Driving patterns of young drivers within a graduated driver licensing system

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ABSTRACT

Young drivers in Israel, as in other parts of the world, are involved in car crashes more than any other age group. In Israel, a graduated driver licensing (GDL) system has been introduced, which requires all new drivers to be accompanied by an experienced driver whenever they drive for the first three months after obtaining a driving license. As part of the efforts to characterize the driving behavior of young drivers in the accompanied driving period and the period immediately thereafter and we conduct a novel experiment, which uses information gathered from an in-vehicle data recorder (IVDR). In the experiment, an IVDR system is installed in the primary vehicles driven by the young drivers in the families that participate in the experiment. The system monitors all trips made by the vehicle and all drivers are identified. We report on results of the analysis of these data. In particular we study the amount of driving young drivers undertake in the accompanied driving period and the period thereafter, and the characteristics of the temporal distributions of these trips. We find striking differences between the driving patterns characteristics in the two periods in all these aspects, and between the IVDR measurements and similar statistics obtained through self reports.

INTRODUCTION

Young drivers in Israel are involved in car crashes more than any other age group. This trend, which is demonstrated in Figure 1, has remained unchanged over the last decade. It is also consistent with similar observations worldwide. For example, Williams *[1]* quotes higher young driver rates of involvement in car crashes in the US normalized by the number of drivers, miles traveled and population size. This phenomenon has received significant media and political attention and prompted various regulatory changes that affect the driver licensing system. In Israel, as part of the effort to tackle this problem, a new graduated driver licensing (GDL) system has been implemented. With this system young adults can begin taking driving lessons, which are given only by professional instructors, at the age of 16.5 years. At this stage, it is illegal for them to drive at all except during these driving lessons. A driving license is issued upon passing theory and on-road driving tests. Students are required to attend a minimum of 28 on-road driving lessons and be 17 years or older before they can undertake the driving test. With the previous system there were no restrictions on novice drivers once they received their licenses. The new system was first introduced in 2000 and in a modified version in November 2004. The current system imposes a requirement that all new drivers, regardless of their age, must be accompanied by an experienced driver whenever they drive for the first three months (two months until November 2004) after obtaining the driving license. An experienced driver must be over the age of 24 years and hold a valid driving license for at least five years. There is no minimum requirement on the amount of driving during the accompanied period. In addition, starting in November 2004, for a period of two years after licensure, unless an experienced driver is present in the car, the number of passengers is limited to two excluding the driver. There are no restrictions on nighttime driving. Figure 2 shows the involvement of young drivers in car crashes in 2002 to 2005 as a function of the months of driving experience they have gained. Note that all this data relates to drivers that participated in the GDL program. The figure shows that the involvement of young drivers in crashes while they are in the accompanied driving period is very low. However, once they enter the solo driving period (after two months in 2002-2004 and three months in 2005), crash rates increase dramatically. These rates then gradually decrease as drivers gain more driving experience. A similar trend was also observed elsewhere in the world *[1]*.

This paper reports on results of research that aims to characterize the driving patterns and behaviors of young drivers during the accompanied driving period and the period immediately thereafter. In contrast with other research in this area, which is mostly based on self reports, this research is conducted using an in-vehicle data recorder (IVDR). The rest of this paper is organized as follows: the next section introduces the practice of graduated driver licensing (GDL). The evaluation of the program impact relies on data collected in an experiment that uses an IVDR system. We therefore present the details of the specific system being used and the design of the experiment it is used in. Next, we present results that characterize the vehicle usage patterns of young drivers in the accompanied period and the period immediately thereafter and relate these results to the characteristics of the GDL program. We then compare the results obtained using the IVDR data with similar statistics that were obtained through the classic means of self reports. We conclude with some closing remarks.

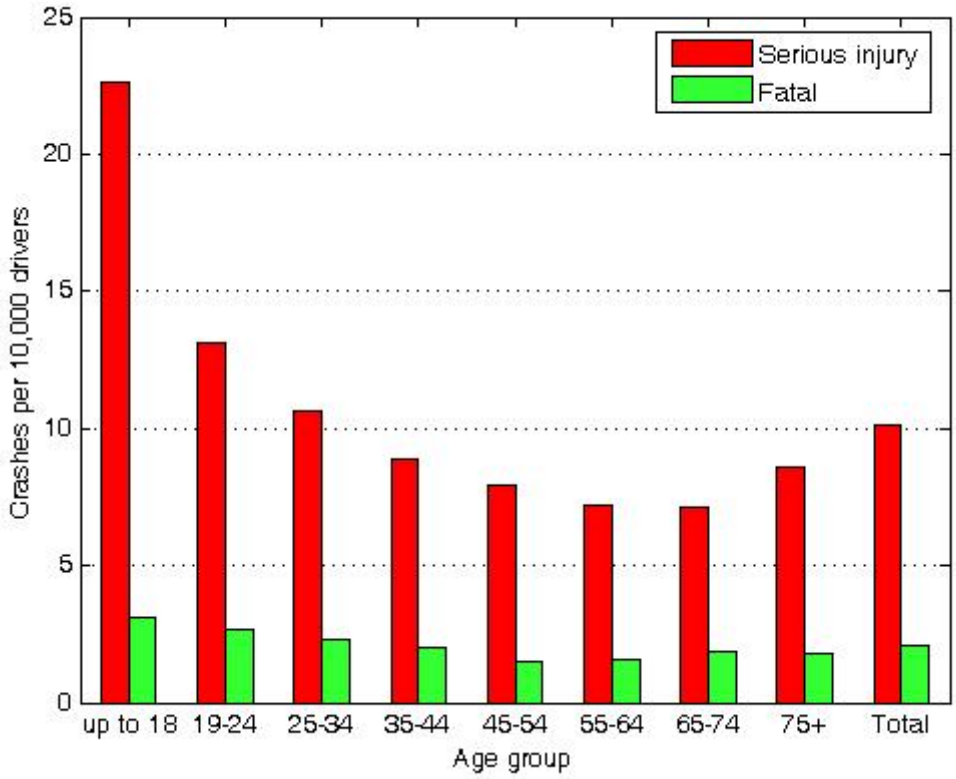

Figure 1 Car crash rates by age group in Israel in 2003 (source: CBS 2004 *[2]*)

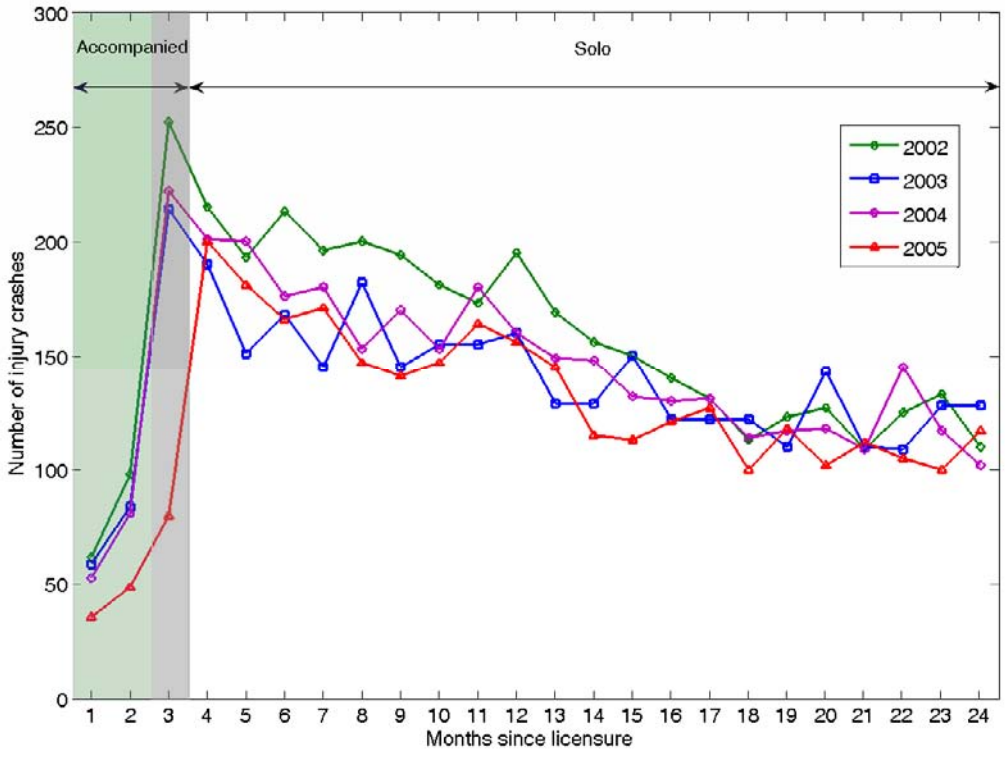

Figure 2 Injury car crashes by months of driving experience in Israel in 2005

GRADUATED DRIVER LICENSING

GDL has now been implemented in a large number of jurisdictions worldwide. Most GDL programs consist of three phases: learner permit, provisional license and full license. The learner permit allows holders to drive only under the supervision of an experienced driver. The provisional license sets certain restrictions on the novice drivers. These restrictions are often set on nighttime driving and on carrying passengers. In addition, during this phase the tolerance to traffic violations, in particular alcohol-related ones, is lower and the associated penalties higher. Many studies have shown that GDL is effective in reducing the involvement of young and novice drivers in car crashes. These reductions are commonly attributed to two factors (*[3]*, *[4]* and *[5]*):

- Reducing the level of exposure to risk. For example, the accompanied driving requirement of the learner permit and the nighttime driving restrictions imposed by the provisional license significantly reduce the amount of driving and in particular night driving that novice drivers undertake.
- Improving the driving knowledge, experience and hazard perception skills through prolonged and more controlled licensure procedures.

While the macroscopic evidence to the success of GDL is compelling, the impact on driving patterns at the level of individual drivers has not been extensively studied. To that end we use an IVDR that monitors the behavior of young drivers and provides quantitative information on their driving patterns in the accompanied period and the period thereafter. We next describe the IVDR system used in this research in detail.

IN-VEHICLE DATA RECORDER

IVDR are on-board devices that record information about the movement, control and performance of the vehicle (*[6]*, *[7]* and *[8]*). Most of the applications of these systems have centered on the car crash event itself (e.g., crash investigations, emergency response, research and development of safety devices). However, the application of IVDR to continuously monitor driving patterns and behavior, and not only during a crash event, has immense potential for research, prevention and training. This direction has been adopted in several on-going recent studies, including the DriveAtalnta experiment *[9]* and the TripSense program *[10]*, which used IVDR data to determine insurance rates for participating vehicles. NHTSA *[11]* has recently conducted an ambitious study in which 100 vehicles were instrumented with IVDR as well as video cameras, radar sensors, GPS and lane trackers for a period of 13 months. Preliminary analysis of the huge data set collected in this study indicates great potential to enrich traffic safety research. The application in this paper demonstrates the usage of an IVDR system to study driving patterns of young drivers and to evaluate the impact of a GDL program.

In this study we use a specialized IVDR called DriveDiagnostics. The system tracks all trips made by the vehicle it is installed in and records the following information:

1. Trip start and end time
2. Driver identification
3. Trip duration
4. Speed profile
5. All maneuvers that have been identified, as will be described next.
6. Evaluation of the severity of each maneuver

The overall framework of the IVDR system is shown in Figure 3. The system incorporates four layers of data collection and analysis: measurement, identification, analysis and reporting. The first layer in the system is the measurement module, which collects the two-dimensional acceleration and speed of the vehicle at a sampling rate of 40 measurements per second. This raw information is analyzed in two information processing layers. The first is a detection and evaluation layer, which incorporates pattern recognition algorithms to identify and classify over 20 different maneuver types in the raw measurements. Examples of these maneuvers include lane changes with and without acceleration, sudden brakes, strong accelerations, excessive speed and so on. The quality of performance of the detected maneuvers is also evaluated. This evaluation is based on parameters of the detailed trajectory of the vehicle during the maneuver, such as its duration and smoothness and extent of sudden changes in the vehicle movement, and on the speed it is performed at. The various information elements are transmitted in real-time, continuously throughout the trip, using wireless networks to an application server, which maintains a database with vehicle-specific and driver-specific trip history that includes statistics of the vehicle usage patterns and the maneuvers that have been recorded. Other relevant information, such as crash records, maintenance and fuel costs etc are also recorded in the database. The next layer, which resides in the application server synthesizes the specific maneuvers that were identified to evaluate an overall driving risk index at the level of the individual trip and of the vehicle overall performance, to characterize and to classify the driver's profile. In the current implementation drivers are classified in three categories (cautious, moderate and aggressive) based on the rate and severity of maneuvers they generate and on their speed profile. The final layer is a reporting layer that provides feedback based on the information collected in the database. This may be done both off-line and in real-time. In an off-line application, various reports that summarize and compare information at the level of the driver, vehicle or an entire fleet are produced and viewed as printed reports or through a dedicated website. Real-time feedback, which typically includes warnings on aggressive behavior or on significant deviations from the normal driving patterns for the specific driver, can currently be provided in two ways: as a text message sent to the driver or to others (e.g. fleet managers, parents of a young driver) or using an in-vehicle display unit.

The DriveDiagnostics system has so far been installed in several hundreds of vehicles in a series of pilots validating its measurements and algorithms. Over 400,000 trips have been analyzed so far. Preliminary validation results (*[12] [13]*) show high correlation between the data collected by the IVDR and the risk of involvement in car crashes.

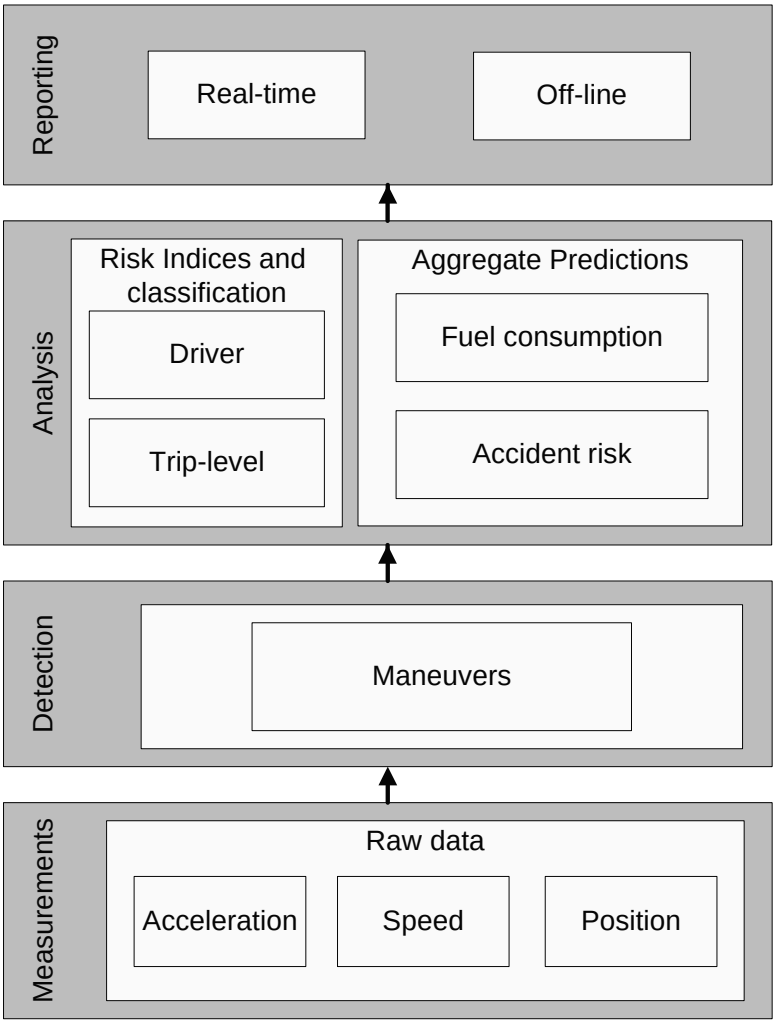

Figure 3 Overall framework of the DriveDiagnostics system

THE GDL EXPERIMENT

The DriveDiagnostics system is installed in the primary vehicle driven by the young driver in families that participate in the experiment. The installation is performed, in most cases, shortly before the young drivers receive their driving licenses. The experiment itself is conducted over eight months for each driver, such that it covers not only the accompanied driving period, but also the period thereafter. The experiment comprises of three stages:

1. **Accompanied driving**: As discussed above, in the first three months after licensure young drivers in Israel must be accompanied by an experienced driver whenever they drive. At this stage the vehicles have already been instrumented but the young drivers and their families do not receive any feedback from the IVDR. Furthermore, only minimal explanation about the purpose and capabilities of the IVDR is given to the families. It is therefore expected that the installation has minimal effect on their behavior.
2. **Blind profiling (solo) stage**: Once the accompanied driving period ends, the driver is allowed to drive without supervision (solo driving) with only a restriction on the number of passengers they can take. At this point drivers still do not receive any feedback from the system. The purpose of this stage, which typically lasts 4-6 weeks, is to characterize

the driving behavior of the fully licensed young drivers and to serve as a benchmark to the evaluation of the impact of the feedback from the IVDR.

3. **Feedback stage**: at the end of the blind profiling, the young drivers and their families are invited to a meeting in which they learn about the IVDR, receive feedback about their own driving behavior since the installation of the system and are given access codes to personal web page, which present the information relating to all the trips they have made. Each driver (young drivers and other family members) can only access the information about the trips made by members of their own family. However, in order to put these figures in context, they also receive information about the average behavior of the participants in the experiment. The web pages are continuously updated in real-time with new information as new trips are made.

The experiment was advertised to young adults and their families in the media, through the driving instructors and in a dedicated web site. Participants in the experiment were chosen out of those families that volunteered to do so. In the screening process, only families who declared that all the trips made by the young driver (both accompanied and solo) will be in the vehicle with the IVDR and that this vehicle is also the main vehicle used by the accompanying person were recruited. In practically all cases, this meant that the vehicle was either the only one in the household or the only one that the young driver was insured to use. It should be noted that the resulting sample is by no means representative of the young drivers' population. It is likely that it is biased towards self selection of families with high awareness and willingness to participate. The resulting sample included 31 young drivers, 20 male and 11 female. The average age of these drivers when they received their driving licenses was 17 years and 4 months, with the youngest being 17 years old and the oldest 18 and 8 months. 24 (77%) of the drivers were under 17 years and 6 months. The results reported next are from analysis of 2842 driving hours within 8246 trips that were taken by the 31 young drivers.

The data collected during the experiment may be used to study several questions. Some of the important ones include the following:

- The amount and characteristics of the driving that young drivers perform during the accompanied period and thereafter.
- Characterization of the driving behavior of young drivers and their families during the accompanied driving period and thereafter.
- Monitoring of the transition from the accompanied driving period to the independent one. Study the impact of the accompanied driving on the driving behavior of young drivers after it is completed.
- Continuous monitoring of young drivers and identification of specific unsafe maneuvers and behaviors they undertake.
- The impact of the feedback on the driving behavior of young drivers and their families.

RESULTS

We report results of analysis of the IVDR data that focuses on the first point listed above, i.e., measurements of the characteristics of driving in the accompanied period and the solo period thereafter. In particular we monitor and compare the amount of driving in the two periods, and the properties of the trips made in terms of the distributions of the trip durations, time of day and day of the week.

Amount of driving

We first examine the amount of driving young drivers undertake in the accompanied period and the period thereafter. This is an important issue since supervised driving experience has a significant impact on accident risk for novice drivers. For example, Gregersen *[14]* found that the risk of accident involvement is 40% lower for drivers with 120 hours of supervised driving compared to those with only 40 hours experience. Table 1 presents summary statistics for the amount of driving in the two periods. In evaluating these results it should be noted that it is possible that young drivers used other vehicles as well. However, given the screening process in recruiting drivers, it is unlikely that the underestimation of the amount of driving is substantial. The results provide an indication on the value that may be derived from the accompanied driving in terms of elevating the experience level of young drivers. In the accompanied period, the average young driver drives 2.02 hours per week, which add up to a total of 26.3 hours during the entire accompanied period. Together with the experience gained in mandatory driving lesson, which on average amounts to about 30-35 hours, the average novice driver in Israel has gained about 60 hours of supervised driving before the provisional license stage. This falls significantly short of recommended values (e.g. in Victoria Australia 120 supervised driving hours *[15]*). Furthermore, some young drivers drive significantly less. The extreme case in our sample is a young driver that only drove for a total of 6.2 hours during the entire accompanied period. Interestingly, a study of attitudes towards the accompanied driving *[16]* indicates that a vast majority of parents and young drivers (83% and 72%, respectively) think it is important to undertake the accompanied driving. Some of the gap between positive attitudes towards accompanied driving and the low amount of actual driving may be explained by the fact that the GDL program is relatively new in Israel, and so parents are not used to this system (which they have not gone through themselves), by the lack of guidelines on desirable levels of accompanied driving and by that the only criterion for the successful completion of the accompanied period is passage of time. Thus, mechanisms to increase the amount of accompanied driving, such as setting or recommending a minimum driving time requirement, may be needed.

Table 1 Amount of driving in the accompanied period and thereafter

Summary Statistics	Driving Time (hr/week/driver)		Number of Trips (trips/week/driver)		Average Trip length (min)	
	Accompanied	Solo	Accompanied	Solo	Accompanied	Solo
Average	2.02	4.45	4.82	13.22	25.2	21.3
Median	1.56	3.99	4.15	12.31	23.1	19.7
Minimum	0.48	0.55	1.20	1.67	15.2	12.8
Maximum	5.67	10.80	14.56	35.69	40.4	38.7
Standard deviation	1.23	3.04	2.77	9.16	6.5	6.3

There is a sharp increase (120%) in the average weekly driving time in the solo driving period that follows the accompanied period. This increase is statistically significant at the 1% level. It is observed not only for the averages but also in all the other relevant summary statistics. The increase is even larger in terms of the numbers of trips drivers undertake. The reason is that drivers not only drive more hours, but they also make shorter trips. However, the correlations between the individual driving times and numbers of trips in the accompanied period and in the solo period are low (0.369 and 0.409, respectively). This result indicates that there is no clear pattern in the relations between the amount of driving in

the accompanied driving period and in the solo driving period, and so drivers that drive little in the accompanied period may be driving much more after it has ended. This phenomenon could be explained by the different nature and purpose of trips during the two periods. A related study based on self reports *[17]* found that most trips (55%) in the accompanied driving phase are trips serving family and household needs rather than trips initiated by and for the young driver. Trips in the solo period indicate a reverse trend.

Distribution during the day

Figure 4 shows the distribution of the driving time during the day in the accompanied period (left) and in the solo period that follows (right). There are significant shifts in the driving patterns between the two periods. These shifts may reflect differences in activity patterns of the young drivers compared to those of the older experienced drivers that accompany them. Most importantly, young drivers shift their driving in the solo period to later hours in the evening and nighttime compared to the accompanied period. The peak driving hour in the accompanied period is 6-7PM (11.2% of the driving time) and the peak four hours are 5-9PM (39.5%). On weekdays these hours are the ones immediately after the end of the working day. In the solo period, the peak hour is 9-10PM (7.9%) and the peak four hours are 7-11PM (27.8%). These hours are typically when the family car becomes more available to the young drivers. Perhaps even more telling, young drivers drive significantly more during the night once they enter the solo period. While in the accompanied period only 2.8% of the driving time is between midnight and 6AM and 11.3% between 10PM and 6AM, 19.0% and 32.0%, respectively, of the driving in the solo period is during these night hours. Coupled together with the more than doubling of the total driving time from the accompanied driving period to the solo period, the results indicate that young drivers who gain little experience in night driving during the accompanied driving period (an average of 0.23 driving hours between 10PM and 6AM per week, for a total of 3.0 during the entire accompanied period), undertake significant driving during this period of the day once they are in the solo period (an average of 1.4 hours per week). As with the overall amount of driving, setting minimum nighttime driving requirements may be useful in tackling this difference.

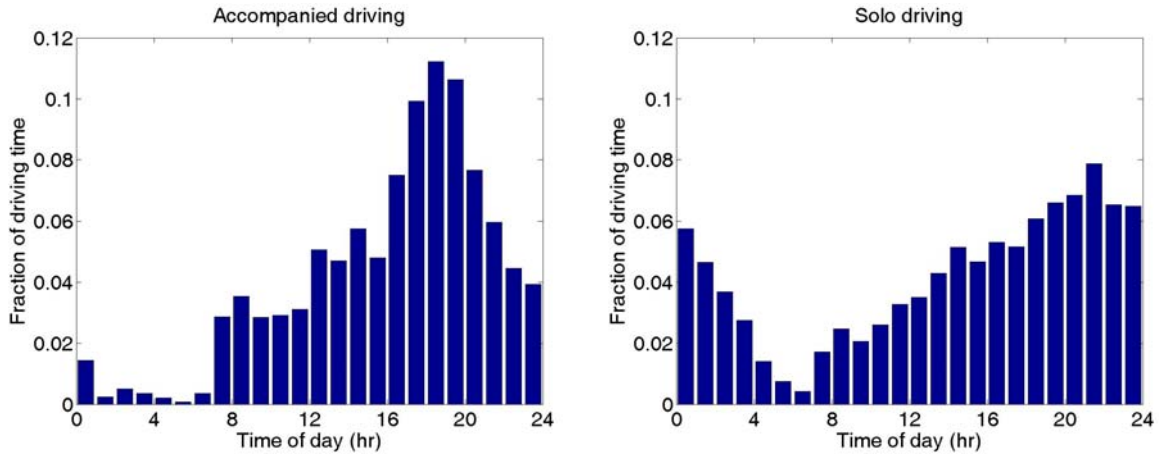

Figure 4 Distribution of driving time over the day in the accompanied (left) and solo (right) driving periods

Distribution during the week

Figure 5 shows the distribution of the driving time during the days of the week in the accompanied period (left) and in the solo period (right). For the purpose of this analysis we define days from 6AM to 6AM on the next day. We also note that in Israel the weekend includes Friday and Saturday. As with the distribution of driving during the day, there are significant differences between the accompanied and solo periods. In the accompanied period, driving times split pretty much evenly among all days. Somewhat higher driving times are observed on Mondays and Tuesdays (15.2% and 15.6% of the driving time, respectively) and especially on Fridays (17.4%), but not on Saturdays (12.7%). However, this pattern changes in the solo period. The amount of weekend driving increases significantly (21.0% on Fridays and 13.8% on Saturdays) at the expense of driving on weekdays (Sundays to Wednesdays) which goes down from 56.8% to 48.6%. Weekend driving rates could have been even higher in both periods if not for three religious young drivers in our sample (9.7% of the sample) who do not drive at all on Saturdays and only on the first half of the day on Fridays. The share of driving on Thursdays also increases (from 13.1% to 16.6%). This increase is mostly in the evening and night driving. These changes are again likely the result of the differences between the activity patterns of the adults that initially accompany the young drivers and the young drivers themselves, who are more active and have better access to vehicles during the weekend.

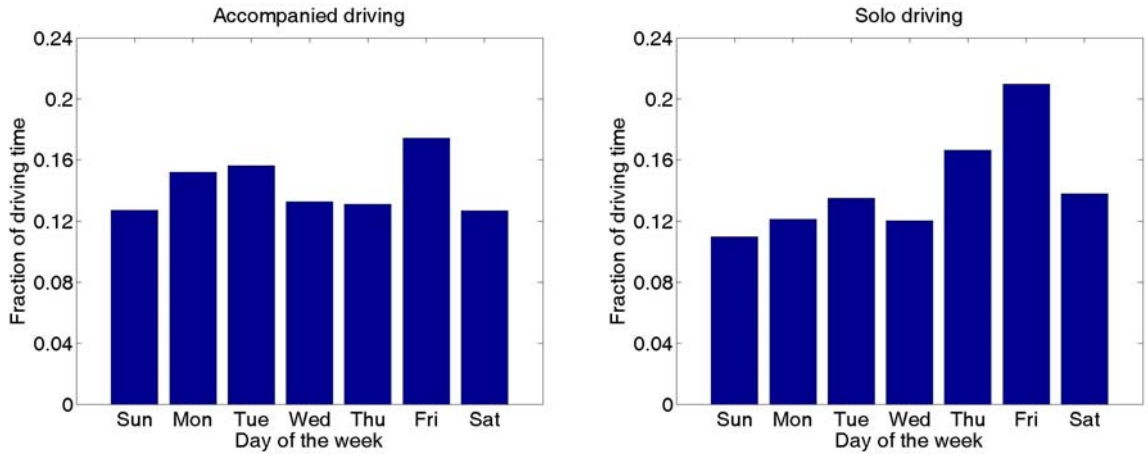

Figure 5 Distribution of driving time over the week in the accompanied (left) and solo (right) driving periods

Distribution over the weeks since licensure

Figure 6 shows the distribution of driving time over the first 29 weeks after licensure: 13 weeks of the accompanied period and the first 16 weeks in the solo driving period. The figure clearly shows the increase in the amount of driving after the transition to the solo period. Within the accompanied period, somewhat higher driving times are observed in the three weeks immediately after licensure and in particular in the second one. To a lesser extent higher driving times are also observed in the last two weeks of the accompanied period. However, overall, the amount of driving through the entire accompanied driving period is more or less even. Earlier in the paper we observed that young drivers may benefit from gaining more driving experience during the accompanied driving period. The result here is important in providing a basis to expect that extending the accompanied driving period would contribute to achieving that goal. In the solo period, driving times are highest in the initial

two weeks and drop down somewhat after that. However, there is no clear pattern on driving times in this period.

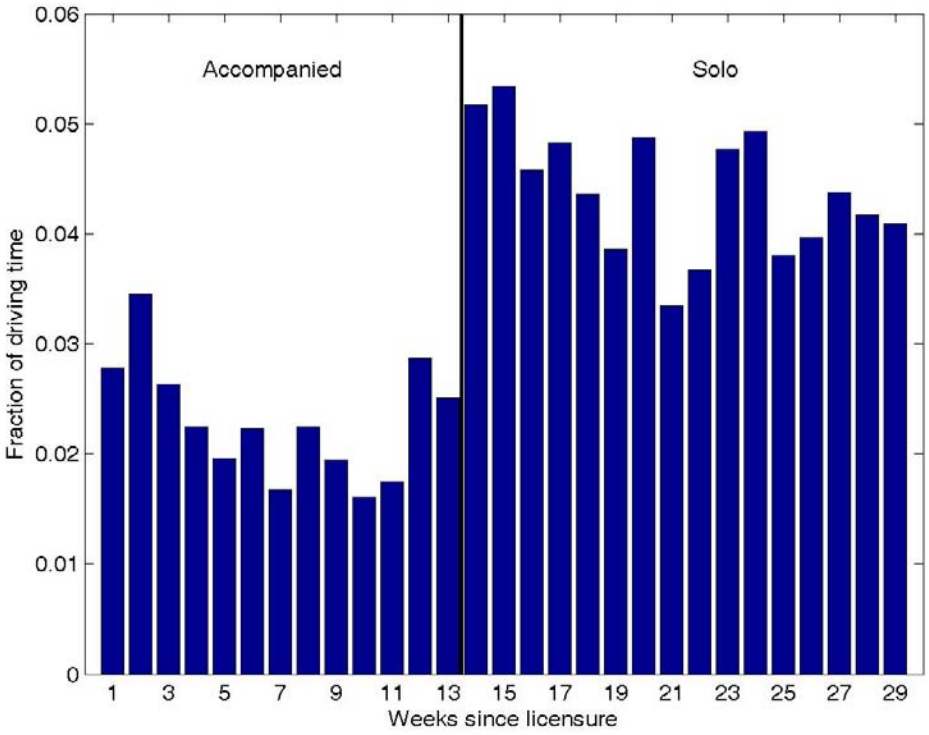

Figure 6 Distribution of driving time over the first 29 weeks after licensure

Differences between male and female drivers

There are significant differences between the driving patterns of male and female drivers both in the accompanied driving period and in the solo driving period. Table 2 summarizes statistics of the driving time and numbers of trips for male and female drivers. Males drive about 40% more hours than females both in the accompanied and solo driving periods. The differences are smaller in terms of number of trips (31% in the accompanied period and 10% in the solo period). This implies that males make longer trips, especially in the solo period. Males also undertake more of their driving in the night hours, especially in the accompanied period, and on weekends.

Table 2 Amount of driving in the accompanied period and thereafter

Summary Statistics		Males		Females	
		Accompanied	Solo	Accompanied	Solo
Driving Time	Total (hr/week/driver)	2.25	4.99	1.64	3.55
	% night driving (10PM – 6 AM)	14.3	31.5	12.8	31.4
	% weekend driving (Fridays - Saturdays)	31.3	36.1	31.0	30.4
Number of Trips	Total (trips/week/driver)	5.31	13.70	4.04	12.43
	% night driving (10PM – 6 AM)	15.6	31.4	10.3	24.3
	% weekend driving (Fridays - Saturdays)	29.9	33.6	28.1	28.4

COMPARISON WITH SELF REPORTS

In this research, we have used IVDR as an alternative to traditional self reported driving questionnaires. In this section we compare our findings with those obtained with self reports in order to evaluate the potential benefits of using IVDR to collect such data. We use results of the analysis of four separate self report surveys that were conducted in Israel. In a survey that was conducted in 2005 and repeated in 2006 *[16]*, young drivers and their parents were asked, among other things, about the amount of accompanied driving they undertook in terms of driving hours and number of trips. These questionnaires were administrated during the accompanied period, close to its end. In another study *[17]* young drivers and their parents who completed the accompanied period were also asked about the amount of day and night driving and about the average length of trips they made. In addition 16 of the young drivers that participated in the experiment described in this paper reported on their driving times using a logbook. Table 3 summarizes the results of these studies and similar statistics that were calculated based on the IVDR data. The differences between the self reports and IVDR data are very large and statistically significant in all cases. The driving times young drivers and their parents report are higher by 140%-300% compared to the IVDR data. Drivers seem to be a little better at estimating the numbers of trips (overestimate by 20%-100%) and the average lengths of trips (overestimate by 33%-45%). Young drivers also reported that almost 40% of their accompanied driving was done at night. However, the IVDR measurements showed that only 14% of the driving was between 10PM and 6AM. While these numbers cannot be directly compared because of the lack of a clear definition of the term night driving in the self report questionnaires, it is clear, especially when coupled together with drivers' over-reporting of their overall driving, that young drivers perceive that they have gained much more nighttime driving experience than they actually have. Furthermore, the over-estimation of accompanied driving is not consistent across drivers. The correlation between the total driving times that were measured by the IVDR and those obtained from the self reports for the 16 drivers who completed these reports is only 0.53.

In summary, IVDR can be used to collect data at a high level of detail that would be very expensive to collect otherwise. Furthermore, even with data that may be easily collected using self reports, IVDR can provide reliable and accurate measurements, and avoid the significant biases that are present in self reports.

Table 3 Comparison of self reports and IVDR data on amount of driving in the accompanied period

Survey	Data	Driving Time (hr/week/driver)	Number of Trips (trips/week/driver)	Average Trip Length (min)
Taubman-Ben-Ari 2005 *[16]*	Young drivers	8.10 (N=214)	8.16 (N=214)	
	Parents	6.06 (N=310)	5.96 (N=318)	
Taubman-Ben-Ari 2006 *[16]*	Young drivers	6.70 (N=278)	6.89 (N=280)	
	Parents	5.74 (N=230)	5.78 (N=240)	
Shinar et al. *[17]*	Young drivers	4.84 (N=97) (41.1% at night)	9.67 (N=441) (35.9% at night)	33.6 (N=463)
	Parents	5.58 (N=95) (39.6% at night)	8.47 (N=424) (38.9% at night)	36.6 (N=433)
IVDR experiment	IVDR (all)	2.02 (N=31) (13.9% at night)	4.82 (N=31) (14.0% at night)	25.2 (N=31)
	IVDR (self-report respondents only)	1.94 (N=16)		
	Self reports	7.63 (N=16)		

SUMMARY

Young drivers in Israel, as in other parts of the world, are involved in car crashes more than any other age group. To tackle this problem, a GDL system has been introduced in Israel, which requires all new drivers to be accompanied by an experienced driver whenever they drive for the first three months after obtaining a driving license. As part of the efforts to evaluate the effectiveness of this system a novel experiment, which uses information gathered from an in-vehicle data recorder (IVDR) is conducted. In the experiment, the DriveDiagnostics IVDR system was installed in the primary vehicle driven by the young driver.

Analysis of the IVDR data indicates significant differences between the behavior of young drivers in the accompanied driving period and the solo period that follows in terms of the amount and temporal characteristics of the trips they make. Young drivers more than double the amount of driving they undertake in the solo period compared to the accompanied period. The timing of their driving time also changes as they drive more during late evening and night hours and during the weekends. These results indicate that the exposure to risk is lower in the accompanied driving period, in which young drivers drive fewer hours and in particular less in riskier conditions during nights and weekends. An average of 26.3 accompanied driving hours significantly raises the experience level of young drivers, which may obtain their driving license with as little as 28 hours of driving instruction. While these results are promising, two problem areas have also been identified: First, the driving experience young drivers have accumulated by the end of the accompanied driving period is short of desired values. Moreover, there are young drivers who drive very little during the three months accompanied period, and so gain very little experience before the solo driving period. It may be necessary to set up minimum driving requirements or guidelines for the accompanied period in order to increase the amount of driving experience young drivers accumulate before the solo driving period. Extension of the accompanied driving period may also contribute to drivers' experience since our results indicate that driving times are roughly evenly distributed over the entire accompanied period. Second, young drivers get relatively little experience in night driving during the accompanied period, but drive extensively at night in the solo period. Minimum accompanied nighttime driving requirements and further

nighttime driving restrictions beyond the accompanied period may thus be useful in mitigating the higher risk created by nighttime driving.

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