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The effect of male teenage passengers on male teenage drivers: findings from a driving simulator study

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Abstract

Studies have shown that teenage drivers are less attentive, more frequently exhibit risky driving behavior, and have a higher fatal crash risk in the presence of peers. The effects of direct peer pressure and conversation on young drivers have been examined. Little is known about the impact on driving performance of the presence of a non-interacting passenger and subtle modes of peer influence, such as perceived social norms. The goal of this study was to examine if teenagers would engage in more risky driving practices and be less attentive in the presence of a passenger (vs. driving alone) as well as with a risk-accepting (vs. risk-averse) passenger. A confederate portrayed the passenger's characteristics mainly by his non-verbal attitude. The relationship between driver characteristics and driving behavior in the presence of a passenger was also examined. Thirty-six male participants aged 16-17 years old were randomly assigned to drive with a risk-accepting or risk-averse passenger. Main outcomes included speed, headway, gap acceptance, eye glances at hazards, and horizontal eye movement. Driver characteristics such as tolerance of deviance, susceptibility to peer pressure, and self-esteem were measured. Compared to solo driving, the presence of a passenger was associated with significantly fewer eye glances at hazards and a trend for fewer horizontal eye movements. Contrary to the hypothesis, however, passenger presence was associated with a greater number of vehicles before initiating a left turn. Results also showed, contrary to the hypothesis, that participants with the risk-accepting passenger maintained significantly longer headway with the lead vehicle and engaged in more eye glances at hazards than participants with the risk-averse passenger. Finally, when driving with the passenger, earlier initiation of a left turn in a steady stream of oncoming vehicles was significantly associated with higher tolerance of deviance and susceptibility to peer pressure, while fewer eye glances at hazards was linked to lower self-esteem. While the results of this study were mixed, they suggest that the presence of a teenage passenger can affect some aspects of teenage driver behavior even in the absence of overt pressure and distraction. Results are discussed in relation to theoretical concepts of social influence and social facilitation models.

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Keywords

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1. Introduction

Teenagers are over-represented in a variety of risky behaviors (Arnett, 1996; Jonah, 1990), and peer presence and influence have often been associated with higher involvement in these behaviors. For example, smoking (Simons-Morton and Farhat, 2010) and drinking (Borsari and Carey, 2001) are more common among teenagers and young adults when their friends engage in these behaviors. Also, teenage drivers accompanied by teenage passengers are more frequently involved in fatal crashes (Chen et al., 2000; Ouimet et al., 2010). Traffic crashes represent the main cause of morbidity and mortality for teenagers (World Health Organization, 2009) and are one of the most serious consequences of negative peer influences. A better understanding of teenage passenger and driver interactions could help guide development of traffic injury prevention efforts.

Risky driving and inattention (due to distraction), which can be affected by teenage passengers, are two of the main behaviors preceding crashes among young drivers (Curry et al., 2012; McKnight and McKnight, 2003). While peer presence is commonly associated with risky behavior, its effect on inattention is probably unique to driving compared to other types of risky behavior. Most observational and experimental studies have shown that the presence of teenage passengers is associated with higher involvement in (i) risky driving practices such as speeding (Shepherd et al., 2011; Simons-Morton et al., 2005; Toxopeus et al., 2011), shorter headway (Simons-Morton et al., 2005), lower safety belt use (Williams et al., 2003); and (ii) inattention such as higher "looked-but-failed-to-see" driving errors (White and Caird, 2010), lower identification of and reaction time to hazardous situations (Gugerty et al., 2004), and more driving errors (Rivardo et al., 2008; Toxopeus et al., 2011). Some epidemiological and observational studies have found stronger negative effects when both the driver and passenger were males (Chen et al., 2000; Ouimet et al., 2010; Simons-Morton et al., 2005). Other studies, however, have indicated beneficial or no effects of passengers. Lower risky driving practices were found for teenage drivers traveling with peer passengers in a naturalistic study (Simons-Morton et al., 2011) and faster reaction times were observed during simulated driving (Toxopeus et al., 2011). Some experimental studies focusing on distraction found no difference between driving with a passenger and driving alone (Drews et al., 2008) or performance deterioration when young drivers were accompanied by a passenger who was talking to them, but not when the passenger was silent (Rivardo et al., 2008; Toxopeus et al., 2011). While many studies demonstrate elevated risk in the presence of teenage passengers, the existence of mixed results suggests that there might be specific conditions under which teenage driving risk is increased or decreased in the presence of passengers.

Another important question is whether both peer influence and distraction affect teenage driving while in the presence of teenage passengers. Most experimental studies have assumed that either peer influence leads to risky driving practices (Oei and Kerschbaumer, 1990; Shepherd et al., 2011) or that distraction results in inattention (Gugerty et al., 2004; Rivardo et al., 2008; Toxopeus et al., 2011; White and Caird, 2010). Both peer influence and distraction could occur under the same circumstances, however. For example, in research on the effects of distraction on driver performance during which study confederates engaged participants in a conversation (Gugerty et al., 2004; Rivardo et al., 2008; Toxopeus et al., 2011; White and Caird, 2010), effects on driver behavior could also be attributed to perceived social norms conveyed by the passengers. Similarly, if the confederate applies

direct peer pressure on the teenager to engage in a risky behavior (Shepherd et al., 2011), there could also be an effect of distraction. It appears that both peer influence and distraction can play a role and their effects could be addressed in the same research design.

Finally, most experimental studies have focused on the effect of peer pressure, though other modes of peer influence may be involved. In general, peers can influence behavior by directly encouraging or discouraging it or by modeling the behavior. They can also influence behavior through their general attitude, expectations, and judgments by suggesting how normative and acceptable a behavior is (or perceptions of peer social norms) and thereby promoting or discouraging a particular behavior. The intensity of these modes of peer influence can also vary. Influences can be direct, such as through verbal and overt nonverbal expressions of encouragement (or discouragement). Influences can also operate indirectly through social norms, which can be transmitted through modeling and verbal and non-verbal actions. In the adoption of smoking, the indirect effect of peers appears to be more important than direct pressure (Nichter et al., 1997), but both processes have been demonstrated in other studies (Simons-Morton and Farhat, 2010). With respect to driving, a pilot study conducted by our research group indicated that 70% of the participants reported that the presence of a teenage passenger (who is in the vehicle, but not talking) impacted their driving performance compared to 25% who reported that direct peer pressure (comments made to the driver) played a role (Ouimet, 2009). These results contrast with those of experimental studies showing no effect of a silent passenger (Rivardo et al., 2008; Toxopeus et al., 2011) but significant effects on increased risky driving behavior of a confederate expressing peer pressure verbally before the driving session (e.g., Oei and Kerschbaumer, 1990). If most of the influence of peer presence leading to increased risk is through perceived social norms and less through direct peer pressure, more research is needed on the role of subtler modes of peer influence on increased risky driving practices and inattention, such as social norms conveyed by a silent and stationary passenger.

Some models, such as peer influence and social facilitation, can help explain the required conditions for increased or decreased risky driving practices and inattention in the presence of a passenger and reconcile some of the discrepant findings in the literature. The conceptual model of peer influence proposed by Brown and colleagues (2008) suggests that four elements are involved in peer influence in teenagers: an event, activation of peer influence, a response, and generation of a measurable outcome. Thus, when applied to the passenger effect, the presence of a teenage passenger in a vehicle driven by a teenager would activate peer influence that can be accepted/acceded, rejected/ignored, or countered by the driver. The selected response may affect risky driving and inattention. The effect of peers on risky driving practices and inattention can also be explained by social facilitation models, which posit that, in the presence of others, the performance of an easy and familiar task is enhanced whereas the performance of a complex and unfamiliar task is degraded (Zajonc, 1965). A meta-analysis of the evidence in support of this perspective concluded that the presence of others is associated with higher speed and accuracy for the completion of simple tasks and lower speed and accuracy for complex tasks (Bond and Titus, 1983). The effect of the presence of others is postulated to be due to increased arousal (Guerin, 1986; Zajonc, 1965) that can be generated by apprehension of being evaluated by others (Cottrell et al., 1968) or increased cognitive load and distraction if the participant's attention is divided between the demands of the task and the social situation (Baron and Kenny, 1986; Sanders and Baron, 1975). The presence of others can also have an effect if a person's attention is focused on reducing the difference between their behavior and perceived conformity to norms (Carver and Scheier, 1981). Applied to driving, it could mean that if the presence of a passenger is meaningful to the driver, it could affect risky behavior and attention as a function of the difficulty and complexity of the task. In summary, the effect of the presence and influence of peer passengers might be more complex than previously known.

Both peer influence and social facilitation models have often ignored individual factors in their explanation of the effects of peers (Brown et al., 2008; Uziel, 2007). Nevertheless, a systematic review of social facilitation models found that participants' characteristics were more important moderators of the effects of the presence of others on performance than the complexity of the task (Uziel, 2007). This review also pointed out performance improvement for people with positive-self-assured attributes (e.g., high self-esteem) and performance impairment for those with negative-apprehensive attributes (e.g., low self-esteem). From the peer influence perview, individual factors in both drivers and passengers are considered to moderate the response to peer influence (e.g., accepting, refusing). These factors include male sex (Cooper et al., 1979; Simons-Morton et al., 2005), high sensation seeking (Slater, 2003), openness or susceptibility to peer influence (Brown et al., 2008), peer characteristics such as sociability (Collins et al., 1985), and having friends who are involved in risky behavior (Shope et al., 2003; Simons-Morton et al., 2011). It is then important to investigate the influence of driver and passenger individual characteristics on driving performance.

In summary, a better understanding of how peers affect teenage driver behavior, the nature of the processes underlying the effects of peers, and the role of teenagers' characteristics could help guide the development of traffic injury prevention efforts. Given the results of studies showing stronger effects when both drivers and passengers are males (Chen et al., 2000; Ouimet et al., 2010; Simons-Morton et al., 2005), the purpose of this study was to determine the effect on male teenage driving behavior of (i) the presence of a male teenage passenger; and (ii) passenger characteristics intended to influence the driver's perceived social norms (i.e., risk-accepting vs. risk-averse passenger). It was hypothesized that teenagers would engage in more risky driving practices and be less attentive in the presence of a passenger (vs. driving alone) and with a risk-accepting (vs. risk-averse) passenger in a driving simulator. An exploratory goal of the study was to examine the relationship between driver individual characteristics and driving performance with a passenger.

2. Methods

2.1 Participants

Male teenage drivers were recruited from high schools and driving schools in Amherst, Massachusetts, United States. In that state, drivers can receive their learner's permit at age 16 and their provisional license (called a junior operator's license; allowing unsupervised driving) at age 16 and a half. An information sheet was distributed to adolescents at high schools and driving schools. Candidates who contacted the research team were pre-screened for inclusion and exclusion criteria over the phone. Inclusion criteria were: (i) male sex; (ii) being 16 or 17 years old; (iii) possessing a provisional driving license; (iv) having driven in the past 3 months; and v) both parental consent and teenage assent. Exclusion criteria were: (i) frequently experiencing motion sickness, either as a passenger or driver, or in other modes of transport; (ii) non-normal or uncorrected vision (i.e., contacts lenses or eyeglasses were accepted). The study required about 75 minutes for which participants received a \$25.00 USD compensation. The study protocol received approval from the Institutional Review Board of the University of Massachusetts Amherst.

2.2 Study design, random assignment, and concealment

This study employed a 2 X (2) mixed design, i.e., a between Passenger Risk Group condition (accepting vs. averse) and a within Passenger Presence condition (passenger vs. no passengers). Hence, each participant had two drives, one with no passengers and the other with a randomly assigned risk-accepting or risk-averse passenger. Restricted randomization (i.e., the random allocation rule) was used to assign participants to a Passenger Risk Group

by an investigator not involved in the testing procedure. The order of the drives (driving alone first vs. driving with the passenger first) was also randomized to account for potential learning effects from repeated exposure to a similar task. Participants and data analysts were blind to the assignment. Passenger type was concealed from the research assistants until the confederate entered the testing room and was introduced to participants.

2.3 Driving simulation and equipment

There were two drive sets comprised of three continuous drives simulating a rural, a suburban, and an urban environment. The drives contained a lead vehicle in front of the participant. A Realtime Technologies fixed-base driving simulator and an eye tracker from ASL Mobile Eye collected data on risky driving practices and inattention measures. The simulator uses a 1995 Saturn sedan equipped to respond to simulated roadways displayed on three large screens in the front and sides of the vehicle providing a 135-degree horizontal field of view. When the driver accelerates, turns, decelerates, etc., the vehicle appears to progress on the simulated road as it would on an actual road. The eye tracker monitors eye glance and horizontal eye movement patterns by way of cameras and a reflector attached to the safety glasses worn by participants. It superimposes cross hairs indicating the driver's fixation point on a video.

2.4 Dependent Variables

Risky driving measures included the percentage of time above the speed limit, headway, and gap acceptance. Inattention measures were eye glances at hazards and horizontal eye movement. The percentage above speed limit was measured at several sections in the rural drive for 15-30 seconds. These sections had posted speed limits of 30 or 45 mph (approximately 50 km/h or 80 km/h). As there was a lead vehicle, the variable was not measured under free speed conditions; however, the locations were chosen such that the lead vehicle was not visible to participants during the measurements. The distance headway in meters, i.e., the average distance between the participant's vehicle and the lead vehicle, was measured in one section of the rural drive for 20-25 seconds. Gap acceptance for left turns at four signalized intersections was measured in the urban and suburban drives. Participants, who followed the lead vehicle, had to make a left turn at the intersection while there was a steady stream of 10 oncoming vehicles from the opposing lane. The number of oncoming vehicles that the participant waited for before making the left turn was recorded, and the mean was calculated for the four intersections. Eye glances at hazards were measured during the rural drives that contained five scenarios, derived from scenarios tested in prior studies (e.g., Pollatsek et al., 2006; Pradhan et al., 2005), where a potential hazard could be obscured from the driver's line of sight (e.g., a pedestrian in a crosswalk obscured from the driver's view by a large vehicle stopped in the parking lane). The mean number of eye glances at predetermined "target zones" (on the forward view) was calculated. Horizontal eye movement refer to the average standard deviation of the horizontal gaze position (i.e., the spread of horizontal scanning); it was measured in pixels at different points in the rural drive when no other variables were collected.

2.5 Questionnaires

Demographic information and data on driving exposure in terms of miles driven in the past week, time since licensing, driving experience with peer passengers, citations and crashes were gathered. Risky driving behavior in the past week was measured with a 19-item questionnaire on a 1 "never" to 5 "always" scale with good internal consistency (Cronbach's alpha > 0.88) (Simons-Morton et al., 2006b). It includes behaviors such as driving under the influence of alcohol or drugs and driving unbelted. The risk perception of crash/injury for newly licensed teenagers was measured with a 14-item questionnaire on a 1 "lowest risk" to

5 "highest risk" scale with good internal consistency (Cronbach's alpha > 0.88) (Simons-Morton et al., 2006a). The Brief Sensation Seeking Scale was designed to measure sensation seeking in adolescents (Hoyle et al., 2002; Stephenson et al., 2003) and contains eight items derived from the 40-item Sensation Seeking Scale Form V (Zuckerman, 1994). Responses are on a 5-item scale from "strongly disagree" to "strongly agree." Internal consistency was acceptable (Cronbach's alpha = 0.76) (Hoyle et al., 2002). Self-esteem was measured with the 10-item Rosenberg Self-Esteem Scale with ratings ranging from 1 "strongly disagree" to 5 "strongly agree" (Rosenberg, 1989) and good internal consistency (Cronbach's alpha > 0.80) (Schmitt and Allik, 2005). The Tolerance of Deviance measure contains 5 items on a 4-point scale from "very wrong" to "not wrong" and has good internal consistency (Cronbach's alpha > 0.80) (Rachal et al., 1975; Shope et al., 2003). The Susceptibility to Peer Pressure measure has 7 questions on a 4-point scale (i.e., "no," "probably not," "probably," and "yes") (Dielman et al., 1987) and has good internal consistency (Cronbach's alpha > 0.85) (Shope et al., 2003). The success of the social norm manipulation (or perception of passenger) was evaluated using 10 questions related to descriptive and injunctive norms, inspired by previous work from Parker and colleagues (1992). Participants were asked the following questions: "As best you can tell, the passenger seemed like someone who probably: is quiet, likes to party, would rather stay home doing homework than going out with friends, seeks thrilling experiences, drives conservatively, switches lanes to weave through slower traffic, drives after drinking alcohol or using illegal drugs, plays the radio so loudly he wouldn't be able to hear other vehicles' horns or sirens, would approve of you following a slow vehicle very closely, and would approve of you driving after drinking two glasses of alcohol in the hour before driving". Participants had to report their impression of the passenger on a 5-point scale from "very unlikely" to "very likely". Internal consistency was good (Cronbach's alpha = 0.84).

2.6 Procedure

Participants had a 5-minute practice drive and then drove the simulator, once without the passenger and once with the passenger (randomized order), who played either the riskaccepting or risk-averse role, according to the randomized schedule. The passenger was a male confederate (the same throughout the entire study) who portrayed both types of passengers differing only in terms of clothing and non-verbal attitude (i.e., risk-accepting passenger wearing casual dark clothes vs. risk-averse passenger wearing a polo shirt tucked in his pants). Table 1 presents the instructions given to the confederate in both Passenger Risk Group conditions. To minimize variability, the confederate was instructed not to look at or speak to the driver again after saying hello and entering the vehicle. Drivers were also instructed not to talk to the passenger. Passengers were introduced to participants with a few lines explaining why they were interested in the study. The risk-accepting passenger was introduced as someone interested in participating in a future study examining the driving performance of students who applied for an emergency vehicle operator license; the riskaverse passenger was introduced as someone interested in participating in a future study looking at the driving performance of mathematics honors students. Before leaving the laboratory, participants completed questionnaires and then received their compensation. Participants were explained the goals of the study and the role of the passenger in a letter sent at the end of the study.

2.7 Analyses

To test the two main hypotheses, main effects of repeated measure analyses of variance were examined for each of the dependent variables. For the exploratory goal, partial correlations, controlling for outcomes with no passengers, were used to examine the relationship between driving outcomes significantly affected by passenger presence and drivers' individual characteristics (i.e., risk perception, sensation seeking, self-esteem, tolerance of deviance,

and susceptibility to peer pressure). Pearson's correlations between outcomes are provided for descriptive purposes. As results of non-parametric and parametric tests were similar for all analyses, only the results of parametric tests are reported. Success of social norm manipulation was examined with a t-test.

3. Results

3.1 General description of the sample

A total of 36 male drivers with a provisional license were recruited for the study. Table 2 presents means and standard deviations (or percentages) for age, driving experience and exposure, and other individual characteristics by Passenger Risk Group. Table 3 presents Pearson's correlations between driving simulation variables, with and without passengers. The results indicate that measures of risky driving practices (e.g., higher speed and shorter headway and gap acceptance) were significantly correlated with each other. Eye glances at hazards with and without passengers were significantly correlated, as were measures of horizontal eye movement. There were no relationships, however, between measures of eye glances at hazards and measures of horizontal eye movement. Apart from one exception (for higher speed and less horizontal eye movement when driving alone), measures of risky driving practices and inattention were not significantly correlated.

3.2 Effects of Passenger Presence and Passenger Risk Group

Table 4 shows means and standard deviations of risky driving practices and inattention by Passenger Presence (passenger vs. no passengers) and Passenger Risk Group (accepting vs. averse). A significant main effect of Passenger Presence was found for gap acceptance with the passenger condition associated with waiting for a greater number of vehicles before initiating a left turn in a steady stream of vehicles than the no passenger condition (F(1, 32) = 5.71, p = 0.023, $\eta^2 = 0.15$). Results also showed a main effect of Passenger Presence on eye glances at hazards; participants glanced less often in the passenger than in the no passenger condition (F(1, 32) = 4.82, p = 0.035, $\eta^2 = 0.13$). A trend was also found for participants displaying less horizontal eye movement with the passenger than when driving alone (F(1, 32) = 3.76, p = 0.061, $\eta^2 = 0.11$). There were no effects of Passenger Presence for the percentage above the speed limit and headway.

The main effects of the Passenger Risk Group were found for headway and eye glances at hazards. Participants in the Passenger Risk Group [accepting] had longer headway (F(1, 32) = 4.40, p = 0.044, $\eta^2 = 0.12$) and more eye glances at hazards (F(1, 32) = 5.96, p = 0.020, $\eta^2 = 0.16$) than those in the Passenger Risk Group [averse]. No effects were found for the percentage above the speed limit, gap acceptance, and horizontal eye movement. While results of Passenger Risk Group were contrary to hypothesis, the success of the social norm manipulation was confirmed as participants who drove with the risk-accepting passenger reported that they found him to be more risk oriented than those who drove with the risk-averse passenger (M = 2.76, SD = 0.63 vs. M = 2.32, SD = 0.45; $t_{(34)} = 2.42$, p = 0.011). Further analysis (not shown) indicated that the best predictors of the participants' perception of passenger risk acceptance, explaining 52% of the variance, were self-reported past risky driving behavior and passenger random assignment (risk accepting or averse).

3.3 Relationship between drivers' individual characteristics and driving performance

An exploratory goal of the study was to examine the relationship between drivers' individual characteristics, which include risk perception, sensation seeking, self-esteem, tolerance of deviance, susceptibility to peer pressure (see Table 2), and measures of driving performance significantly affected by passenger presence (i.e., headway, gap acceptance, eye glances at hazards). Results of partial correlations, controlling for outcomes while driving alone,

indicated that earlier initiation of a left turn in a steady stream of oncoming vehicles was significantly correlated with higher scores for tolerance of deviance (pr = -0.38, p = 0.026) and susceptibility to peer pressure (pr = -0.38, p = 0.024). Lower eye glances at hazards was significantly correlated with lower self-esteem (pr = 0.37, p = 0.03). No significant results were found for headway.

4. Discussion

In contrast to previous studies focussing on peer pressure, the current study aimed to better understand if perceived social norms can trigger risky behavior and inattention in the presence of a passenger. This is important because social norms appear to be a common mode of peer influence leading to increased risky driving (Ouimet, 2009). This study also attempted to reduce to a minimum the potentially distracting effect of passengers. The mode of activation of peer influence was based on the passenger's non-verbal portrayal, before data collection, of social norms regarding risk. The passenger was instructed to behave in a specific way to indicate his attitude about risk acceptance, but not to talk or provide non-verbal cues during data collection.

4.1 Effects of Passenger Presence and Passenger Risk Group

One of the first goals of the study was to examine if passenger presence increases inattention and risky driving. Results showed that attention decreased in the presence of the passenger, but risky driving was not affected. The former finding is consistent with previous results from experiments in which drivers interacted verbally with the passenger (Gugerty et al., 2004; Toxopeus et al., 2011; White and Caird, 2010). However, the effect of passenger presence on inattention was not found in other studies when the passenger was silent (Rivardo et al., 2008; Toxopeus et al., 2011) and could not see the drivers' performance (Rivardo et al., 2008). The results of the current study indicate that the presence of a "not-neutral" passenger had an impact on teenage driving performance. The nature of the effect of the passenger, which could be due to different factors including increased arousal or cognitive load (Baron and Kenny, 1986; Sanders and Baron, 1975; Zajonc, 1965), should be examined in future studies as previous studies have shown that increased cognitive load was associated with less road scanning (Sodhi et al., 2002).

In contrast to measures of inattention, some measures of risky driving, such as speed and headway, were not affected by passenger presence; a finding similar to that reported by Drews et al. (2008). Higher speed, however, was found in other studies using a more direct mode of peer influence and a higher intensity of influence (Oei and Kerschbaumer, 1990; Shepherd et al., 2011). In the current study, the measurement of speed when following a lead vehicle, as opposed to free speed, most certainly affected the speed and correlations between speed and headway, which could explain the discrepant results between studies.

Finally, participants took more time before initiating a left turn when with a passenger than when alone. To our knowledge, this is the first experimental study to measure gap acceptance in a driving simulator with and without a passenger. With fixed-based simulation, breaking and turning are often reported by participants as the main elements differing from real driving conditions. This situation, and the results reported in an observational study (Ebbesen and Haney, 1973), where drivers who had to wait before turning left took more risks when alone than when with passengers might reflect a concern by participants to not expose the passenger to a potentially negative outcome. It might also suggest that principles of social facilitation models (Zajonc, 1965) apply here. Gap acceptance tasks may have been considered by participants to be complex and unfamiliar. The task coupled with the possible increased arousal associated with passenger presence could have increased workload and contributed to the slower execution (Baron and Kenny,

1986; Sanders and Baron, 1975). It is also possible that inattention is the first driving feature impacted by passenger presence and that risky driving practices are only affected when stronger modes of peer influence or increased arousal occur, or when potential distractions are more prominent.

Another goal of the study was to examine if risky driving and inattention vary according to the Passenger Risk Group condition. Comparisons between the risk-accepting and riskaverse passenger conditions were not significantly different for speed, gap acceptance, and horizontal eye movement. Moreover, while increased risky driving practices and inattention were expected with the risk-accepting passenger, in fact, participants with the risk-accepting passenger maintained longer headway with the lead vehicle and glanced at more hazards than participants with the risk-averse passenger. One plausible explanation for these unexpected results is that some features of the risk-accepting and risk-averse passengers were perceived unpredictably by participants. The success of the social norm manipulation was supported as participants who drove with the risk-accepting passenger reported that they found him to be more risk oriented compared to those who drove with the risk-averse passenger. It is possible, however, that the risk-averse passenger, who was introduced as a mathematics honor student and instructed to be more tentative and withdrawn in his attitude than the risk-accepting passenger, was also perceived as less accepting of the participant than the risk-accepting passenger. Future studies are needed to clarify if other characteristics, including perceived social rank (Cohen and Prinstein, 2006) and feelings of acceptance, might also play a role or interact with perceived social norms. While the results were contrary to our expectations, this study shows that very small changes in the characteristics of the passenger affected driver behavior.

4.2 Relationship between drivers' individual characteristics and driving performance

An exploratory goal of the study was to examine whether there was a relationship between driver individual characteristics and measures of driving performance with a passenger. For risky driving practices, the results showed significant relationships between earlier initiation of a left turn in a steady stream of oncoming vehicles and higher tolerance of deviance susceptibility to peer pressure. A relationship between self-report risky practices while driving alone and tolerance of deviance and susceptibility to peer pressure has been demonstrated in the past (Shope et al., 2003). For inattention, the results indicated a significant association between higher glances at hazards and higher self-esteem. In a review of the literature on social facilitation models, better performance in the presence of others was found for people with higher self-esteem than for those with lower self-esteem (Uziel, 2007). It is possible that lower self-esteem in combination with passenger presence might increase participants' arousal and workload, leading to lower performance. The respective mediating effect of tolerance of deviance, susceptibility to peer pressure, and self-esteem on risky driving practices and inattention in the presence of passengers warrants more detailed investigation.

4.3 Strengths

This randomized controlled experiment has several strengths including a design allowing causal inferences, the use of a subtler mode of peer influence than in previous studies (e.g., Shepherd et al., 2011), and the study of peer influence in a dynamic social context (e.g., Cohen and Prinstein, 2006; Gardner and Steinberg, 2005) using driving simulation rather than self-reported and retrospective measures. Several experimental studies have demonstrated the effect of peer influence on risk behavior in other research areas (Bauman and Fisher, 1986; Borsari and Carey, 2001, for a review; Cohen and Prinstein, 2006; Gardner and Steinberg, 2005). With few exceptions (e.g., Gugerty et al., 2004; Shepherd et al., 2011), the evidence on the effect of peer passengers on increased risk comes mainly

from national databases (e.g., Chen et al., 2000; Ouimet et al., 2010) and field observations (e.g., Simons-Morton et al., 2005; Williams et al., 2003). These two methods are suitable for understanding the scope of the problem, but inappropriate for understanding the causes underlying behavior. Fortunately, the availability of driving simulators allows for the experimental randomized manipulation of driving conditions, including passenger presence and characteristics, and the careful measurement of driving behavior, without actual risk (Ouimet et al., 2011). The external validity of driving simulators has been demonstrated in a number of studies (e.g., Blaauw, 1982; Fisher et al., 2007; Riemersma et al., 1990).

4.4 Limitations

Participants in this study were volunteers and, by definition, they might not be representative of the population of teenage drivers. Also, results might not be generalizable to females or older male teenagers and young adults. The sample size was small, but it is comparable to those of studies using a stronger mode of peer influence or discussions between drivers and passengers or between passengers (e.g., Gugerty et al., 2004; Shepherd et al., 2011). This study did not examine the effects of multiple passengers, which are associated with a higher fatal crash risk than one passenger (Chen et al., 2000), nor the influence of multiple peers at the same time or as a reciprocal and transactional process (Brown et al., 2008). While teenagers are more likely to drive with friends in real life than with strangers, confederates unfamiliar to participants are often used in laboratory experiments in order to increase internal validity and decrease sources of confound. While many studies with confederates have shown the negative direct effect of peer pressure on behavior, friends in a vehicle might influence behavior in a more subtle way than by direct peer pressure (Ouimet, 2009). The effect of perceived norms conveyed by a friend has been demonstrated in other situations (Chein et al., 2011). This study examining the effect of a subtle mode of peer influence was a carefully designed experiment to limit the effects of confounds. While the results suggest that a subtle mode of influence from a stranger can affect some aspects of teenage driving, the attempt to manipulate perceived norms might have been too subtle to elicit risky behavior in the presence of a confederate; it is possible that some other unmeasured aspects linked to the manipulation might have played a role. Inspired by the results obtained in the current study, another study examining the effect of more salient norms was designed and the results showed effects of passenger type in the expected direction (Bingham et al., submitted for publication).

5. Conclusions

This study showed that passenger presence had a detrimental effect on measures of driving attention. Contrary to hypothesis, risk was actually lower in the presence of a risk-accepting passenger than in the presence of a risk-averse passenger. The results of this study suggest that relatively small differences in the mainly non-verbal behavior and the appearance of the passenger had an impact on teenage driver behavior. The impact on teenage driver behavior of the presence of a non-interacting teenage passenger and driver characteristics need to be further considered.

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Highlights

• Studies have shown that direct peer pressure and conversations affect young driver behavior.

- Impact of non-interacting passenger and subtle modes of peer influence on driver behavior are unknown.
- Driver attention was affected by passenger presence.
- Driver characteristics were associated with driving performance with a passenger.

Table 1

Instructions for the confederate by Passenger Risk Group (accepting, averse)

Instruction	Passenger Risk Group	
	Accepting	Averse
a) Walk with	assurance	indecision
b) Say hello by looking at the participant	while nodding without smiling in his direction	while smiling briefly in his direction
c) While research assistant explains how simulator works (and participant can observe passenger)	look with an "attitude" at the research assistant	look with a shy expression at the research assistant
d) After hearing how the simulator works	smile as if excited and say "OK, let's go" with enthusiasm	say "OK" with a shrug and no enthusiasm
e) Enter vehicle	in an aggressive manner (i.e., open and close the door briskly)	cautiously (i.e., open and close the door carefully)
f) Sit in the vehicle	by putting legs slightly towards driver or spread legs wide in a slouching way	upright, self-contained, withdrawn, and turn legs slightly towards the vehicle door
g) Appear	attentive and interested in the vehicle and surroundings throughout the ride	not fully present, a bit preoccupied and tentative, as if you might as well be somewhere else

 $\label{eq:Table 2} \textbf{Means and standard deviations (or percentages) of individual characteristics by Passenger Risk Group (accepting, averse) (n = 36)}$

	Passenger R	isk Group
	Accepting (n = 18)	Averse (n = 18)
	M (SD) or %	M (SD) or %
Individual characteristics		
Years of age	16.72 (0.46)	16.67 (0.49)
Months since provisional licensure	5.04 (5.80)	4.70 (4.60)
Miles driven in the past week	76.36 (69.07)	58.56 (72.34)
Drove with male friends in the past (yes)	66.67%	77.78 %
Citations and crashes since licensure (yes)	27.78%	11.11%
Risky driving (19 items) ^a	2.69 (0.55)	2.69 (0.32)
Risk perception (14 items) ^b	3.22 (0.54)	3.19 (0.47)
Sensation seeking (8 items) ^C	3.58 (0.67)	3.47 (0.64)
Self-esteem (10 items) $^{\mathcal{C}}$	4.25 (0.43)	4.09 (0.42)
Tolerance of deviance $(5 \text{ items})^d$	2.49 (0.51)	2.54 (0.47)
Susceptibility to peer pressure $(7 \text{ items})^e$	1.06 (0.52)	1.07 (0.30)

Note. Scale ranges from

 $^{^{}a}$ 1 "never" to 5 "always";

 $^{^{}b}1$ "lowest risk" to 5 "highest risk";

 $^{^{}c}$ 1 "strongly disagree" to 5 "strongly agree;

 $^{^{}d}$ 1 "very wrong" to 4 "not wrong";

^e0 "no", 1 "probably not", 2 "probably", and 3 "yes".

Table 3

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Pearson's correlations between driving simulation variables with passenger and no passengers (n = 36)

	Driving wi	Driving with passenger (P)	(P)			Driving w	Driving with no passengers (NP)	ngers (NP)	
	Speed	Headway	Gap acceptance	Eye glances at hazards	Horizontal eye movement	Speed	Headway	Headway Gap acceptance Eye glances at hazards	Eye glances at hazards
Speed (P)	-	-	-	-		-	-		
Headway (P)	-0.62	-	-	!				-	-
Gap acceptance (P)	-0.42	0.21	-	-			1	-	-
Eye glances at hazards (P)	0.03	0.10	-0.17	-		-	-	!	-
Horizontal eye movement (P)	0.01	0.00	0.02	-0.23		-	-	!	-
Speed (NP)	0.70	**	-0.29^{\dagger}	0.20	-0.18			-	-
Headway (NP)	-0.59	%*** 0.74	0.18	0.22	-0.03	**		-	-
Gap acceptance (NP)	-0.50	0.36	0.15	0.06	-0.08	-0.39	0.28^{\dagger}		-
Eye glances at hazards (NP)	0.27	-0.22	-0.27	* 0.41	-0.11	0.28^{\dagger}	-0.17	-0.01	-
Horizontal eye movement (NP) -0.03	-0.03	-0.05	0.01	-0.19	***	-0.36	-0.07	-0.09	-0.01

 $^{^{7}}$ p < 0.10; * 8 p < 0.05;

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^{**} p < 0.01;

^{***} p < 0.001.

Table 4

Means and standard deviations of risky driving practices and inattention by Passenger Presence and Passenger Risk Group (accepting, averse) (n = 36)

	Passenger Presence	Passenger F	Risk Group
		Accepting	Averse
Variables	M (SD)	M (SD)	M (SD)
% above speed limit		- 0.02 (0.11)	0.00 (0.11)
Passenger	-0.02 (0.12)		
No passengers	-0.01 (0.12)		
Headway in meters		188.79 (38.35)*	160.30 (44.17)
Passenger	178.37 (50.00)		
No passengers	170.72 (42.83)		
Gap acceptance a		1.08 (0.47)	1.16 (0.49)
Passenger	1.27 (0.59)*		
No passengers	0.98 (0.66)		
Mean eye glances at hazards		0.74 (0.20)*	0.54 (0.29)
Passenger	0.58 (0.35)*		
No passengers	0.70 (0.28)		
Horizontal eye movement b		33.90 (16.65)	35.79 (16.06)
Passenger	33.34 (17.64) [†]		
No passengers	36.35 (17.97)		

Note.

 $^{^{\}dot{7}}p<0.10;$

^{*} p < 0.05.

^aMean number of vehicles before initiating left turns.

 $[^]b{\rm Spread}$ of horizontal eye movement in pixels.