

Impulsivity and Aggression in Young Drivers Assessed in Short Driving Simulator Scenarios

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Abstract

Interactions between gender, impulsivity, and driving anger, and young people's driving behaviour were assessed in an immersive driving simulator. Personality measures included the Impulsivity Questionnaire, the Driving Anger Scale, and the Driving Anger Expression Scale. Five short driving scenarios were used: T-junction gap acceptance, following distance, approaching amber traffic lights, merging following traffic lights, and overtaking. Two forms of each scenario were created: a provocative ("hot"), and a matched neutral ("cool") form. For example, in merging lanes following a traffic light scenario, in the hot form, a car in the other lane would "race" the participant's vehicle to the merge point; in the cool form, the other vehicle would merge in a more orderly fashion. Dependent variables comprised difference scores derived from the vehicle dynamics data between the hot and cool driving scenarios. From an initial screen of 278 participants 52 (55% female; age $M = 19.13$ years) were selected, half of whom had high impulsivity and anger scores, while the other half had low scores on both these measures. Results included main effects for Gender, and Impulsivity, and a Gender, Impulsivity, and Driving Anger 3-way interaction. Overall, young impulsive males had a higher tendency for risky driving than females did. However, high impulsivity, low driving anger males exhibited risky driving behaviour differently, suggesting the influence of other motivational factors, such as venturesomeness.

Introduction

In the 12 months ending June 2015, persons aged 17-25 years comprised approximately 13% of Australia's population, while accounting for just over 21% of motor vehicle accident deaths (Department of Infrastructure and Regional Development, 2015). As driving behaviour directly affects crash outcomes, motivations associated with young persons' driving behaviour are likely to be relevant to informing safe driver interventions targeting this demographic. Factors affecting driving behaviour include personality (Constantinou et al., 2011), with impulsivity and anger (expressed as aggression) known to have potentially adverse consequences for road safety (Bina, Graziano, & Bonino, 2006; Dahlen, Martin, Ragan, & Kuhlman, 2005; Deffenbacher et al., 2003; Jonah, 1986; Jonah, Thiessen, & Au-Yeung, 2001). Compared with older drivers, young drivers have been observed being more likely to drive faster, to exceed speed limits, and to drive closer to a lead vehicle (Glendon, 2007; Glendon & Sutton, 2005). They also accept narrower gaps when merging, and are more likely than older drivers to accelerate when approaching an amber light (Jonah, 1986). Younger drivers also have a propensity to weave through traffic and to pass other vehicles more frequently than older drivers do (Jonah et al., 2001), while young male drivers are more likely to run red lights (Hemenway & Solnick, 1993). It has been concluded that young male drivers' failure to maintain a safe following distance and engage in illegal passing could be attributed to their propensity for aggressive driving (Claret et al., 2003).

Dahlen et al. (2005) found that impulsivity in young people contributed to predicting risky and aggressive driving behaviour, particularly using the vehicle to express anger. Compared with their non-accident-involved counterparts, male adolescents who reported a motor vehicle accident-related injury had higher scores on measures of impulsivity, inattention, conduct problems, and emotional lability (Jelalian et al., 2000). Deffenbacher, Lynch, Oetting, and Swaim (2002) found that trait

driving anger was strongly related to self-reported aggressive driving behaviour, and that compared with females, males' manifestations of anger were associated with greater risk taking and aggressive expression while driving. González-Iglesias et al. (2012) found that males expressed greater anger at police presence, while females expressed greater anger at traffic obstructions. Other sex differences in anger expression included females exhibiting a more adaptive attitude. An evident gap in the literature is the extent to which sex-related anger differences might extend to a wider range of driving schemas. Sex differences across a number of contrasting traffic scenarios are therefore a focus of the current study.

Driving behaviour was assessed in a driving simulator in matched driving scenarios: one being a "cool" version, in which another vehicle's movements and traffic conditions were designed as being unlikely to provoke aggressive and/or impulsive driving. In contrast the corresponding "hot" scenarios were designed to provoke such behaviour. In their driving simulations, both Richer and Bergeron (2012), and Duan, Li, and Salvendy (2012) showed how the behaviour of other vehicles can elicit risky driving in young people. Simulated driving offers the opportunity to study driving behaviours in a risk-free environment, also allowing for experimental control over, and manipulation of, driving scenarios. Laboratory-based study can also include measures of personality factors known to influence driving outcomes, which for ethical, safety, and practical reasons, could be neither generated nor manipulated in naturalistic studies (Yan et al., 2008).

Method

Participants and measures

A convenience sample of Griffith University School of Applied Psychology students ($N = 278$, 73% female, mean age 20.1 years) possessing either a Learners, or a Provisional, or an Open driving licence completed two questionnaires: Eysenck's (1985) I₇ Impulsiveness Questionnaire (I₇), and Deffenbacher, Oetting, and Lynch's (1994) Driving Anger Scale (DAS), before undertaking any simulated drives. The I₇ has three subscales measuring Impulsivity, Venturesomeness, and Empathy. Reported Cronbach's α for the I₇ impulsivity scale were: males .84, and females .83 (Eysenck et al., 1985). The DAS is a 33-item self-report questionnaire which measures the intensity of anger experienced on six subscales: hostile gestures (3 items, example: "Someone honks at you about your driving"), illegal driving (4 items, example: "Someone is weaving in and out of traffic"), police presence (4 items, example: "A police officer pulls you over"), slow driving (6 items, example: "Someone is slow in parking and holding up traffic"), discourtesy (9 items, example: "Someone is driving right on your back bumper"), and traffic obstructions (7 items, example: "You are stuck in a traffic jam"). Participants were asked to rate the amount of anger they experience regarding specific driving situations on a scale from one (*none at all*) to five (*very much*). Possible scores ranged from 33 to 165. All items are summed for an overall score. Reported Cronbach's α for the DAS was .90 (Deffenbacher et al., 1994). From screening the initial participant sample, two groups were selected for participation in the driving simulator study. Participants were aged between 17 and 24 years and lacked motion sickness susceptibility as determined by Golding's (1998) MSSQ. One group (13 females, 12 males) consisted of participants scoring high on impulsivity (> 8), anger (> 142), or both; the other group (14 females, 13 males), scored low on these measures (impulsivity < 6 ; anger < 78). Informed consent was obtained from all participants and the research complied with Griffith University's Human Research Ethics approved protocol (PSY/D8/10/HREC).

Equipment

A fixed-base, immersive driving simulator was used to measure driving behaviour. Driving scenarios, which included a secondary intelligent vehicle (IV), were created using OKTAL SCANer™ studio 2.1 software. Images were projected via a Christie® Mirage HD6 1080 DLP onto

an Immersaview double curvature screen, 2.2 metres high and 3.2 metres around. Participants interacted with the simulated virtual environment via Logitech® G27 wheel and pedals module with a Logitech Evolution® Playseat positioned so that the participant's head was 2.0 metres from the screen. Simulated vehicle dynamics measured on a number of parameters were sampled twenty times a second and stored for analysis using the SCANer™ software. The human interactive vehicle (HIV) was always simulated as having automatic transmission.

Short Driving Scenarios

“Hot” (provocative) and “cool” (non-provocative) versions of five traffic scenarios were created. These paired scenarios were designed to differentiate participants' driving behaviour resulting from impulsive and aggressive driving decisions under provocation from their “normal” driving behaviour, that is, without provocation. Each trial lasted approximately 30–45 seconds with no speed limits indicated in the scenarios.

T-junction Gap Acceptance

On a single-lane road, the HIV began positioned at a T-intersection ready to turn left. The view of the road was towards the oncoming traffic from the right at a constant speed of 60 km/h until the participant moved off and turned left to merge. The hot scenario comprised a series of smaller gaps (of 3, 5, 4, 5, 4, & 7 seconds), while the cool scenario comprised fewer but larger gaps (of 6, 9, & 12 seconds) between vehicles. A lack of feasible gaps may compromise a driver's patience leading them to accept a smaller gap. Alternatively, a larger gap detected further away may result in a driver dismissing an acceptable gap in order to accept a later, larger, and more favourable gap.

Following Distance

This scenario assessed the risky driving behaviour of close following. On a single-lane road, the HIV began positioned 70 metres behind the IV, which was programmed to travel at the same speed as the HIV up to 80 km/h, at which point it maintained a constant speed. In the cool scenario, the IV continued at 80 km/h regardless of the HIV driver's behaviour. In the hot scenario, in the event that the HIV driver accelerated to be within 66 metres (safe travelling distance), the IV provocatively braked and decelerated to 60 km/h.

Amber/Red Traffic Light Acceptance

The HIV began either 190 metres (cool trial) or 250 metres (hot trial) from a set of traffic lights. The traffic lights were programmed to change from green to amber when the HIV driver was either 140 metres (hot trial), or 80 metres (cool trial) away. Duan et al. (2012) found that at three seconds' duration, if a driver braked, then they would stop at the intersection as the lights turned red, whereas if a driver accelerated then they would just pass through the intersection as the lights turned red. In the current study, consistent with most Queensland traffic light intersections, the amber light appeared for four seconds so that the critical time for passing through traffic lights was four seconds (approximately 78 metres driving at 60 km/h). A driver who accelerated rapidly to drive through the amber light from a distance representing more than four seconds, would thereby generate a different driving acceleration profile from a driver who steadily decelerated to a stop.

Merging Following Traffic Lights

This task was set on a dual-lane road where the left lane ended 75 metres after a set of traffic lights. The HIV began positioned at the left lane at the traffic lights (red) with the IV in the right lane. In the cool scenario, the IV was programmed to accelerate steadily and proceed at 60 km/h. In the hot scenario, the IV was programmed to continue at the same speed as the HIV, thereby being

positioned directly alongside the HIV (the intelligent vehicle's bonnet was visible, see Fig. 1), until a short distance from the lane merging, at which point the IV accelerated past the HIV driver. In the latter (hot) scenario, the escalating competition for road space might be expected to provoke aggressive driving behaviour.

Overtaking

The HIV began positioned 70 metres behind the IV on a dual lane road. In the cool scenario, the IV was programmed to travel at the same speed as the HIV up until 80 km/h, at which point it maintained a constant speed. In the hot scenario, in the event that the HIV driver accelerated to be within 66 metres (safe travelling distance) of the IV, the IV was programmed to brake and decelerate to 60 km/h. If the HIV driver attempted to overtake, then the IV was programmed to continue at the same speed as the HIV, thereby being positioned directly alongside the HIV (the IV's bonnet was visible on the left) so that the participant was unable to move back into the left lane. If the HIV driver attempted to gain on the IV, again there would be competition for road space and an opportunity for further displays of aggressive driving to be evoked (see Fig. 2, Richer & Bergeron, 2012). This scenario again assessed drivers' competition for road space in a slightly different environment from the merging scenario, while similarly distinguishing participants' behaviour resulting from impulsive and aggressive driving decisions.



Figure 1. The screen shot on the left shows the start of the merging lanes scenario at the traffic lights: the instrumentation and instructions are displayed on the screen. The screen shot on the right shows the hot scenario near its end where the IV is winning the race to the merge point.



Figure 2. The screen shot on the left shows the start of the overtaking scenario with instructions. The overtaking scenario in progress is shown on the right. The car ahead is the IV.

Procedure

Participants were familiarised with the driving simulator, the on-screen instructions and instrumentation, and were allowed to practice operating the HIV within the T-junction and following distance scenarios without feedback until they reported feeling comfortable with the

controls. This normally took about five minutes. Participants were then informed that there would be 20 scenarios, each lasting for approximately 30-45 seconds, and that a black screen would appear between each scenario, with a break provided after the first ten trials. It was explained that participants would be required to operate the HIV from a stationary position each time and as far as possible to “drive” as they normally would in an actual vehicle. Each of the ten scenarios (five scenarios \times “hot” and “cool” conditions) was repeated and presented in a unique randomised trial order for each participant so as to eliminate order effects. Each simulator session lasted about 55 minutes.

All participants were tested blind by the second author. At the end of the testing session, they completed Deffenbacher’s et al.’s (2002) 49-item Driving Anger Expression Inventory (DAX). Cronbach’s α for total aggressive expression (verbal, physical, & vehicular) has been reported as .90 (Deffenbacher et al., 2002). The DAX was included as a self-report measure to assess driving anger just within the simulated driving behaviour.

Results

Data from the initial participant screen ($N = 278$) yielded a positive correlation between Impulsivity and Driving Anger ($r = .28, p < .001$). There were no significant differences between males and females on either Impulsivity or Driving Anger.

HIV dynamic measures obtained via the OKTAL SCANeR™ studio 2.1 software used for each scenario are outlined in Table 1 (cf. Yan et al., 2008). The dependent variables (DVs) were difference scores [(Hot 1 + Hot 2) – (Cool 1 + Cool 2)] computed for each of these measures. Using difference scores meant that each participant acted as their own control. Driving behaviour at baseline (cool scenarios) could then be compared with that in provocative traffic/environmental conditions (hot scenarios). A few participants were not included in the analyses due to their data being univariate outliers, and/or reporting motion sickness, headache, or lack of vigilance during testing.

Correlations were calculated for each scenario to test relationships among vehicle dynamic difference measures and personality factors. For the Amber Traffic Light scenario, Impulsivity was negatively correlated with Acceleration@Amber Light ($r = -.33, p < .05$), and for the Overtaking scenario, the DAS correlated with Lane Position SD. All correlations between the DAS and DAX, and Impulsivity and DAX were significantly positive, indicating that participants’ expressed driving anger feelings in the simulated environment, as assessed by the DAX (i.e., state anger measure), were similar to dispositional driving anger and impulsivity, as assessed by the DAS and I_7 .

Three-way between-groups MANOVAs were performed on DVs in each scenario to investigate the effects of Impulsivity, Driving Anger, and Gender differences on driving behaviour. Age was included as a covariate. The Overtaking scenario yielded significant results on the combined DVs to reveal main effects of Gender, $F(4, 28) = 5.41, p = .002, \eta^2_p = .44$, and Impulsivity, $F(4, 28) = 2.97, p = .037, \eta^2_p = .30$, and a 3-way Impulsivity \times Anger \times Gender interaction, $F(4, 28) = 5.40, p = .002; \eta^2_p = .44$. In further analysis of each DV in the same scenario, the Impulsivity \times Anger \times Gender interaction was significant for acceleration noise, $F(1, 31) = 12.15, p = .001, \eta^2_p = .28$, and for maximum speed, $F(1, 31) = 20.82, p < .001, \eta^2_p = .40$. Males who were high on Impulsivity and low on Driving Anger demonstrated greater differences than any other group between hot and cool scenarios for both variables. In contrast, males who were high on Impulsivity and high on Driving Anger demonstrated the lowest differences in acceleration noise, with a similar pattern being obtained for maximum speed. Females who were low on Impulsivity and high on Driving Anger demonstrated the lowest differences in maximum speed between hot and cool trials (see Figs. 3 & 4).

The main effect of Gender was significant for acceleration noise, $F(1, 31) = 9.98, p = .004, \eta^2_p = .24$; compared with females, males demonstrated greater differences in acceleration noise between hot and cool scenarios. There was a main effect of Driving Anger for maximum speed, $F(1, 31) =$

7.33, $p = .011$, $\eta^2_p = .19$; participants with a higher predisposition for Driving Anger demonstrated smaller differences in maximum speed compared with those low on Driving Anger.

Table 1: Dependent Variables for each Scenario¹

| T-Junction Gap Acceptance Scenario | |
|--|---|
| Acceleration Noise | Fluctuation in acceleration whilst undertaking the manoeuvre |
| Maximum Speed | Maximum speed of HIV driver whilst making the manoeuvre |
| Following Distance Scenario | |
| Acceleration Noise | As above |
| Maximum Speed | As above |
| SD Lane Position | Amount of movement back-and-forth across the lane; greater movement may be indicative of frustration at a slow lead vehicle |
| Time to Collision | Relative stopping distance between HIV and IV, where smaller values may be indicative of frustration at a slow lead vehicle |
| Rate Deceleration @ 80 km/h | Responsiveness of HIV driver to reduced rate of acceleration of IV ahead once it reached 80 km/h |
| Amber/Red Traffic Lights Scenario | |
| Acceleration Noise | As above |
| Maximum Speed | As above |
| Acceleration @ Amber Light | Difference in rate of acceleration in the moments preceding, and the moments following, appearance of the amber light |
| Merging Following Traffic Lights Scenario | |
| Acceleration Noise | As above |
| Maximum Speed | As above |
| Acceleration @ LANEX | HIV driver's rate of acceleration at the point at which they merge from the left lane into the right lane |
| Overtaking Scenario | |
| Acceleration Noise | As above |
| Maximum Speed | As above |
| SD Lane Position | As above |
| Time to Collision | As above |
| Attempted to overtake² | Whether HIV merged into right lane in an attempt to overtake the IV ahead in the left lane |

¹All DVs were calculated as difference scores between hot and cool trials.

²Dichotomous variable, which was not included in MANOVAs.

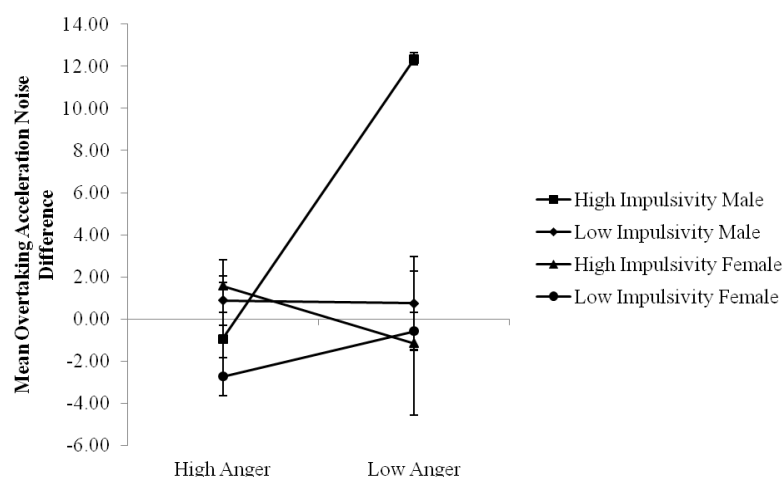


Figure 3. Overtaking scenario. Mean Acceleration Noise difference scores by Gender, Impulsivity, and Anger. Error bars are ± 1 SEM on this and all subsequent graphs.

There was a main effect of Impulsivity for acceleration noise, $F(1, 31) = 6.94, p = .013, \eta^2_p = .18$, such that those with a greater predisposition for Impulsivity demonstrated greater differences in acceleration noise than did those low on Impulsivity. In the other scenarios, only the Merging Following Traffic Lights scenario produced significant results for individual DVs. There was a significant interaction between Driving Anger and Gender for maximum speed, $F(1, 31) = 7.41, p = .011, \eta^2_p = .19$; such that males who were low on Driving Anger demonstrated greater differences in maximum speed between hot and cool trials, while females who were low on Driving Anger demonstrated negative differences (see Fig. 5). Interestingly, both males and females who were high on Driving Anger demonstrated minimal differences in maximum speed. For females, in the Following Distance scenario, Gender was significant on time to collision difference, $F(1, 31) = 6.71, p = .014, \eta^2_p = .18$, such that males exhibited negative differences in time to collision between hot and cool scenarios.

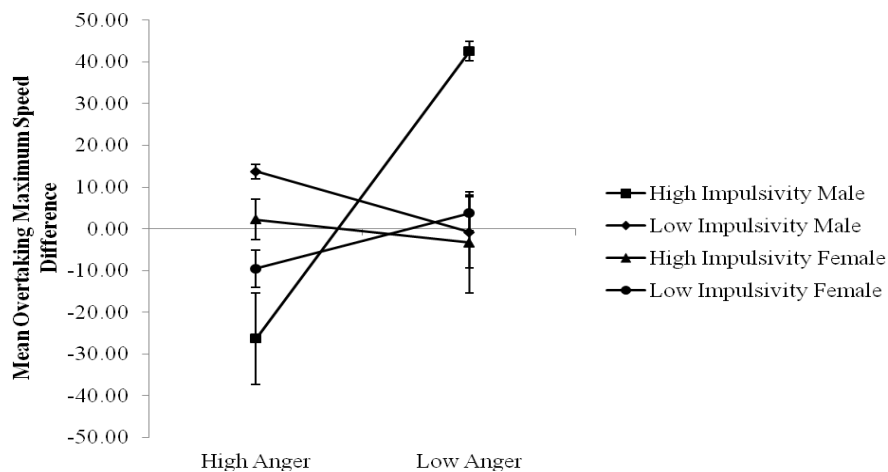


Figure 4. Overtaking scenario. Mean Maximum Speed difference scores by Gender, Impulsivity, and Anger.

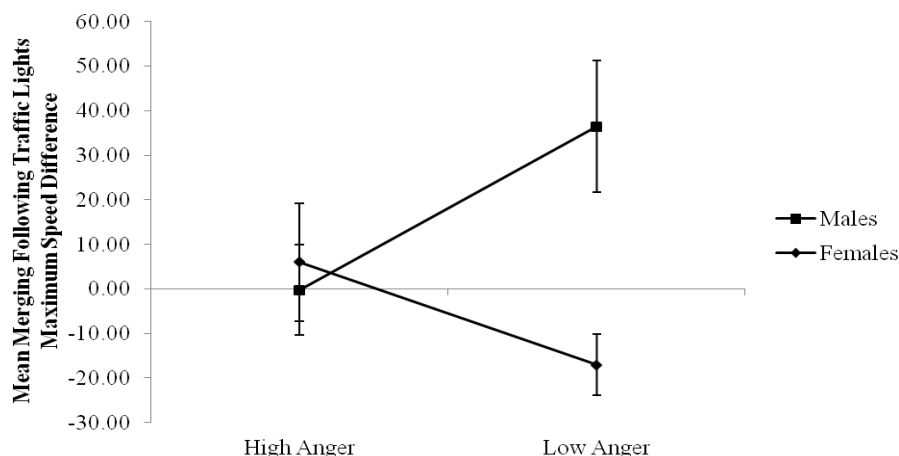


Figure 5. Merging Following Traffic Lights scenario. Mean Maximum Speed Difference scores by Gender and Anger.

Discussion

The significant effect for Impulsivity on overtaking manoeuvres indicated that with greater emotional regulation, young drivers exercised greater caution towards provocative behaviour of the IV in this scenario. On the other hand, driving anger did not have such a clear effect on risky

driving, with males and females exhibiting different patterns of behaviour as a product of Impulsivity and Driving Anger. Overall, males showed significantly greater mean difference values than did females, which suggested that male participants were particularly susceptible to provocation by the behaviour of other drivers. In particular, the hypothesis that males demonstrated significantly riskier driving behaviour than females did was supported by significant main effects of Gender for both the overtaking MANOVAs and the between-subjects effect for overtaking acceleration noise. The fact that females' mean difference values were close to zero, or even negative, suggested that they were more consistent in their driving behaviour, and might be expected to exercise greater caution or even submission in provocative on-road situations.

While the driving simulator enabled a high degree of control over the scenarios and highly accurate measures of participants' driving behaviours across identically programmed scenarios, an inevitable limitation was that the ecological validity of this methodology was not assessed in this study. However, Wang et al. (2010) found that visual attention and task measures mapped very closely between simulated and naturalistic driving environments. Nevertheless, because a driving simulator study practically involves zero risk to participants, it remains the case that interpretation of findings from this study is premised on the assumption that driving behaviour exhibited in a driving simulator is a reliable indicator of on-road driving behaviour.

Two of the scenarios developed in the current study suggested that this novel methodology of comparing matched hot and cool scenarios could yield important results, especially for males. Road safety implications of the findings might include: devising vehicle-activated roadside signage messages that target impulsivity and anger issues at locations shown by the study to be critical (e.g., where merging traffic occurs, and where overtaking presents a particular hazard). Such an intervention has been initiated as a pilot, and evaluated by the Queensland Department of Transport and Main Roads (Queensland Government, 2012). Peer influence on adolescent risk taking is well established (Albert, Chein, & Steinberg, 2013), and there is evidence that peer passengers can impact young drivers' behaviours, including speed choice and following distance in both simulated (Lenné, Liu, Salmon, Holden, & Moss, 2011), and naturalistic driving (Hutton, Sibley, Harper, & Hunt, 2002). For both young drivers and their passengers these issues might be addressed using media (e.g., TV) vignettes that capture the essence of the current findings (e.g., a young male driver about to behave impulsively when seeking to overtake where it is unsafe to do so, and being advised by a passenger mate to be patient). In a literature review of novice driver training methods, although Beanland, Goode, Salmon, and Lenné (2013) determined that effects of simulator training on road safety remained inconclusive, these authors identified simulator training as having some impact on driving skills. Thus, Following Paaver et al. (2013), brief simulator-based interventions as part of a driver education program, taking into account personal psychological risk factors, which differ between males and females, may have a role driver training.

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