HARD BRAKING EVENTS AMONG NOVICE TEENAGE DRIVERS BY PASSENGER CHARACTERISTICS

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Summary: In a naturalistic study of teenage drivers (N = 42) hard braking events of ≤-0.45 *g* were assessed over the first 6 months of licensure. A total of 1,721 hard braking events were recorded. The video footage of a sample (816) of these events was examined to evaluate validity and reasons for hard braking. Of these, 788 (96.6%) were estimated valid, of which 79.1% were due to driver misjudgment, 10.8% to risky driving behavior, 5.3% to legitimate evasive maneuvers, and 4.8% to distraction. Hard braking events per 10 trips and per 100 miles were compared across passenger characteristics. Hard braking rates per 10 trips among newly licensed teenagers during the first 6 months of licensure were significantly higher when driving with teen passengers and lower with adult passengers than driving alone; rates per 100 miles were lower with adult passengers than with no passengers. Further examination of the results indicates that rates of hard braking with teenage passengers were significantly higher compared with no passengers: 1) for male drivers; 2) during the first month of licensure. The data suggest that that novice teenage driving performance may not be as good or safe when driving alone or with teenage passengers than with adult passengers and provide support for the hypothesis that teenage passengers increase driving risks, particularly during the first month of licensure.

INTRODUCTION

Crash rates are elevated during the first months of licensure, particularly among younger novices (McCartt, Shabanova, & Leaf, 2003; Mayhew, Simpson, & Pak, 2003; Twisk & Stacey, 2007). The novice driver problem is common to Western societies, but is particularly acute in North America because teenagers can get licensed at age 16 in most regions of these countries. The problem may be due to performance deficits related to inexperience, risk taking, or a combination of the two. A better understanding of the nature of risk is needed, including the variability in risk during the early months of licensure.

In addition to inexperience, the presence of passengers is known to affect crash risk and driving performance among young drivers. Chen, Baker, Braver, and Li (2000) found that fatal crash risk was 45% higher in the presence of one teenage passenger compared to no passengers. Simons-Morton, Lerner, and Singer (2005) observed vehicles exiting high school parking lots and found that on nearby roadways teenage drivers drove faster and had shorter following distance/closing rates compared with usual traffic, particularly in the presence of male teen passengers. In contrast, it is thought that adult passengers may provide protective effects by co-driving and managing the in-vehicle context, but there is little if any data to confirm this (Simons-Morton, Ouimet, & Catalano, 2008).

Hard braking is one of several useful measures of performance and risk. The landmark 100-Car Study - a naturalistic driving study with high-mileage drivers aged 18 or older - examined the rates per million miles of longitudinal deceleration at different *g* force range (i.e., -0.30 to -0.39, -0.40 to -0.49, -0.5 to -0.59) of safe, moderately safe, and unsafe drivers, defined by their crash experience. Unsafe drivers had higher rates in each range and safe drivers had the lowest rates in each range (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2008). Hard braking events at thresholds $\leq$-0.45 *g* have also been used alone or as part of a composite measure of performance and risk in naturalistic and test track studies (Prato, Lotan, & Toledo, 2009; McGehee et al., 2007; Wierwille, Lee, DeHart, & Perel, 2005).

This paper is the first report of the Naturalistic Teenage Driving Study in which the vehicles of 42 newly-licensed teen drivers were instrumented so that driving performance and risk over time could be followed. The purpose of the present research is to evaluate hard braking rates per 10 trips and per 100 miles for each driver/passenger category over the first 6 month of licensure. The hypothesis is that hard breaking rates will be higher for teenagers when carrying teenage passengers than when driving alone or with adult passengers.

METHOD

Participants

Forty-two newly-licensed teenagers (M = 16.4 years old; SD = 0.2), 20 males and 22 females, were recruited from within a 50 mile radius of Blacksburg and Roanoke (Virginia) through driving schools and newspaper advertisements and provided with a monthly participation incentive. Participants' vehicles were instrumented within approximately 2 weeks of obtaining a provisional driver's license allowing independent driving. Written parental consent and teen assent were obtained for each participant.

Apparatus

The instrumentation package, designed and developed at the Virginia Tech Transportation Institute (VTTI), consisted of a computer (LINUX-based PC) that received and stored data from a network of sensors in the vehicle (Klauer et al., 2008). Sensors described in this paper included an accelerometer, a GPS, and four continuous camera views monitoring the driver's face and driver side of the vehicle, the forward view, the rear view, and an over-the-shoulder view of the driver's hands and surrounding areas. Another camera provided periodic still shots of the interior vehicle cabin, which were blurred to protect the anonymity of the passengers.

Measures

Hard braking. Operationally defined as any longitudinal deceleration ≤-0.45 *g*. Using software developed in-house, each rapid longitudinal deceleration occurring in the first 6 months of driving was identified. This cut-off point of ≤-0.45 *g* was selected because it could be compared with previous research (Klauer et al., 2008) and represented relatively rare events.
Exposure in trips and miles. A trip was operationally defined as ignition-on to ignition-off for 0.2 mile or more. The mileage of each trip was assessed by a transmission pulse sensor.
Passenger characteristics. A sample of ≤-0.45 *g* hard braking events were reviewed by trained data coders, who recorded driver identity, number of passengers, general age of passengers (preteen [≤ 13 years old], teen [14-18 years old], young adult [19-25 years old], adult [25+ years old]), and gender of passengers. Passenger categories included: 1) no passengers; 2) at least one adult passenger; 3) only teen passenger(s); and two subcategories of teen passengers: 4) only teen passengers with at least one male teen; 5) only female teen passengers.

Analyses

Each of a sample of events was classified as valid or invalid (pot hole or other bump in the road); valid events were classified as legitimate evasive maneuver, misjudgment, distraction, or risky driving behavior. For each driver/passenger category, hard braking rates were calculated by dividing the number of hard braking events by 10 trips and 100 miles. Rates were calculated by both trips and miles because of a priori uncertainty about which might be the better denominator. The relative risks (RR) were defined as the ratio of the event rate of the target passenger category to the event rate of the reference group, which was the no passenger condition. The 95% confidence intervals (CI) of the relative risks were used to determine if a passenger category had a significantly higher hard braking rate than the no passenger category (Rothman & Greenland, 1998). Event rates and relative risks and confidence intervals were obtained for the first 6 months and for each month separately. Analyses were conducted using the iri command in STATA 9 (Statacorp, 2005).

FINDINGS

A total of 1,721 hard braking events ≤-0.45 *g* were recorded. To validate the events, a sample of 816 of these events ≤-0.45 *g* were reviewed (inter-rater reliability was 93.7%), and 788 of the 816 (96.6%) were classified as valid. Of the valid events, 79.1% were due to driver misjudgment, 10.8% to risky driving, 5.3% to legitimate evasive maneuvers, and 4.8% to distraction.
Given the high validity rate, the analyses were conducted on the 1,721 events. Table 1 shows the number of hard braking events, trips, and miles for each driver/passenger category. Most trips were taken with no passengers and few trips were taken with adult passengers (4.9% of all trips). Trips and miles with pre-teens and young adults accounted for less than 2% and are not considered in the analyses. Teenage males drove more often with teenage male passengers and female drivers drove more often with female passengers.

Table 1. Teenage Drivers' Number of Hard Braking Events, Trips, and Miles by Passenger Category

	Teen Drivers								
	All (N = 42)			Males (n = 20)			Females (n = 22)		
Passenger category	Events	Trips	Miles	Events	Trips	Miles	Events	Trips	Miles
No passengers	1,155	13,446	45,437	388	6,300	20,285	767	7,146	25,152
Adult	43	968	7,444	17	380	3,055	26	588	4,389
Teen	523	5,181	21,526	228	2,712	1,1491	295	2,469	10,034
Male	277	2,876	12,371	160	1,985	8,452	117	891	3,919
Female	246	2,305	9,155	68	727	3,039	178	1,578	6,115

A frequency distribution of events, trips, and miles is shown in Table 2. The majority of teenage drivers had fewer than 30 events over the 6 months, but six had more than 100 events. There was also substantial variability in trips and miles. Over the first six months of driving, two drivers drove >4,000 miles and seven drove ≤1,000 miles.

Table 2. Frequency Distribution of Events, Trips, and Miles for Teenage Drivers

Events		Trips		Miles	
Range	N	Range	N	Range	N
≤ 10	10	≤ 200	3	≤ 500	0
11-20	7	201-300	5	501-1,000	7
21-30	6	301-400	5	1,001-1,500	7
31-40	4	401-500	13	1,501-2,000	13
41-50	4	501-600	4	2,001-2,500	8
51-60	4	601-700	3	2,501-3,000	1
61-100	1	701-800	2	3,001-4,000	1
101-200	5	801-900	2	4,001-5,000	4
>200	1	901-1,000	3	>5,000	1
		>1,000	2		

Figure 1 shows the deceleration rates per 10 trips and per 100 miles by passenger categories for teenage drivers summed over months 1-6 and for each month. Rates summed over 6 months compared to the no passenger condition were lowest with adult passengers, slightly higher for teen passengers per 10 trips and similar per 100 miles. However, during the first month of licensure, rates for teenage drivers were notably higher with teen passengers than with no passengers. Analyses were also run using ≤-0.5 g force deceleration and the rates were similar to those using ≤-0.45 g (data not shown).

Trips and miles were highly correlated (r=.74), but varied by passenger condition. Notably, the miles per trip were about twice as long with adult passengers (7.7 miles/trip) than with teenage passengers (4.2 miles/trip) or with no passengers (3.4 miles/trip), suggesting that the nature of trips with adult passengers may have been somewhat different than other trips.

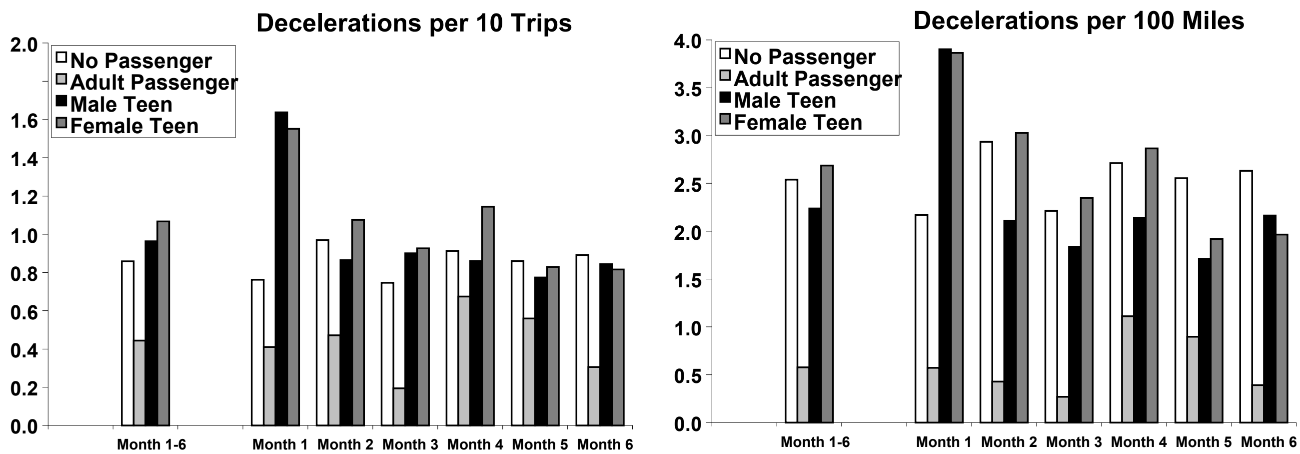

Figure 1. Teenage Drivers' Deceleration Rates per 10 Trips and per 100 Miles for Each Passenger Category

Shown in Table 3 are the relative risks and 95% confidence intervals for hard braking per 10 trips and 100 miles for each driver-passenger category. With the no passenger condition as the referent, rates with adult passengers were significantly lower for both trips and miles. Deceleration rates were higher for all teenage drivers with teen passengers by 10 trips, but not by 100 miles. When analyzing by male and female teenage drivers separately, higher relative risks were found only for male drivers with both male and female teenage passengers.

Table 3. Teenage Drivers' Relative Risks of Hard braking per 10 Trips and 100 Miles and their 95% Confidence Intervals for Each Passenger Category

		Teen Drivers		
		All	Male	Female
	Passenger category	RR (CI)	RR (CI)	RR (CI)
	No passengers	1.00	1.00	1.00
by 10 Trips	Adult	**0.52 (0.37-0.70)**	0.73 (0.42-1.18)	**0.41 (0.27-0.61)**
	Teen	**1.17 (1.05-1.30)**	**1.36 (1.15-1.61)**	1.10 (0.96-1.26)
	Male	1.12 (0.98-1.28)	**1.31 (1.08-1.58)**	1.22 (1.00-1.49)†
	Female	**1.24 (1.08-1.43)**	**1.52 (1.16-1.97)**	1.05 (0.89-1.24)
by 100 Miles	Adult	**0.23 (0.16-0.31)**	**0.29 (0.17-0.47)**	**0.19 (0.13-0.29)**
	Teen	0.95 (0.86-1.06)	1.04 (0.88-1.22)	0.95 (0.83-1.09)
	Male	0.88 (0.77-1.01)	0.99 (0.82-1.19)	0.98 (0.80-1.19)
	Female	1.06 (0.92-1.21)	1.17 (0.89-1.52)	0.95 (0.81-1.13)

Note. RR = relative risk; CI = confidence interval. † Confidence interval includes 1.

DISCUSSION

This first set of analyses from the Naturalistic Teenage Driving Study examined hard braking rates over the first 6 months of licensure by driver and passenger characteristics. Our data show that most hard braking events were due to misjudgment (about 80%), risky driving behavior accounted for about 11%, and including only a few events of horseplay. Our teenage participants drove rarely with adult passengers and about twice as often on their own as with teenage passengers. Relative risk calculations comparing 6-month rates of hard braking events of $\leq$-0.45 *g* relative to driving with no passengers were lower for teenagers driving with adult passengers and higher for all teenage drivers with teen passengers by trip, but not by mile, probably because trips with adults were longer and the purpose and driving conditions of these trips may have been somewhat different than trips with teenage passengers or no passengers. Analyses of male and female teenage drivers separately indicated that teenage passenger risk was higher only for male drivers, consistent with other research indicating that teenage passenger effects on other risky driving outcomes are greatest for male teenage drivers (Simons-Morton et al., 2005). In analyses of hard braking rates by month, relative risks were higher for teenage drivers with teenage passengers during the first month, but not months 2-6 and no effect of the sex of the passenger was found. It should be noted that the sample is composed of regional volunteers.

By view video footage it was possible to determine that nearly all hard braking events were valid and were due mainly to misjudgment, usually resulting in late reaction to the need to stop and therefore to hard braking. Therefore, hard braking events appear mainly to represent performance errors. The protective effect of adult passenger presence may be due to co-driving, where the adult passenger communications observations about traffic conditions and anticipated maneuvers, thereby reducing judgment errors. This protective effect could also be a reflection of adult passenger effects, intentional or not, on teenage driver attention and the in-vehicle social environment. Conversely, the increased risk of teenage passenger presence may be due to effects on the in-vehicle social environment leading to judgment errors. Future analyses will examine passenger effects over time of various *g* force measures of hard braking, acceleration, and yaw. The study design also enables future comparisons of *g* force rates under similar driving conditions of teenagers and their parents who are participating in the study.

The data provide the first empirical evidence from the Naturalistic Driving of Teenage Drivers Study about variability in *g* force events by passenger characteristics. The conclusion of this research is that the study participants experienced a lower rate of hard braking with adult passengers than with no passengers. The study provided partial support for the hypothesis that hard braking rates would be higher with teenage passengers than with no passengers, but the date were not consistent, except for the first month of licensure. These data provide support for licensing policies and parenting practices that limit the conditions under which teenagers are allowed to drive during the early months of licensure when teens may not have fully developed driving skills and may be prone to judgment errors when driving alone or with teenage passengers.

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