web site at least once a month - by groups and month.

Figure 2 shows that the number of families that entered the website of the IVDR system, to retrieve driving feedback, was high in the intervention group (*Parental Training*) during the first months from day of starting receiving feedback. A one-way between subjects ANOVA found significant differences between the three feedback groups at the 95% confidence level [$F(2,154) = 4.466$, $p = 0.013$]. Post hoc comparisons using the Boneferroni test showed that the entry counts for the *Parental Training* group ($M = 6.91$, $SD = 0.65$) were significantly higher than entry counts for the *Individual Feedback* group ($M = 4.27$, $SD=0.70$) and also higher than entry counts for the *Family Feedback* group ($M = 4.60$, $SD=0.68$; $p=0.06$).

These results indicate that most probably there are differences in the use of the feedback among the different intervention groups.

5.2. Young drivers' driving behavior

The four groups of young drivers in the experiment are compared with respect to their monthly rates of IVDR events. Figure 3 presents the averages and standard deviations

of event rates for the four groups for 11 months corresponding to the last two months of the accompanied driving period, and first nine months of solo driving. In the figure, accompanied driving period months are indicated with negative values and month 0 is the first month of solo driving. Due to limitations in recruiting and installation of the IVDR, only partial data was available for the first month of accompanied driving period (month -3) and therefore it was excluded from analysis.

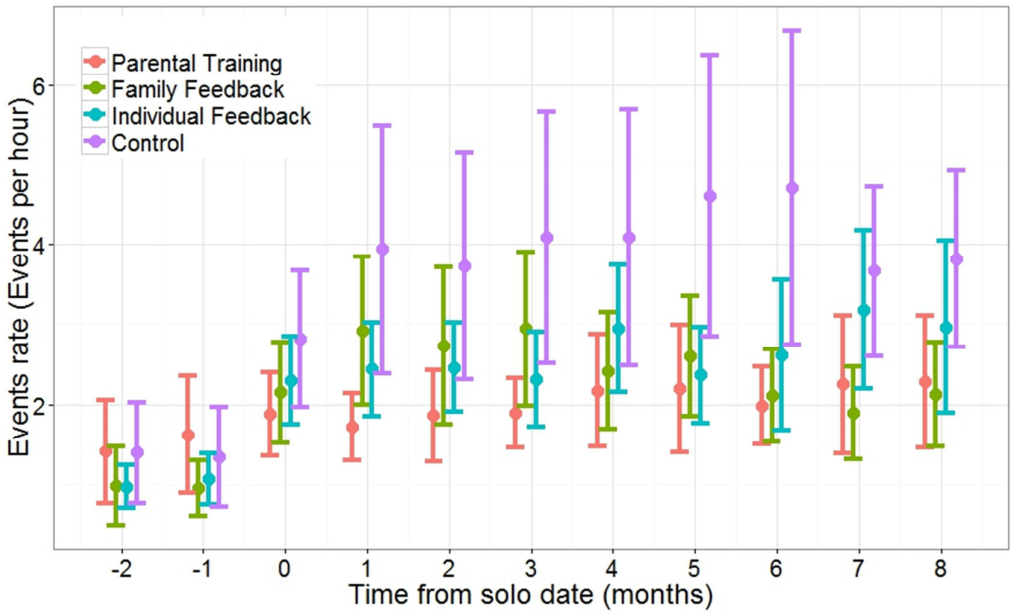


Figure 3: Averages and standard deviations of event rates for the experiment groups by month.

Figure 3 shows that, from the beginning of the solo driving period, the C_{ontrol} group consistently recorded the highest event rates. The *Parental Training* group, which received the most elaborate form of feedback and parental training, recorded the lowest event rates. One-way ANOVA tests for the event rates among the four groups found statistically significant differences in the solo period at the $p<0.05$ level [$F(3,213) = 3.141$, $p=0.026$] but not in accompanied driving period [$F(3,196) = 0.884$, $p=0.451$]. Thus the groups were similar with respect to event rates in the accompanied driving period, when no feedback was provided to any of the four groups, but differed in the solo period. To further examine these differences, a negative binomial regression model was developed which provide the possibility to control for the impact of other factors, such as the parents' driving behavior.

The data used for estimation includes 2011 observations over 11 months for 217 young drivers. It is unbalanced as some young drivers did not drive the equipped vehicle during all of the 11 months. Parameters estimates of the random effects negative binomial model are presented in Table 2.

Table 2: Random Effects Negative Binomial Model of Young Drivers' Event Rates

Variable	Estimate (Std. Error)	P-value
Constant	-0.551 (0.166)	**<0.001**
Solo	0.798 (0.080)	**<0.001**
Parental Training x Accompanied	0.068 (0.203)	0.738
Family Feedback x Accompanied	0.007 (0.211)	0.973
Individual Feedback x Accompanied	0.095 (0.203)	0.637
Parental Training x Solo	-0.342 (0.118)	**0.004**
Family Feedback x Solo	-0.100 (0.122)	0.411
Individual Feedback x Solo	-0.100 (0.116)	0.387
Parents' events rate	0.101 (0.016)	**<0.001**
Offset	1.000	Fixed
σ_{b0}	0.834	
Dispersion parameter	4.328 (0.202)	
Observations	1944	
Number of drivers	193	
Log-likelihood	-7017.16	

The variable *Solo* captures differences in the event rates between the accompanied driving period and solo period. Its coefficient is positive, which, as expected, indicates that the event rates for the solo driving period are higher compared to those during the accompanied driving period. It should be noted that initially we estimated models with month-specific effects. But, the results did not indicate significant differences among the accompanied driving period months and among the solo months, and so these were grouped together in these two categories.

The differences in event rates among the experiment groups are captured by the *Group* variables that interact with a dummy variable for the driving period ("*Accompanied" driving period* or "*Solo"*). The *Control* group is the reference for comparison for these variables. In the accompanied driving period, there are no significant differences in the event rates among any of the treatment groups (*Individual Feedback*, *Family Feedback* and *Parental Training*) and the *Control* group. In the solo period, the *Parental Training* group has a 29% lower expected event rate compared to the *Control* group. This difference is statistically significant. The *Family Feedback* and *Individual Feedback* groups also have lower expected

crash rates, but the differences were smaller (10%) and not statistically significant. The difference between the *Parental Training* and *Family Feedback* groups captures the marginal utility of the training in vigilant care. However, the difference does not reach statistical significance (p-value=0.156). Thus, while the combined effect of the feedback and Parental Training on event rates relative to the *Control* group is significant, the results are inconclusive regarding the contributions of the two components to the effects separately.

In the model, *Parents' event rates* were also included. This variable is defined by:

$$Parents'\ events\ rates\ (i) = max\ \{maxM(i), max\ F(i))\} \quad \textbf{(2)}$$

$$maxM(i) = max_t\left(\frac{N_{M(i)t}}{D_{M(i)t}}\right), \quad maxF(i) = max_t\left(\frac{N_{F(i)t}}{D_{F(i)t}}\right) \quad \textbf{(3)}$$

Where, $maxM(i)$ and $maxF(i)$ are the highest event rates recorded during the experiment for the mother and the father of driver i, respectively. The choice of maximum event rates rather than the mean of event rates correspond to modeling extreme behaviors as indicators for parental influence. Similarly, taking the most "aggressive" parent corresponds to the existence of "aggressive" driving behavior at the family setting. Indeed, the coefficient of this variable is positive and statistically significant, which implies an association between the event rates of young drivers and the "aggressive" driving behavior of their parents.

5.3. Parents' driving behavior

We now investigate the changes in the driving behavior of parents during the period in which their child begins driving. Averages and standard deviations of monthly event rates for the fathers and mothers in the four experiment groups are presented in Figure 4 and Figure 5, respectively.

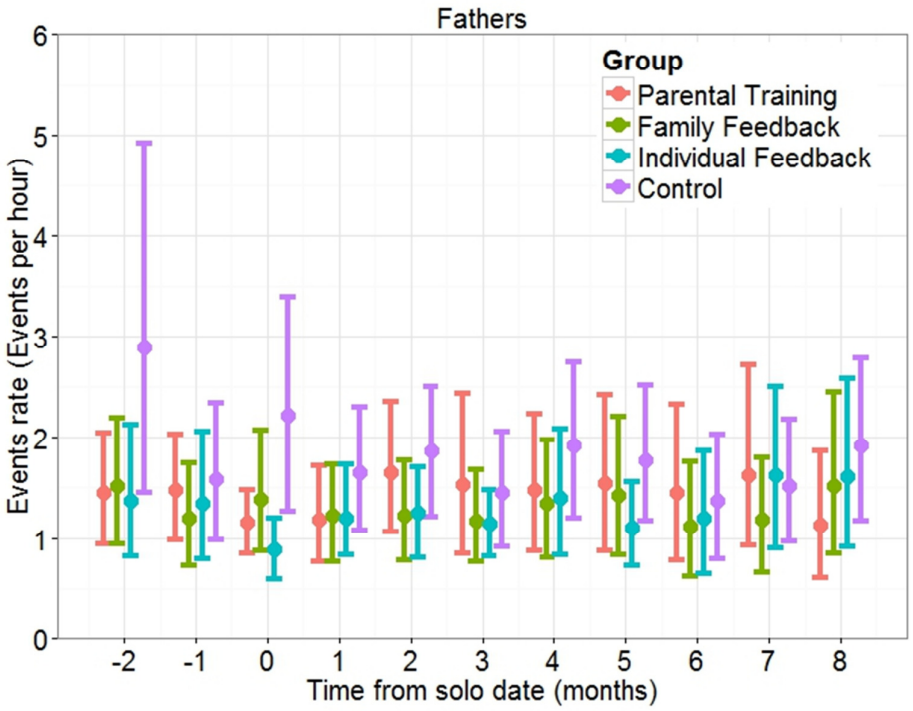


Figure 4: Averages and standard deviations of event rates for fathers in the various experiment groups by month.

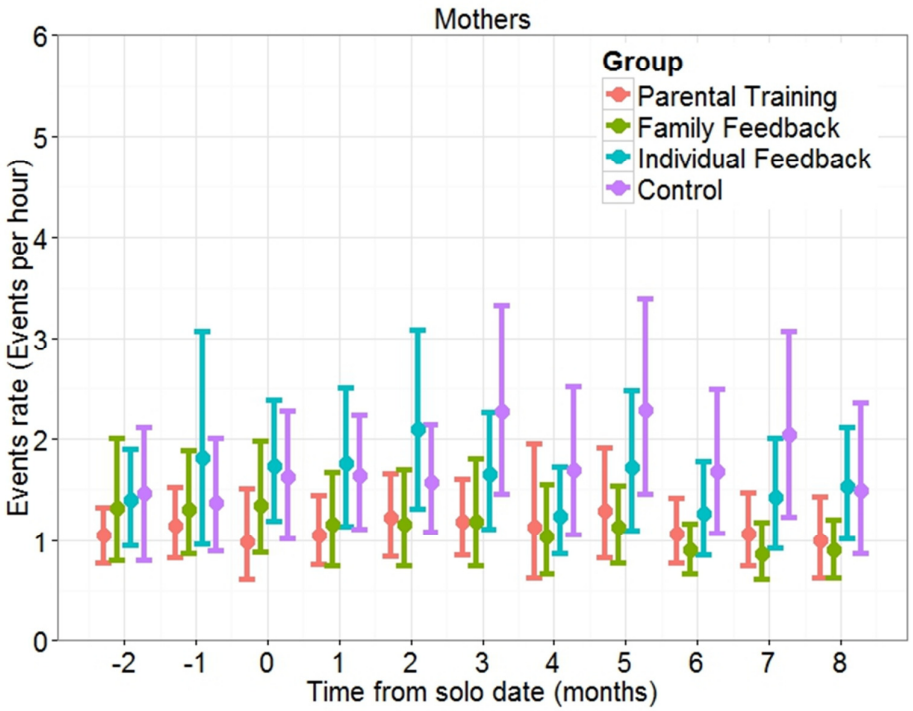


Figure 5: Averages and standard deviations of events rates for mothers in the various experiment groups by month.

For both the fathers and the mothers, one-way ANOVA tests for the event rates among the four groups did not find any significant differences neither in the solo period at the $p<0.05$ level ([$F(3,198) = 1.372$, $p=0.253$] and [$F(3,166) = 1.679$, $p=0.173$] , respectively), nor in the accompanied driving period ([$F(3,183) = 1.551$, $p=0.203$] and [$F(3,149) = 0.824$, $p=0.482$], respectively).

To further investigate parents' behavior, random effects negative binomial regression models for the event rates for the parents were estimated, Table 3 presents the estimation results.

Table 3: Random Effects Negative Binomial Model of Parents' Event Rates (Events per Hour)

	Fathers		**Mothers**	
	Estimate (Std. Error)	**p-value**	**Estimate (Std. Error)**	**p-value**
Constant	0.035(0.172)	0.840	-0.127(0.167)	0.447
Solo	0.026(0.076)	0.732	0.143(0.076)	0.061
Parental Training x Accompanied	-0.013(0.238)	0.961	-0.074(0.227)	0.742
Family Feedback x Accompanied	-0.156(0.252)	0.541	-0.005(0.229)	0.982
Individual Feedback x Accompanied	-0.134(0.248)	0.590	0.223(0.229)	0.329
Parental Training x Solo	-0.255(0.099)	**0.010**	-0.267(0.104)	**0.011**
Family Feedback x Solo	-0.150(0.108)	0.171	-0.352(0.103)	**<0.001**
Individual Feedback x Solo	-0.130(0.105)	0.225	-0.157(0.106)	0.136
Offset	1.00	Fixed	1.00	Fixed
σ_{b0}	0.989		0.919	
Dispersion parameter	8.902 (0.655)		7.964 (0.528)	
Observations	1410		1584	
Number of drivers	158		170	
Log-likelihood	-4349.62		-5006.04	

The results presented in Table 3 show that, as with the teen drivers, there were no significant differences among the event rates for parents in the four experiment groups during the accompanied driving period in which no feedback was provided. In the solo period, the events rates for the *Parental Training* group were 23% lower compared to those for the *Control* group, for both fathers and mothers. These differences are statistically significant. Parents in the other experiment groups also had lower event rates compared to the *Control* group (by 12% and 15% for the fathers and mothers, respectively, in the *Individual Feedback* group and by 14% and 30% for the fathers and mothers, respectively, in the *Family Feedback* group). But these differences were statistically significant only for *Family Feedback* mothers. Thus, although the intervention was directed toward influencing the behavior of novice young drivers, it also affected the behavior of parents, with both fathers and mothers being affected in the *Parental Training* group and mothers in the *Family Feedback* group.

6. Summary and Discussion

This study evaluated the potential of various feedback forms on driving behavior and parental training in vigilant care to affect the driving behavior of young novice male drivers during their first year after licensure, and the driving behavior of their parents.

The driving behavior was measured by the rate (per driving hours) of g-force events that were recorded for the driver. The analysis indicates that after novice young drivers complete their accompanied driving obligations their risky behavior significantly increases. This result is consistent with the findings of earlier studies (Lotan and Toledo, 2007; Mayhew et al., 2003; McCartt et al. 2003). The event rates measured for the parents were also found to be a significant factor positively correlated with the event rates of the young drivers. In other words, young drivers imitate their parents' driving behavior (Taubman Ben-Ari et al., 2005). In terms of the four experiment groups, in the accompanied driving period, when no feedback was provided to any of the participants, the groups were similar with respect to the event rates. However, within the solo driving period, the *Control* group was consistently the worst in terms of event rates. These differences in event rates were largest and statistically significant compared to the *Parental Training* group. The differences between the *Control* group and the other two groups (*Individual Feedback* and *Family Feedback*) and between these groups and the *Parental Training* group were not statistically significant. Thus, our results provide evidence that the combined treatment of IVDR feedback and Parental Training on vigilant care reduces the event rates of young drivers. These results suggest that simply installing a technology and providing feedback is not enough when trying to create a change in young drivers'

behavior. This finding supports conclusions reached in several other studies that pinpoint parental involvement as a key element in improving driving safety of young drivers (e.g. Farmer et al., 2009; Hartos et al., 2001, 2002; McCartt et al., 2003; Shope et al., 2001; Simons-Morton and Ouimet 2006, Simons-Morton, 2007). However, while the combined effect of the feedback and parental guidance on event rates relative to the *Control* group is significant, the results are inconclusive regarding the contributions of the two components to the effects separately. This could stem from the fact that the participating families are mostly families that already have some awareness on road safety, and thus this might reduce the potential effectiveness of the parental training on vigilant care. Furthermore, it could be the case that positive effects in the parental guidance group are attributed to the personal contact with them. This effect has not been isolated; hence future research on larger populations is encouraged.

A reduction effect was found also in the event rates of the parents. As with the effects on young drivers, the effects appeared in all treatment groups, for both fathers and mothers, but were most pronounced (and significant) in the *Parental Training* group. It appears then that in exercising vigilant care over their child's driving, parents become more ready to watch over their own driving as well. Thus, the intervention has broader impact effect beside the targeted population.

The main limitation of this study is that most of the participating families are families with relatively good road safety records of both the young driver and the parents. These are families who have some awareness on road safety, partly through participation in Or Yarok safety projects, and thus, these are not families with high occurrence of aggressive behaviors, as measured by the IVDR, nor high risk of involvement in road crashes. Despite this fact, as was shown in the results, the intervention could improve their driving behavior. It is expected that applying this intervention to families with lesser awareness to traffic safety may have a larger effect on driving behavior. The main challenge is therefore to convince such families to participate in this type of activities. Beyond the research arena – the challenge is to reach wide dissemination of IVDR for young drivers accompanied by parents' involvement, and to find the suitable incentives for its sustainability.

Future research directions could include applying the intervention to a broader population, with larger diversity with respect to their driving records, culture, and behaviors. The blast in mobile phone development made it possible to make these technologies even simpler. Currently there are some smart-phone applications that provide similar services (monitoring and feedback). These applications are much more easy-to-use, cheap, easy to install and easily accessible. Still however, several important issues such as validity, acceptance, commitment to use, and the verification

of continuous operation, need to be seriously addressed and investigated prior to their use.

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References

Bolker, B., Skaug, H., Magnusson, A., Nielsen, A., 2012. Getting started with the glmmADMB package.

Carney, C., McGehee, D.V., Lee, J.D., Reyes, M.L., Raby, M., 2010. Using an event-triggered video intervention system to expand the supervised learning of newly licensed adolescent drivers. American Journal of Public Health, 100(6), 1101-1106.

Dingus, T.A., Klauer, S.G., Neale, V.L., Petersen, A., Lee, S.E., Sudweeks, J., Perez, M.A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z.R., Jermeland, J., Knipling, R.R., 2006. The 100-car naturalistic driving study phase II – results of the 100-car field experiment, Report DOT-HS-810-593, Department of Transportation, Washington DC.

Farah, H., 2011. Age and gender differences in overtaking maneuvers on two-lane rural highways. Transportation Research Record: Journal of the Transportation Research Board, No. 2248, 30–36.

Farah, H., Musicant, O., Shimshoni, Y., Toledo, T., Grimberg, E., Omer, H., Lotan, T., 2013. The first year of driving – Can IVDR and parental involvement make it safer? Preprints of the Transportation Research Board 92nd Annual Meeting CD-ROM, No., 13-1531.

Farmer, C.M., Kirley, B.B., McCartt, A.T., 2009. In-vehicle monitoring and the driving of teenagers. Insurance Institute for Highway Safety, 44, 2-8.

Farmer C.M., Kirley, B.B., McCartt, A.T., 2010. Effects of in-vehicle monitoring on the driving behavior of teenagers. Journal of Safety Research. 41(1), 39-45.

Guttman, N., Gesser-Edelsburg, A., 2010. "The Little Squealer" or "The Virtual Guardian Angel"? Young drivers' and their parents' perspective on using a driver monitoring technology and its implications for parent-young driver communication. Journal of Safety Research. 42(1), 51-59.

Guttman, N., 2013. My son is reliable" young drivers' parents' optimism and views on the norms of parental involvement in youth driving. Journal of Adolescent Research 28(2), 241-268.

Hartos, J.L., Eitel, P., Simons-Morton, B.G., 2001. Do parent-imposed delayed licensure and restricted driving reduce risky driving behaviors among newly licensed teens? Prevention Science, 2(2), 113-122.

Hartos, J.L., Eitel, P., Simons-Morton, B.G., 2002. Parenting practices and adolescent risky driving: A three month prospective study. Health Education and Behavior, 29(2), 194-206.

Israel Central Bureau of Statistics (ICBS), 2011. Involvement in Road Accidents (in Hebrew).

Lebowitz, E., Dolberger, D., Nortov, E., Omer, H., 2012. Parent training in nonviolent resistance for adult entitled dependence. Family Process, 51(1), 90-106.

Lerner, N., Jenness, J., Singer, J., Klauer, S., Lee, S., Donath, M., Manser, M., Ward, N., 2010. An exploration of vehicle-based monitoring of novice teen drivers: Final Report. NHTSA, DOT HS 811 333.

Levavi, L., Shachar, I., Omer, H., (in press). Training in non-violent resistance for parents of violent children: Differences between fathers and mothers. Journal of Systemic Therapies.

Lewis-Evans, B., 2010. Crash involvement during the different phases of the New Zealand 47 Graduated Driver Licensing System (GDLS). Journal of Safety Research, 41(48), pp. 359-365.

Lotan, T., Toledo, T., 2007. Driving patterns of young drivers within a graduated driver licensing system. Preprints of the Transportation Research Board 86th Annual Meeting CD-ROM, No., 07-1080.

Lotan, T., Albert, G., Ben-Bassat, T., Ganor, D., Grimberg, E., Musicant, O., Hakkert, S., Toledo, T., 2010. Potential benefits of in-vehicle systems for understanding driver behavior; a series of small-scale ND studies in Israel. PROLOGUE Deliverable D3.2, Or Yarok, Hod Hasharon, Israel.

Mayhew, D.R., Simpson, H.M., Pak, A., 2003. Changes in collision rates among novice drivers during the first months of driving. Accident Analysis and Prevention, 35(5), 683–691.

McCartt, A.T., Shabanova, V.L., Leaf, W. A., 2003. Driving experience, crashes and traffic citations of teenage beginning drivers. Accidents Analysis and Prevention, 35(3), 311-320.

McCartt, A.T., Teoh, E.R., Fields, M., Braitman, K.A., Hellinga, L.A., 2010. Graduated licensing laws and fatal crashes of teenage drivers: a national study. Traffic Injury Prevention, 11(3), 240-248.

McGehee, D.V., Raby, M., Carney, C., Lee, G.D., Reyes, M.L., 2007. Extending parental mentoring using an event-triggered video intervention in rural teen drivers. Journal of Safety Research, 38(2), 215–227.

Musicant, O., Lotan, T., Toledo, T., 2007. Safety correlation and implications of an in-vehicle data recorder on driver behavior, Preprints of the 86th Transportation Research Board Annual Meeting, Washington DC.

Neale, V.L., Klauer, S.G., Knipling, R.R., Dingus, T.A., Holbrook, G.T., Petersen, A., 2002. The 100 car naturalistic driving study phase I: experimental design, Report DOT-HS-808-536, Department of Transportation, Washington DC, 2002.

NHTSA, 2009. Traffic Safety Facts, 2008. U.S. Department of Transportation, National Center for Statistical Analysis, Washington, D.C.

OECD/ECMT, 2006. Young drivers: the road to safety. European Conference of Ministers of Transport, OECD Publishing.

Ogle, J.H., 2005. Quantitative assessment of driver speeding behavior using instrumented vehicles. PhD dissertation, Georgia Institute of Technology.

Ollefs, B., Schlippe, A.V., Omer, H., Kriz, J., 2009. Youngsters with externalizing behavior problems: effects of parent training (in German). Familiendynamik, 34, 256-265.

Omer, H., 2004. Non-violent resistance: A new approach to violent and self-destructive children. NY Cambridge University Press.

Omer, H., 2011. The new authority: family, school and community. NY: Cambridge University Press.

Prato, C., Toledo, T., Lotan, T., Taubman-Ben-Ari, O., 2010. Modeling the behaviour of novice young drivers during the first year after licensure. Accident Analysis and Prevention, 42(2), 480-486.

Simons-Morton, B.G., Hartos, J.L., Leaf, W.A., 2002. Promoting parental management of teen driving. Injury Prevention, 8, 23-24.

Simons-Morton, B.G., Ouimet, M.C., 2006. Parent involvement in teen driving: A review of the literature. Injury Prevention, 12, i30-i37.

Simons-Morton, B.G., 2007. Parent involvement in novice teen driving: Rationale, evidence of effects, and potential for enhancing graduated driver licensing effectiveness. Journal of Safety Research, 38(2), 193–202.

Simons-Morton, B.G., Ouimet, M.C., Zhang, Z., Lee, S.L., Klauer, S.E., Wang, J., Chen, R., Albert, P.S., Dingus, T.A., 2011. Crash and risky driving involvement among novice adolescent drivers and their parents. The American Journal of Public Health, 101(12), 2362-2367.

Shope, J.T., Wallar, P.F., Raghunathan, T.E., Patil, S.M., 2001. Adolescent antecedents of high-risk driving behavior into young adulthood: substance use and parental influences. Accident Analysis and Prevention, 33(5), 649-658.

Taubman - Ben-Ari, O., Mikulincer, M., Gillath, O., 2005. From parents to children—similarity in parents and offspring driving styles. Transportation Research Part F, 8, 19–29.

Taubman - Ben-Ari, O., Katz-Ben-Ami, L. 2012. The contribution of family climate for road safety and social environment to the reported driving behavior of young drivers. Accident Analysis and Prevention, 47, 1-10.

Taubman - Ben-Ari, O., Katz-Ben-Ami, L., 2013. Family climate for road safety: A new concept and measure. Accident Analysis and Prevention, 54, 1-14.

Toledo, T., Lotan, T., 2007. In-vehicle data recorder for evaluation of driving behavior and safety. Transportation Research Record: Journal of the Transportation Research Board, 1953, 112-119.

Toledo, T., Musicant, O., Lotan, T., 2008. In-vehicle data recorder for monitoring and feedback on drivers' behavior. Transportation Research Part C: Emerging Technologies, 16(3), 320-331.

Weinblatt, U., Omer, H., 2008. Non-violent resistance: A treatment for parents of children with acute behavior problems. Journal of Marital and Family Therapy, 34(1), 75-92.