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Experimental Effects of Injunctive Norms on Simulated Risky Driving Among Teenage Males

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Abstract

Objective—Teenage passengers affect teenage driving performance, possibly by social influence. To examine the effect of social norms on driving behavior, male teenagers were randomly assigned to drive in a simulator with a peer-aged confederate to whom participants were primed to attribute either risk-accepting or risk-averse social norms. It was hypothesized that teenage drivers would engage in more risky driving behavior in the presence of peer passengers than no passengers, and with a risk-accepting compared with a risk-averse passenger.

Method—66 male participants aged 16 to18 years holding a provisional driver license were randomized to drive with a risk-accepting or risk-averse passenger in a simulator. Failure to Stop at a red light and percent Time in Red (light) were measured as primary risk-relevant outcomes of interest at 18 intersections, while driving once alone and once with their assigned passenger.

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Results—The effect of passenger presence on risky driving was moderated by passenger type for Failed to Stop in a generalized linear mixed model (OR = 1.84, 95% CI [1.19, 2.86], $p < .001$), and percent Time in Red in a mixed model (B = 7.71, 95% CI [1.54, 13.87], $p < .05$).

Conclusions—Exposure of teenage males to a risk-accepting confederate peer increased teenage males' risky simulated driving behavior compared with exposure to a risk-averse confederate peer. These results indicate that variability in teenage risky driving could be partially explained by social norms.

Keywords

social norms; social influence; risk behavior; adolescents; randomized trial

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Teenage drivers have higher crash rates than older drivers (National Highway Traffic Safety Administration, 2011), making motor vehicle crashes the leading cause of mortality and a major cause of injury for U.S. teenagers (Centers for Disease Control and Prevention & National Center for Injury Prevention & Control, 2012). The high crash rate among teenage drivers is generally attributed to inexperience, young age, and risk taking (Williams, 2003), leading to both inattention-related (Lee et al., 2009) and risky-driving-related crashes (Simons-Morton et al., 2011; Williams, 2003). Driving safely is a complex undertaking that requires routine execution of good judgment and skill, which can be cognitively demanding for novices and develop only gradually over years of driving experience (Groeger, 2000; Twisk & Stacey, 2007; Williams, 2003). Therefore, novice teenage drivers, particularly males, are at especially high crash risk in the most demanding driving conditions, such as at night (Williams, 2003), while engaged in secondary tasks (National Highway Traffic Safety Administration, 2009), and in the presence of teenage passengers (Curry, Mirman, Kallan, Winston, & Durbin, 2012; Ouimet et al., 2010).

Epidemiological studies of fatal crash records indicate that the presence of a teenage passenger significantly increases the risk of fatal crash involvement among teenage drivers, particularly male teenage drivers (Chen, Baker, Braver, & Li, 2000; Ouimet et al., 2010). In a study in which vehicles were observed on nearby roads after exiting high school parking lots, risky driving behavior was greater among teenage drivers compared with usual traffic, particularly among teenage drivers with male teenage passengers (Simons-Morton, Lerner, & Singer, 2005). Curry and Mirman, Kallan, Winston, and Durbin (2012) reported that teenagers were more likely to have engaged in aggressive or illegal driving behavior just prior to a crash with peer passengers compared with no peer passengers. However, a recent naturalistic study reported no association between passenger presence and risky driving or crash outcomes (Simons-Morton et al., 2011). Moreover, several studies have reported that the association between teenage passengers and teenage driving risk varied by the gender of the passenger (Ouimet et al., 2010; Simons-Morton et al., 2005), suggesting the possibility that some of the variability in passenger effects may be due to social norms (Shope & Bingham, 2008).

Extensive research has established that peers exert powerful effects on adolescent risk behavior (Borsari & Carey, 1999; Gardner & Steinberg, 2005; Poulin, Dishion, & Haas, 1999; Simons-Morton & Chen, 2006), which could be from peer pressure or normative influences. Several major theories, including the theory of normative social behavior (Rimal & Real, 2005), which served as the primary guiding framework for this study, emphasize the particular importance of injunctive norms on adolescent risk behavior. Injunctive norms are individuals' perceptions of the behavioral expectations of social referents, which may be particularly influential when coupled with the belief that nonconformity will result in social sanctions, such as not being liked, accepted, or included (Cialdini, 2001). The theory of normative social behavior posits that injunctive norms moderate the association between individuals' beliefs about the prevalence (descriptive norms) and social acceptability of a behavior among their peers and their own risk behavior (Rimal & Real, 2005). Accordingly, behaviors such as risky driving may be more likely to occur when perceived as preferred or expected by important others.

In the driving context, the perception that one's friends drive in a risky manner is associated with higher rates of speeding (Simons-Morton et al., 2012) and other risky driving, as measured by elevated gravitational-force event rates from hard braking or sharp cornering (Simons-Morton et al., 2011). These findings are consistent with neural (brain image) findings suggesting that the mere presence of a peer heightens sensitivity of the adolescent brain's reward system to opportunities for risk-taking (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011). However, there is considerable variability in peer influence on teenage risk behavior (Allen & Antonishak, 2008) and the mechanisms that contribute to the variability in adolescent risk behavior require clarification across domains (Hartup, 2005; Prinstein & Dodge, 2008).

Driving simulation, which is highly associated with on-road driving (Fisher, Pradhan, Pollatsek, & Knodler, 2007), is a potentially useful and safe method for investigating the effect of peer influences on risky-driving behavior. Accordingly, a few simulator-based experimental studies have shown increased inattention when confederate peer passengers engaged teenage drivers in conversation (Gugerty, Rakauskas, & Brooks, 2004; White & Caird, 2010). Also, studies using computerized driving games have demonstrated an effect of direct verbal expressions of peer pressure on increasing risky driving behavior (Gardner & Steinberg, 2005; Shepherd et al., 2011; Tian & Kerschbaumer, 1990). For example, Shepherd, Lane, Tapscott, and Gentile (2011) reported that college students using a driving game console engaged in greater risky driving when persuaded to do so by confederate peers. Chein, Albert, O'Brien, Uckert, and Steinberg (2011) reported greater risky driving in the Stoplight driving game when observed by peers than when unobserved. Ouimet et al. (2013) reported greater inattention to potential driving hazards, but not more risky driving in the presence of a peer passenger exhibiting a risk-accepting appearance and nonverbal attitude compared with a peer passenger exhibiting a risk-averse appearance and nonverbal attitude. Although a growing body of literature has assessed correlational relationships between teen passengers and crash risk (Ouimet et al., 2010), and driving simulator studies have addressed factors ranging from distraction (Drews, Pasupathi, & Strayer, 2008) to the appearance and nonverbal attitudes of passengers (Ouimet et al., 2013), no experimental studies have assessed the impact of injunctive norms on risky driving behavior in teens. Establishing causal evidence for the effect of passenger norms would inform public health policy and interventions.

Purpose

The purpose of this experiment was to examine the effect of passenger presence and risk-accepting or risk-averse injunctive norms on male teenagers' simulated driving performance. It was hypothesized that (a) teenagers would engage in more risky driving behaviors in the presence of a peer passenger, and (b) that this effect would be moderated by injunctive norms exhibited by the confederate peer passenger.

Method

Participants

Participants were recruited from high schools in Ann Arbor, Michigan and surrounding communities. Eligible participants included 66 males aged 16 to 18 years (M = 16.97; SD = 0.56), who had held for 4–9 months a Level 2 Michigan driver license (allowing independent driving with restrictions), drove at least twice a week on average, and were insensitive to motion sickness. Contact lenses were allowed but eyeglasses were not because they hampered automated eye tracking. In addition, for a separate fMRI portion of the study (which occurred in a separate session, data not reported here; details in Falk et al. (in press), participants were required to be neurotypical (e.g., without diagnosed neurological abnormalities), not currently taking psychoactive medications, right-handed, not claustrophobic, and without any metal in their bodies (dental fillings excluded). Teen assent and parental consent were obtained. Participants were compensated $50 for completing the 150-min to 180-min protocol for the simulation study. The study protocol was approved by the University of Michigan Behavioral Sciences/Health Sciences Institutional Review Board, which judged the deception involved to be mild and required no specific participant debrief in this regard. Participants were debriefed about the nature of the research and probed for suspicion, but not informed that the passenger was a study confederate so as not to harm the ongoing integrity of the study. Participant flow is shown in Appendix A.

Study Design and Procedures

In a crossover 2 × 2 mixed design, participants were randomized to either a risk-accepting or a risk-averse passenger condition (between-subjects), and each participant drove two simulated drives (within-subject), one alone (solo drive) and one with a passenger (passenger drive). To control for potential order effects, the drive presentation order (solo drive or passenger drive first) and the simulated world presentation order (World A or World B first) were counterbalanced. Experimenters remained out of sight during the drives.

A young appearing (i.e., 16- to 18-year-old-looking) male confederate was randomly assigned to portray either a risk-accepting or a risk-averse peer during the predrive priming activities and passenger during the simulated drive. The predrive priming activities included the confederate passenger arriving late, explaining why he was late, watching and rating videos with the participant, and briefly driving the simulator. As a risk-accepting teen, the confederate arrived late and said, "Sorry I was a little late getting here. Normally I drive way faster, but I hit like every red light." As the risk-averse confederate, he said, "Sorry I was a little late getting here. I tend to drive slowly, plus I hit every yellow light." Next, the confederate and participant watched two videos together (order counterbalanced). The videos were of real driving taken from the perspective of an unseen passenger. That is, the viewer saw what a passenger in the vehicle would have seen of the forward roadway as the vehicle moved through traffic, but could not see or hear (no audio) the actual driver or other possible occupants. One video showed vehicles passing gradually on either side of the driver, indicating that the driver was going slightly slower than other traffic. The other video showed the vehicle aggressively passing other vehicles and weaving in and out of traffic. Immediately after each video the participant was asked to respond verbally to two questions on a scale of 1 to 10: (a) How similar is your driving to the driver in the video? (b) How likely would you be to ride with the person in this video? The confederate responded after the participant so that he could always respond in a manner that was more or less risk accepting, depending on the role he was playing. The experimenter then indicated that the study participant had been randomly selected to be the driver for the experiment and the confederate was assigned to be the passenger. The confederate was then told, in the presence of the participant, that because he was chosen to be the passenger he would be allowed to drive the simulated vehicle for a few minutes before the experiment. The participant rode in the passenger seat while the confederate drove through a simulated urban environment, aggressively and unbelted in the risk-accepting condition (e.g., accelerating faster, braking harder, and accelerating to get through yellow lights), and conservatively and belted in the risk-averse condition (e.g., accelerating evenly, braking gently, and stopping at amber lights). Thereafter the confederate maintained his character as risk accepting or risk averse via his attitude and manner (i.e., more self-confident and proud of his driving ability in the risk-accepting group, and less so in the risk-averse group).

After the predrive priming, participants drove the preallocated counterbalanced drives. Participants were asked to drive as they would normally and to follow all traffic rules and speed limits that were set at 35 miles per hour (mph; about 56 kph). To minimize variability in the experimental exposures, the participant and confederate were asked not to talk during the experimental drives. The confederate and experimental staff were blind to condition until just before the experiment. Effectiveness of the experimental manipulation was assessed by survey items administered during the debriefing at the end of the experimental session.

Driving simulation—The fixed-base Drive Safety simulator consisted of the front three-quarters of the body and front interior of a sedan located in a dedicated lab space equipped with a computer-controlled LCD instrument cluster, operating foot controls, a torque motor providing steering force feedback, and a sound system that provided subdued road sounds and vibration. Road scenes were projected at 1024 × 768 pixels at 60 Hz on each of three forward screens and one rear screen, providing 120 degrees of forward field of view, and 40 degrees of rear field of view visible through the side and rearview mirrors. (Simulator photographs in Appendix B).

Three simulated drivable worlds were programmed for this study. The first world was a 5–10 min practice/coaching drive that allowed participants to acclimatize to the simulator. The two experimental worlds (World A & World B) were each 15–20 min, depending on driver performance. Each driving world contained a daylight urban setting with a series of signalized intersections, ambient traffic, and relevant cultural elements (e.g., buildings, trees, signs, pedestrians). Intersections were placed along a straight path such that the participant had no reason to make left or right turns during the drive. All elements in the worlds, such as moving traffic and pedestrians, were programmed to minimize the chance of crashes, loss of control, or other events that would interrupt the drive.

The primary scenarios of interest were the light phase changes (green to yellow to red) at the signalized intersections, which were programmed to begin when the participant was within a certain temporal or closing distance of the intersection. Temporal distance is a time-to-arrival measure that takes into account the distance from the intersection midpoint and the velocity of the vehicle, thus controlling for variability in speed approaching the intersection. The intersection signal phase changes were used to produce *dilemma zones* at some intersections, requiring participants to stop abruptly at an yellow light or risk being in the intersection when the light was red, a common experience of everyday driving, reflective of risk taking, and relevant to safety (Gazis, Herman, & Maradudin, 1960). Each simulated world contained 42 four-way signalized intersections, which were identical in terms of technical attributes, but visually different landscapes, and spaced 200 m apart. The signals at the intersections were designed to be green or yellow 6.0 s, 3.4 s, 3.0 s, or 2.6 s before the vehicle entered the intersection (e.g., the amber light then lasted 3.4 s before turning red) and the order of light color conditions was designed to reduce monotony, predictability, and clustering of similarly timed yellow lights. Shorter distances created dilemma zones, forcing the driver to quickly decide to stop or continue.

Measures—Participants completed three in-lab, online surveys using a secure Internet service 7–10 days before the simulator experiment, a brief predrive survey immediately before the simulator experiment, and a postdrive survey immediately following the simulator experiment. The predrive measures were selected as randomization checks because they have been linked to risky driving in previous research and could affect the outcome of the experiment if they varied by treatment group despite randomization. The postdrive measures were developed as manipulation checks (to test the success of the experimental manipulation).

Predrive survey (randomization checks): Resistance to peer influence was measured by 10 paired items such as: "Some people think it's more important to be an individual than to fit in with the crowd, but, other people think it's more important to fit in with the crowd than to be an individual." Participants were asked to choose the statement that best described them and then rate how true that statement was (*sort of true of me* or *really true of me*). Validity and reliability of this scale has been verified in diverse samples with good model fit statistics in confirmatory factor analysis and acceptable internal consistency with Cronbach's alpha > .70 (Steinberg & Monahan, 2007).

Friends' approval of risky driving was adapted from a scale by Chawla, Neighbors, Logan, Lewis, and Fossos (2009), who reported alphas of .73 and .69, and included 11 items that asked participants to indicate on a 5-point scale (1 = *very unlikely* to 5 = *very likely*) how likely it is that their friends would approve of their doing specific risky driving behaviors. Example behaviors are: driving 10 mph (16 kph) over the speed limit and running a red light.

Friends' risk behavior: Four separate items asked about the substance use behavior of participants' friends (e.g., How many of your closest friends . . . smoke cigarettes, drink alcohol, get drunk, use marijuana?) with response options of 1 = *none*, 2 = *a few*, 3 = *some*, 4 = *most*, 5 = *all*). Previous research reported an alpha of .80 (Simons-Morton et al., 2012).

Friends' risky driving: Nineteen items asked about friends' driving: "How many of your friends do each of the following . . .?" (e.g., always wear safety belts, follow road rules carefully, often exceed speed limits; 1 = *none*, 2 = *a few*, 3 = *some*, 4 = *most*, 5 = *all*). Previously, alphas between .80 and .90 were reported for four administrations of the instrument (Simons-Morton et al., 2011).

Driving risk perceptions (Simons-Morton, Hartos, Leaf, & Preusser, 2006) were measured by 24 items that asked participants to indicate the level of risk (1 = *lowest risk* to 5 = *highest risk*) for crash or injury of various driving behaviors, such as driving under the influence of alcohol, late at night, speeding between intersections to make the light, passing through an intersection on a yellow light, taking turns fast, running red lights, and speeding up to get through an intersection before the light turns red. Alphas reported in previous research were .88 (Hartos & Simons-Morton, 2006) and .85 (Simons-Morton et al., 2012).

Social expectations of driving scale: This 15-item scale, adapted by the research team for U.S. teenagers from Akers' social learning theory (Scott-Parker, Watson, & King, 2009), asked participants to rate their agreement (1 = *strongly disagree* to 7 = *strongly agree*) with statements such as: "I don't care if I get caught by the police for doing something I think is fun," with a reported alpha of .74 for the scale.

Postdrive survey (manipulation checks): The following items were adapted or created for this study as assessments of the success of the social norms manipulation.

Perception of passenger was adapted from a previous study (Ouimet et al., 2013) to measure participants' perceptions of the confederate passenger as risk-accepting or risk-averse by asking them to indicate how likely (1 = *very unlikely* to 5 = *very likely*) it was that 22 characteristics (e.g., outgoing, thrill seeking, rule following) described him.

Identification with passenger was measured by seven items that asked participants to indicate (1 = *no*, 2 = *maybe*, 3 = *yes*) their identification with the passenger (i.e., is the passenger someone with whom you could identify or someone you liked?).

Passenger approval was measured by 10 items asking participants how likely it was (1 = *very unlikely* to 5 = *very likely*) that the passenger would approve of their involvement in 10 driving behaviors. Example behaviors included driving 10 mph above the speed limit and following a slow vehicle very closely.

Passenger pressure was measured by eight items asking how much pressure (1 = *none* to 7 = *a lot*) participants felt from the passenger regarding eight driving-related behaviors, including to drive aggressively or pay attention to the passenger.

Dependent measures: The driving simulator data, such as participants' vehicle coordinates and traffic signal phase condition, were recorded at 60 Hz. Of the 42 signalized intersections in each of the drives, 19 were programmed to remain green as participants approached them, five intersections changed to amber at 6 s, and six intersections changed to yellow at 3.4 s, six at 3.0 s, and six at 2.6 s. All participants stopped at the intersection when the phase change to yellow occurred at 6 s. Using data averaged across the 18 intersections at 2.6 s, 3.0 s, and 3.4 s (termed "valid" to indicate they presented a dilemma about stopping or going) two driving outcome dependent variables were calculated: (a) Failed to Stop: stopped versus did not stop at yellow intersection, and (b) percent Time in Red: time in an intersection during the red light phase divided by total time × 100 averaged over all 18 intersections. The first measure is more indicative of the propensity to drive riskily or break traffic rules, reflecting the driver's expressed decision at that particular situation, and the second measures the real risks associated with the presence of a vehicle within intersection boundaries during the red signal phase. A decision to not stop at an amber light can result in varying durations in the intersection during a red phase.

Analyses

A randomization check tested treatment group differences in the baseline survey measures. Similarly, the effect of the confederate manipulation was evaluated by comparing treatment groups on measures of their perceptions of the confederate. Group comparisons were tested in SAS (Version 9.2). The primary driving-performance comparisons included solo versus passenger drives (passenger presence) and risk-averse versus risk-accepting passenger conditions (passenger condition). A generalized linear mixed model (PROC GLIMMIX) was used to examine effects of passenger presence (solo or passenger two-level within-subjects variable), passenger type (risk-averse or risk-accepting passenger two-level between-subjects variable), and their interaction on Failed to Stop (a binary variable with a binomial distribution assumption) using logit link. A mixed model (PROC MIXED) was used to examine effects of passenger presence, passenger condition, and their interaction on percent Time in Red (a continuous variable), using the REPEATED statement, normality distribution assumption, and Compound Symmetry variance-covariance structure. Potential outliers were screened (none identified) and the assumption of normality was tested for paired difference of percent Time in Red between solo and passenger drives using Kolmogorov– Smirnov (K-S) *D* and Shapiro-Wilk *W* tests. Outcome variables and most survey variables had complete data (N = 58). Missing values were found for some demographic and survey variables, ranging from 1.2% to 5.2%. Participants with missing data were compared with those with complete data using *t* tests and no significant differences were found on any dependent measure; therefore, missingness was considered to be at random and ignorable. Possible carry-over effects of passenger presence were tested, as follows: (a) for percent Time in Red, *t* tests were calculated within each passenger condition comparing the mean values of the two drives from the solo-first-then-passenger order versus those from the passenger-first-then-solo order; and (b) for Failed to Stop, GLIMMIX model was used within each passenger condition to compare # intersections of Failed to Stop/# of valid (dilemma zone) intersections between two drives from the solo-first-then-passenger order versus those from the passenger-first-then-solo order. The results of both GLIMMIX and Mixed models included drive presentation order (i.e., passenger or solo drive first order) to control for possible carryover effects and possible baseline survey postrandomization group differences.

Results

Study Participants

Seven of the 66 recruited participants did not complete the driving simulation—five due to simulator sickness and two because of technical issues with the simulator—and were excluded from analyses. Due to an incidental parent report of a previous Autism spectrum diagnosis that the teenage participant had not disclosed during the prescreening, the participant was excluded from these analyses given that the phenomenon under consideration is explicitly social (peer influence) and that Autism is known to specifically affect responsiveness to social cues. Those who completed the protocol did not differ from those who did not on demographics and other baseline characteristics. There was no significant difference, $t(52) = -0.26$, $p = .79$ in the mean number of months of licensure between participants who were randomly assigned to the risk-averse ($M = 6.35$ and $SD = 2.11$) and the risk-accepting ($M = 6.50$ and $SD = 1.74$) conditions. Ultimately, 58 participants were included in the analyses ($n = 31$ risk-accepting condition and $n = 27$ risk-averse condition). As indicated in Table 1, the sample was 84% White.

Test of Randomization

Descriptive statistics for survey measures are shown overall and by passenger condition in Table 2. The only baseline difference was greater friends' risk behavior the risk-averse than the risk-accepting condition ($p = .03$).

Participants' Perceptions of the Passenger (Manipulation Check)

Participants were compared on their perceptions of the confederate. Results indicated that the experimental manipulation was successful, with participants in the risk-accepting passenger condition, compared with those in the risk-averse condition, reporting that the passenger was significantly more risk accepting ($M_{\text{risk-accepting}} = 3.78$, $M_{\text{risk-averse}} = 1.83$, $t(56) = 16.82$, $p < .001$), put more pressure on them ($M_{\text{risk-accepting}} = 4.46$, $M_{\text{risk-averse}} = 3.16$, $t(56) = 7.69$, $p < .001$), and approved more of their driving in a risky way ($M_{\text{risk-accepting}} = 4.08$, $M_{\text{risk-averse}} = 1.98$, $t(56) = 17.16$, $p < .001$). Risk-accepting condition participants also reported that the confederate passenger was a person they identified with more ($M_{\text{risk-accepting}} = 2.46$, $M_{\text{risk-averse}} = 2.13$, $t(56) = 2.96$, $p < .01$). These results were consistent with participants' subjective impressions at debrief.

Risky Driving Outcomes

The results of K-S D ($D = 0.10$, $p = .15$ for percent Time in Red) and Shapiro-Wilk W tests ($W = 0.98$, $p = .48$ for percent Time in Red) indicate normal distributions of paired differences for both outcome variables. The simulated worlds were created to minimize the likelihood of a crash, and accordingly, there were no crashes in any of the study drives.

Carry-Over Effects

No significant carry-over effects were found for either outcome variable by passenger condition, satisfying the assumption of the crossover design. (A 2 × 2 table is included in Appendix D showing *M*s and *SD*s for each cell and results of the *t* tests and GLMMIX model. Despite the lack of statistical significance, given the mean differences shown in Appendix D, we controlled for presentation order in the analytic models.

Main effects of passenger presence and passenger type, and interaction effects—We first tested the effects of passenger presence (solo vs. passenger) using GLIMMIX and Mixed models, controlling for drive presentation order and for baseline difference in friends' risk behavior (data for main effects not shown). Significant effects of passenger presence were found for both measures of risky driving: (a) Failed to Stop (OR = 1.49, 95% CI [1.20, 1.85], $p < .01$); those driving with a passenger were more likely to fail to stop compared with those driving solo; and (b) percent Time in Red (B = 4.75, *SE* = 1.60, 95% CI [1.53, 7.96], $p < .01$); those driving with a passenger had higher percent Time in Red compared with those driving solo.

The effects of passenger presence were moderated by passenger type, as shown in Table 3, with significant interactions of passenger presence by passenger type for Failed to Stop (B = 0.61, OR = 1.84, 95% CI [1.19, 2.86], $p < .001$) and percent Time in Red (B = 7.71, 95% CI [1.54, 13.87], $p < .05$). Figure 1 shows the magnitudes of the two outcome variables by passenger type and passenger presence and Figure 2 illustrates the interaction effects. Shown in Figure 2–1 are the probabilities indicating that participants driving with a risk-accepting passenger were more likely to fail to stop compared to those driving with a risk-averse passenger (OR = 2.52, 95% CI [1.49, 4.27], $p < .001$). Similarly, partici pants driving with a passenger were more likely to fail to stop compared with those driving solo in the risk-accepting passenger condition (OR = 1.98, 95% CI [1.45, 2.69], $p < .001$), but not in the risk-averse condition. Figure 2–2 (data for simple effects not shown) indicates participants driving with a risk-accepting passenger had higher percent Time in Red (B = 13.86, *SE* = 4.11, 95% CI [5.62, 22.10], $p < .01$) compared with those with a risk-averse passenger, and participants driving in the presence of a passenger had higher percent Time in Red (B = 8.86, *SE* = 4.41, 95% CI [0.02,17.71, $p < .05$]) compared with those driving solo in the risk-accepting, but not the risk averse passenger condition.

Discussion

This study demonstrated the effect of passenger presence on simulated risk driving was moderated by passenger type, supporting the conclusion that perceived social norms influenced simulated risky driving behavior in our sample of recently licensed male teenage drivers. Compared with driving solo, risky driving was significantly greater among teenage males when they drove with a passenger, but significantly higher with a risk-accepting peer passenger compared with a risk-averse passenger.

Previous observational studies have reported that teenage passenger presence increases teenage driving risk (Ouimet et al., 2010). Moreover, an effect of teenage passengers on teenage simulated risky driving has been reported in several studies. In one recent study, teenagers demonstrated greater activation in reward-related brain regions and engaged in more risky decisions in a driving game when observed by peers than when not observed (Chein et al., 2011). Thus, peer passenger presence could promote riskier teenage driving performance by increasing reward sensitivity, consistent with broader accounts of increased reward salience in teens (Albert, Chein, & Steinberg, 2013). These findings converge with previous research by Shepherd et al. (2011), who found that adolescents randomized to play a driving video game alone or with two peers (who could tell the driver how to react to the proposed scenario) took more risks, focused more on the benefits of risky behavior, and made riskier decisions than when alone. However, a naturalistic teenage driving study reported no effect of teenage passengers on teenage crash/near crash or risky driving rates (Simons-Morton et al., 2011). Also, two studies, one based on the Fatal Accident Reporting System (Ouimet et al., 2010) and one based on observations of teenager's risky driving behavior (Simons-Morton et al., 2005), reported that risk was greater with male than female teenage passengers. Hence, there is reason to believe that teenage driving behavior might vary according to characteristics of the teenagers involved. One explanation for the variability in teenage passenger effects, including differences by the gender of the driver and passenger, is social norms.

The present study provided a systematic test of normative influences on male teenage risky driving. The moderation by passenger type of the relationship between simulated risky driving and passenger presence support the contention that injunctive norms affect risk behavior, consistent with the theory of normative social behavior (Rimal & Real, 2005), within which the study was framed. Prior driving simulation studies have reported negative effects on distraction and hazard detection when teenage passengers engaged young drivers in conversation or exerted direct peer pressure (Gugerty et al., 2004; Shepherd et al., 2011). The current study carefully manipulated injunctive norms regarding risky driving to test the hypothesis that participants would alter their driving behavior to conform to their perceptions of the confederate passenger's acceptance of, or aversion to risky driving, in the absence of any direct engagement with the passenger. The effect of passenger norms on risky driving has not previously been well tested.

Our study provides evidence that teenagers' normative perceptions interact with passenger presence and alter simulated risky driving, beyond the effect of passenger presence alone. Only one previous study examined the effect of norms by manipulating the physical appearance and nonverbal attitudes of the confederate passenger (Ouimet et al., 2013). The subtle manipulation in that study resulted in a marginal difference in participants' perceptions about the confederate passengers' norms regarding risk acceptance and significant results were found for passenger presence and inattention to hazards, but not for simulated risky driving. In the current study, the appearance of the confederate passenger and his behavior in the car were the same across conditions; therefore, the interpretation of findings in the current study are not confounded by confederate appearance and can more confidently be causally attributed to normative influences. By manipulating injunctive norms through predrive priming, participants' self-reported perceptions of passenger norms in the postdrive survey differed substantially by treatment condition. The finding that risky driving was greater in the presence of a risk-accepting than a risk-averse passenger is consistent with an effect of injunctive norms on teenage male risky driving behavior. The findings are also consistent with research showing that injunctive norms influence other health-risk behaviors (i.e., college drinking; Rimal & Real, 2005), and provide support for the robustness of the theory across risk domains.

Strengths and Limitations

Strengths of the research include high internal validity from the randomized experimental design and the effective confederate passenger deception, and external validity from the use of a fixed-based driving simulator to assess risky driving. However, generalization of the study findings could be limited by the inclusion of only male teenagers and the narrow focus on driving behavior associated with signalized intersections. Likewise, study participants were closely clustered around average rates of resistance to peer influence for this age group (Steinberg & Monahan, 2007); therefore, it is unclear to what extent these findings would generalize to participants at more extreme ends of the distribution on such measures. Although we are confident that our predrive manipulation altered the drivers' perceived norms using a multicomponent priming manipulation, it may be of interest to further dissect the components of the priming manipulation in future studies. The use of an age-peer confederate passenger allowed substantial experimental control, but may have provided participants with a somewhat artificial experience compared with the influence of actual friends. The confederate, however, exerted minimal pressure within the driving environment, which suggests that the results may underestimate the effects of peer influence in the real world.

Conclusion

The relationship between passenger presence and simulated risky driving was moderated by passenger type. Exposure of male teenagers to unfamiliar same-sex peer passengers with risk-accepting norms increased simulated risky-driving behavior. These results provide evidence that injunctive norms may explain in part the variability in driving risk associated with teenage passengers. Additional research is needed that explores the variability in peer influence on adolescent risky driving behavior by driver characteristics and driving conditions.

Acknowledgments

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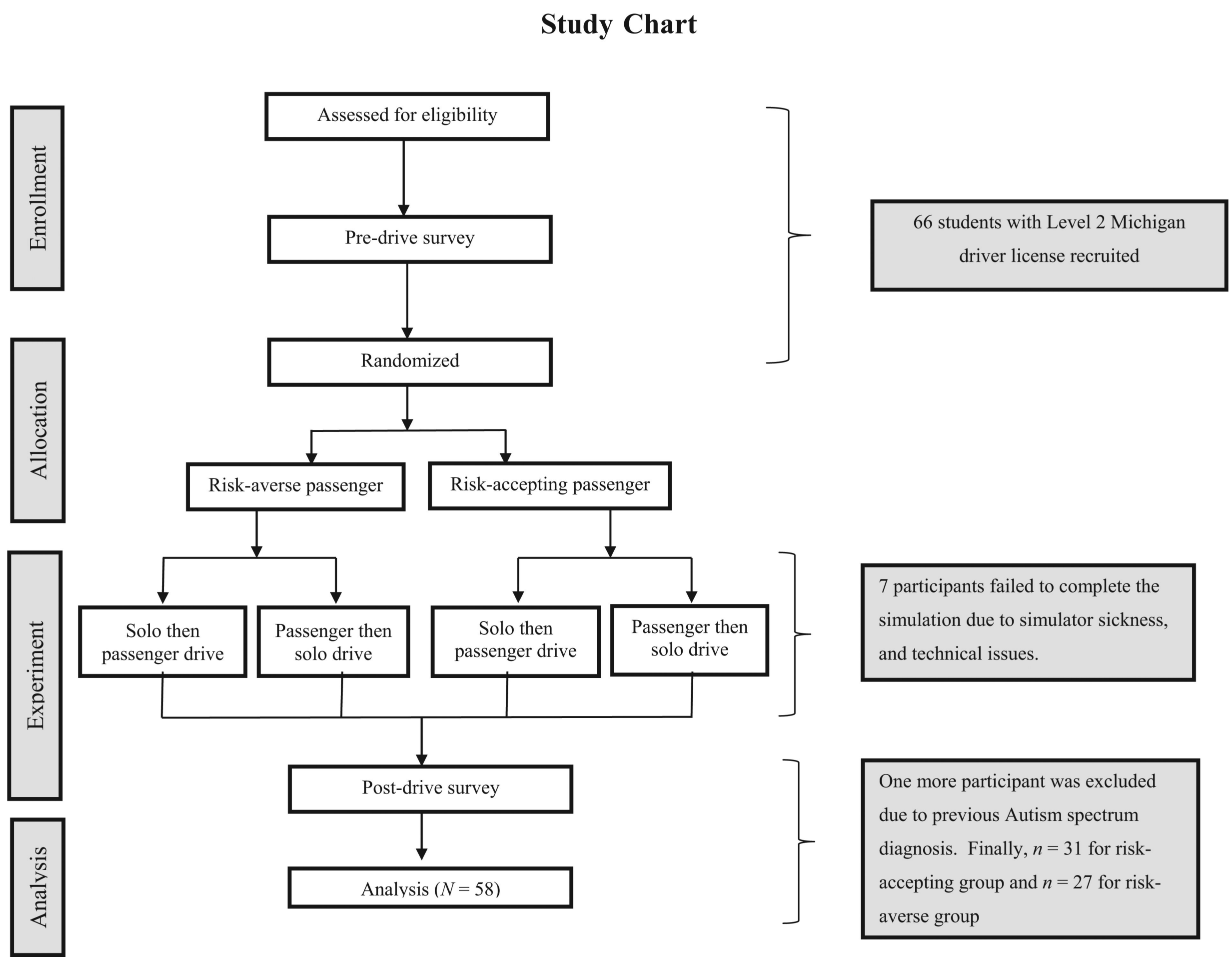
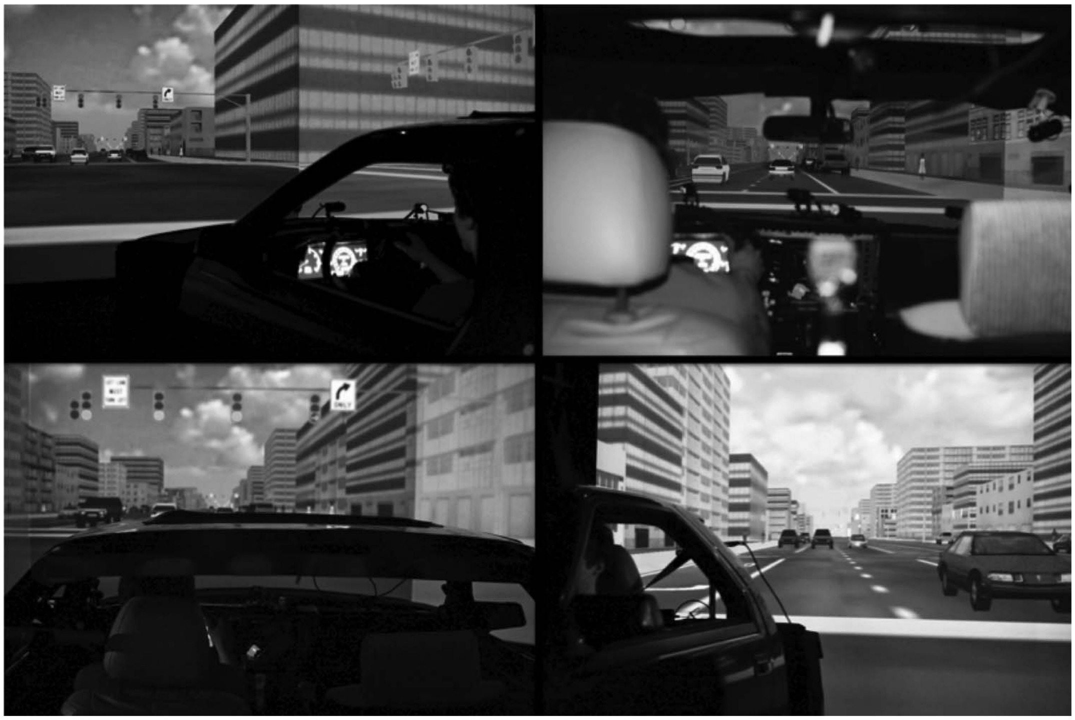
Appendix



Appendix A.
Study Chart

Appendix



Appendix B.

Driving Simulator Photographs

Appendix

Appendix C

Results of Checking for Carry-Over Effects

	Risk-averse passenger condition								Risk-accepting passenger condition							
	Solo then passenger			Passenger then solo			*t*	*p*	Solo then passenger			Passenger then solo			*t*	*p*
	N	*M*	*SD*	N	*M*	*SD*			N	*M*	*SD*	N	*M*	*SD*		
Percent failed to stop	32	16.32	17.51	30	25.93	20.96	−1.41	.17	26	27.99	20.87	28	40.25	24.08	−1.57	.13
Average percent time in red	16	11.45	10.64	15	18.34	14.02	−1.55	.13	13	19.21	13.32	14	29.03	17.37	−1.64	.11

Note.

Percent Failed to Stop = (# intersections of Failed to Stop/# of 18 intersections) × 100; Percent Time in Red = (time in intersections during the red light phase/total time in all 18 intersections) × 100; Average percent Time in Red = averaged percent time in red of first and second drives. A *t*-test was used for percent Time in Red and GLIMMIX model was used for Failed to Stop to compare the difference between Solo then Passenger and Passenger then Solo orders by passenger type.

Appendix D

Results of Doubly-Multivariate Repeated Measures

In addition to repeated-measures ANOVA for each of the outcome variables, we also conducted doubly-multivariate repeated measures to confirm the effects of passenger norms. The results of doubly-multivariate repeated measures showed that there are significant overall treatment effects on the two dependent variables (i.e., percent Failed to Stop and percent Time in Red, Wilks' Lambda: $F(2,55) = 3.58$, $p = .03$; Pillai's Trace: $F(2,55) = 3.78$, $F(2,55) = 5.70$, $p = .006$; Pillai's Trace: $F(2,55) = 5.70$, $p = .006$). Results of univariate analyses show that (a) in the passenger drive, there is a significant difference in percent Failed to Stop, $F(1,56) = 12.43$, $p < .001$, and percent Time in Red, $F(1,56) = 10.93$, $p = 0.002$; and (b) in the solo drive, there is no significant difference in percent Failed to Stop, $F(1,56) = 10.93$, $F(1,56) = 0.77$, $p = .19$, and percent Time in Red, $F(1,56) = 1.89$, $p = .17$, between the risk-averse and risk-accepting conditions. The multivariate results confirm our manipulated risk-averse and risk-accepting conditions, and the univariate results are consistent with our results (Table 3) using percent Failed to Stop and percent Time in Red as separate dependent variables. However, we report the two dependent variables separately because they are important and distinct indicators.

References

Albert D, Chein J, Steinberg L. The teenage brain: Peer influences on adolescent decision making. Current Directions in Psychological Science. 2013; 22:114–120. doi:10.1177/0963721412471347.

Allen, JP.; Antonishak, J. Adolescent peer influences: Beyond the dark side.. In: Prinstein, MJ.; Dodge, KA., editors. Understanding peer influence in children and adolescents. Guilford Press; New York, NY: 2008. p. 141-160.

Borsari BE, Carey KB. Understanding fraternity drinking: Five recurring themes in the literature, 1980–1998. Journal of American College Health. 1999; 48:30–37. doi: 10.1080/07448489909595669. [PubMed: 10485163]

Centers for Disease Control and Prevention, & National Center for Injury Prevention and Control. Web-based injury statistics query and reporting system (WISQARS). 2012. Retrieved from http://www.cdc.gov/injury/wisqars/index.html

Chawla N, Neighbors C, Logan D, Lewis MA, Fossos N. Perceived approval of friends and parent as mediators of the relationship between self-determination and drinking. Journal of Studies on Alcohol and Drugs. 2009; 70:92–100. [PubMed: 19118397]

Chein J, Albert D, O'Brien L, Uckert K, Steinberg L. Peers increase adolescent risk taking by enhancing activity in the brain's reward circuitry. Developmental Science. 2011; 14:F1–F10. doi: 10.1111/j.1467-7687.2010.01035.x. [PubMed: 21499511]

Chen LH, Baker SP, Braver ER, Li G. Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. The Journal of the American Medical Association. 2000; 283:1578–1582. doi: 10.1001/jama.283.12.1578.

Cialdini, RB. Influence: Science and practice. 4th ed.. Harper Collins; New York, NY: 2001.

Curry AE, Mirman JH, Kallan MJ, Winston FK, Durbin DR. Peer passengers: How do they affect teen crashes? Journal of Adolescent Health. 2012; 50:588–594. doi:10.1016/j.jadohealth.2011.10.016. [PubMed: 22626485]

Drews FA, Pasupathi M, Strayer DL. Passenger and cell phone conversations in simulated driving. Journal of Experimental Psychology: Applied. 2008; 14:392–400. doi:10.1037/a0013119. [PubMed: 19102621]

Falk EB, Cascio C, Carp C, Tinney FJ, Brook O'Donnell M, Bingham CR, Simons-Morton BG. Neural responses to exclusion predict susceptibility to social influence. Journal of Adolescent Health. in press.

Fisher DL, Pradhan AK, Pollatsek A, Knodler MA. Empirical evaluation of hazard anticipation behaviors in the field and on driving simulator using eye tracker. Transportation Research Record. 2007; 2018:80–86. doi:10.3141/2018-11.

Gardner M, Steinberg L. Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. Developmental Psychology. 2005; 41:625–635. doi: 10.1037/0012-1649.41.4.625. [PubMed: 16060809]

Gazis D, Herman R, Maradudin A. The problem with the amber signal light in traffic flow. Operations Research. 1960; 8:112–132. doi:10.1287/opre.8.1.112.

Groeger, JA. Understanding driving: Applying cognitive psychology to a complex everyday task. Psychology Press; Hove, UK: 2000.

Gugerty L, Rakauskas M, Brooks J. Effects of remote and in-person verbal interactions on verbalization rates and attention to dynamic spatial scenes. Accident Analysis and Prevention. 2004; 36:1029–1043. doi:10.1016/j.aap.2003.12.002. [PubMed: 15350880]

Hartos, JL.; Simons-Morton, BG. Parents and their newly-licensed teen drivers: Promoting parent management of novice teen driving.. In: Devore, DM., editor. New Developments in parent-child relations. Nova Science Publishers; New York, NY: 2006. p. 284-302.

Hartup WW. Peer interaction: What causes what? Journal of Abnormal Child Psychology. 2005; 33:387–394. doi:10.1007/s10802-005-3578-0. [PubMed: 15957565]

Lee SE, Klauer SG, Olsen ECB, Simons-Morton BG, Dingus TA, Ramsey DJ, Ouimet MC. Detection of road hazards by novice teen and experienced adult drivers. Transportation Research Record. 2009; 2078:26–32.

National Highway Traffic Safety Administration. An examination of driver distraction as recorded in NHTSA databases (HS-811 216). U.S. Department of Transportation; Washington, DC: 2009.

National Highway Traffic Safety Administration. Traffic safety facts, 2009: A compilation of motor vehicle crash data from the fatality analysis reporting system (HS-811 402). U.S. Department of Transportation; Washington, DC: 2011.

Ouimet MC, Pradhan AK, Simons-Morton BG, Divekar G, Mehranian H, Fisher DL. The effect of male teenage passengers on male teenage drivers: Findings from a driving simulator study. Accident Analysis and Prevention. 2013; 58:132–139. doi:10.1016/j.aap.2013.04.024. [PubMed: 23727554]

Ouimet MC, Simons-Morton BG, Zador PL, Lerner ND, Freedman M, Duncan GD, Wang J. Using the U.S. National Household Travel Survey to estimate the impact of passenger characteristics on young drivers' relative risk of fatal crash involvement. Accident Analysis & Prevention. 2010; 42:689–694. doi:10.1016/j.aap.2009.10.017. [PubMed: 20159095]

Poulin F, Dishion TJ, Haas E. The peer influence paradox: Friendship quality and deviancy training within male adolescent friendships. Merrill-Palmer Quarterly. 1999; 45:42–61.

Prinstein, MJ.; Dodge, KA. Current issues in peer influence research.. In: Prinstein, MJ.; Dodge, KA., editors. Understanding Peer Influence in Children and Adolescents. The Guilford Press; New York, NY: 2008. p. 3-17.

Rimal RN, Real K. How behaviors are influenced by perceived norms a test of the theory of normative social behavior. Communication Research. 2005; 32:389–414. doi:10.1177/0093650205275385.

Scott-Parker B, Watson B, King MJ. Understanding the psychosocial factors influencing the risky behaviour of young drivers. Transportation Research Part F: Traffic Psychology and Behaviour. 2009; 12:470–482. doi:10.1016/j.trf.2009.08.003.

Shepherd JL, Lane DJ, Tapscott RL, Gentile DA. Susceptible to social influence: Risky "driving" in response to peer pressure. Journal of Applied Social Psychology. 2011; 41:773–797. doi: 10.1111/j.1559-1816.2011.00735.x.

Shope JT, Bingham CR. Teen driving—Motor-vehicle crashes and factors that contribute. American Journal of Preventive Medicine. 2008; 35:S261–S271. doi:10.1016/j.amepre.2008.06.022. [PubMed: 18702980]

Simons-Morton B, Chen RS. Over time relationships between early adolescent and peer substance use. Addictive Behaviors. 2006; 31:1211–1223. doi:10.1016/j.addbeh.2005.09.006. [PubMed: 16229958]

Simons-Morton BG, Hartos JL, Leaf WA, Preusser DF. Increasing parent limits on novice young drivers: Cognitive mediation of the effect of persuasive messages. Journal of Adolescent Research. 2006; 21:83–105. doi:10.1177/0743558405282282.

Simons-Morton BG, Lerner N, Singer J. The observed effects of teenage passengers on the risky driving behavior of teenage drivers. Accident Analysis and Prevention. 2005; 37:973–982. doi: 10.1016/j.aap.2005.04.014. [PubMed: 15921652]

Simons-Morton BG, Ouimet MC, Chen R, Klauer SG, Lee SE, Wang J, Dingus TA. Peer influence predicts speeding prevalence among teenage drivers. Journal of Safety Research. 2012; 43:397–403. doi:10.1016/j.jsr.2012.10.002. [PubMed: 23206513]

Simons-Morton BG, Ouimet MC, Zhang Z, Klauer SE, Lee SE, Wang J, Dingus TA. The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. Journal of Adolescent Health. 2011; 49:587–593. doi: 10.1016/j.jadohealth.2011.02.009. [PubMed: 22098768]

Steinberg L, Monahan KC. Age differences in resistance to peer influence. Developmental Psychology. 2007; 43:1531–1543. doi: 10.1037/0012-1649.43.6.1531. [PubMed: 18020830]

Tian TS, Kerschbaumer DM. Peer attitudes, sex, and the effects of alcohol on simulated driving performance. The American Journal of Drug and Alcohol Abuse. 1990; 16:135–146. doi: 10.3109/00952999009001578. [PubMed: 2330934]

Twisk DA, Stacey C. Trends in young driver risk and countermeasures in European countries. Journal of Safety Research. 2007; 38:245–257. doi:10.1016/j.jsr.2007.03.006. [PubMed: 17478195]

White CB, Caird JK. The blind date: The effects of change blindness, passenger conversation and gender on looked-but-failed-to-see (LBFTS) errors. Accident Analysis and Prevention. 2010; 42:1822–1830. doi:10.1016/j.aap.2010.05.003. [PubMed: 20728633]

Williams AF. Teenage drivers: Patterns of risk. Journal of Safety Research. 2003; 34:5–15. doi: 10.1016/S0022-4375(02)00075-0. [PubMed: 12535901]

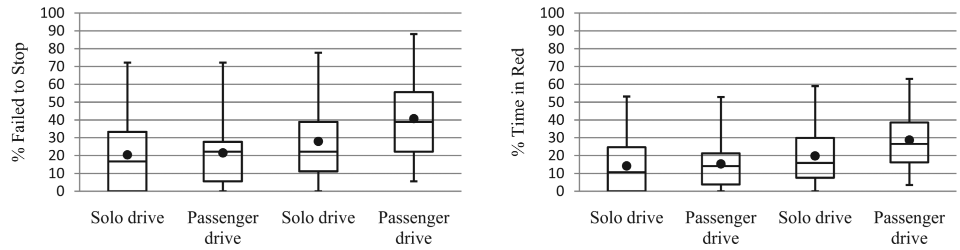


Figure 1.

Box and whisker plot of dependent variable by passenger presence and passenger condition. Percent Failed to Stop = (# intersections of Failed to Stop/total number of valid intersections) × 100. Percent Time in Red = (time in intersection during the red light phase/ total time in intersection) × 100, averaged over all 18 intersections.

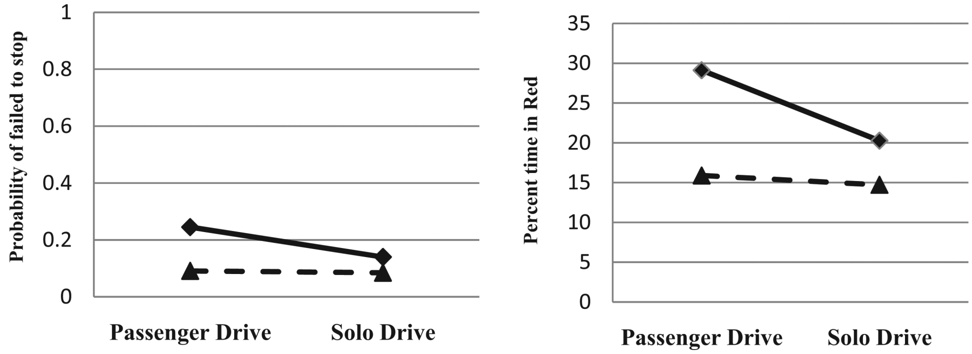


Figure 2.
Interaction between Passenger Presence and Passenger Type.

Table 1

Sample Demographic Characteristics (N = 58)*

	Total	Study condition			
		Risk-averse passenger (*n* = 31)		Risk-accepting passenger (*n* = 27)	
	N	*n*	%	*n*	%
Race					
Black	4	4	100.0	0	0.0
White	46	21	44.7	25	54.4
Asian	3	2	66.7	1	33.3
Other	2	2	100.0	0	0.0
Hispanic/Latino					
Yes	4	3	75.0	1	25.0
No	53	27	50.0	26	49.1
Age					
16	37	21	60.0	16	40.0
17	15	7	46.7	8	53.3
18	4	3	75.0	1	25.0

Note. Chi square tests revealed no significant differences but the results should be used with caution because many cell sizes are less than 5. Of 66 recruited, five were lost due to simulation sickness, two due to technical problems during the drives, and one was disqualified due to a diagnosis of autism.

*The numbers may not add to the total due to missing values.

Table 2

Survey Measures by Passenger Condition (N = 58)

						Passenger condition			
				Total		Risk-averse passenger (n = 31)		Risk-accepting passenger (n = 27)	
	# of Items	Range[a]	Alpha[b]	*M*	*SD*	*M*	*SD*	*M* [c]	*SD*
Resistance to peer influence	10	1–4	.60	2.96	0.46	3.03	0.45	2.89	0.46
Friends' approval of risky driving	11	1–5	.66	2.85	0.49	2.82	0.53	2.90	0.44
Friends' risk behavior	4	1–5	.80	2.34	0.73	2.54	0.75	2.12*	0.64
Friends' risky driving	19	1–5	.88	2.32	0.47	2.33	0.54	2.31	0.38
Driving risk perceptions	24	1–5	.90	3.55	0.49	3.63	0.52	3.47	0.45
Social expectations of driving	15	1–7	.75	2.84	0.63	2.77	0.73	2.93	0.50

[a]The higher score represents greater resistance, approval, risk behavior, risk perceptions, social expectations, and sensation seeking.

[b]The alpha coefficients are for the current study.

[c]Independent *t*-tests were used to conduct the mean comparisons.

*$p < .05$ compared with risk-averse passenger.

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Table 3

Associations of Passenger Condition and Passenger Presence With Failed to Stop and Percent Time in Red

	Variable	***B*** [#]	***SE***	***DF***	***t***	***p***
Logit of failed to stop [†]	Passenger condition (PC)					
	Risk-averse passenger	0.54	0.34	55	1.62	0.11
	Risk-accepting passenger	Ref				
	Passenger presence (PP)					
	Passenger drive	0.08	0.16	55	0.48	0.64
	Solo drive	Ref				
	PC * PP	0.61	0.22	55	2.78	<.01
Percent time in red [‡]	Passenger condition (PC)					
	Risk-averse passenger	5.84	4.14	54	1.41	0.16
	Risk-accepting passenger	Ref				
	Passenger presence (PP)					
	Passenger drive	1.16	2.10	56	0.55	0.58
	Solo drive	Ref				
	PC * PP	7.71	3.08	56	2.50	0.02

Note.

The corresponding odds ratios (OR) and 95% Confident Intervals (CI) are as follows: PC (OR = 1.72; 95% CI [0.88, 3.37]), PP (OR = 1.08; 95% CI [0.78, 1.48]), and PC * PP (OR = 1.84; 95% CI [1.19, 2.86]).

Both models are controlling for drive presentation order and for baseline difference in friends' risk behavior.

[†] Generalized linear mixed model was used with binomial distribution assumption and logit link.

[‡] Mixed model was used with REPEATED statement, normality distribution assumption, and Compound Symmetry variance-covariance structure.

[#] To report the results in a consistent format we reported logit of Failed to Stop in the table.