Effect of mobile phone use and aggression on speed selection by young drivers: a driving simulator study

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Abstract

Aggressive driving has been associated with engagement in other risky driving behaviours, such as speeding; while drivers using their mobile phones have an increased crash risk, despite the tendency to reduce their speed. Research has amassed separately for mobile phone use and aggressive driving among younger drivers, however little is known about the extent to which these behaviours may function independently and in combination to influence speed selection behaviour. The main aim of the current study was to investigate the effect of driver aggression (measured by the Driving Anger Expression Inventory) and mobile phone use on speed selection by young drivers. The CARRS-Q advanced driving simulator was used to test the speed selection of drivers aged 18 to 26 years (N = 32) in a suburban (60kph zone) driving context. A 2 (level of driving anger expression: low, high) X 3 (mobile phone use condition: baseline, hands-free, hand-held) mixed factorial ANOVA was conducted with speed selection as the dependent variable. Results revealed a significant main effect for mobile phone use condition such that speed selection was lowest for the hand-held condition and highest for the baseline condition. Speed selection, however, was not significantly different across the levels of driving anger expression; nor was there a significant interaction effect between the mobile phone use and driving anger expression. As young drivers are over-represented in road crash statistics, future research should further investigate the combined impact of driver aggression and mobile phone use on speed selection.

Introduction

Mobile phone use while driving

Mobile phone use while driving is a risky behaviour as attention is diverted away from the road and the primary task of driving. While it is broadly acknowledged that crash risk is increased from mobile phone use while driving, quantifying the exact increase in risk has proven challenging, mainly due to methodological limitations within studies (e.g., unreliable data collection methods) [15]. Recent publications, however, examining previous studies and accounting for their limitations, have suggested the increase in crash risk may be between one and threefold [15, 33]. Despite this increased risk, 98% of young Australians aged 15 to 24 years have a mobile phone, and 69% report using it while driving [25].

Multiple Resource Theory [31] purports that humans have several different pools of resources (e.g., input, output and processing modalities) that are finite and can be accessed simultaneously. When a secondary activity requires resources from the same pool as the primary activity, depending on the level of task complexity, they will compete for these resources and subsequent performance decrements can arise [31]. As driving is a high demand task, when the distracting activity is of a similarly high demand and uses the same resources as driving, performance is likely to be compromised and subsequent crash risk is increased [19]. For these reasons, mobile phone use while driving is a risky behaviour as it requires the same resources that are also necessary for safe driving (e.g., cognitive and physical resources).

Studies (including simulator studies) have consistently found that drivers on their mobile phones tend to reduce their speed [15, 16, 32]. Consistent with Multiple Resource Theory, this reduction in speed may occur in order to compensate for one's divided attention and increased mental workload; thereby maintaining a constant level of risk perception [21, 29].

The relative degree of distraction incurred by mobile phones in hand-held and hands-free modes has also been of interest to researchers. Many countries legislate against the use of mobile phones while driving; however this legislation often only concerns phones in the hand-held mode (e.g., Australia, France) [29]. Despite some studies finding no difference in interference to the driving task between hand-held and hands-free modes, many studies have found the tendency for the hand-held mode to interfere more [30]. Specifically, studies have shown that drivers tend to slow down more while talking on a mobile phone in hand-held mode compared to a hands-free mode; possibly because talking on a mobile phone in hand-held mode involves physical as well as cognitive distraction, whereas the hands-free mode involves only cognitive distraction [29, 30].

Aggressive driving

Aggressive driving can generally be defined as a behaviour that is intended to have a negative impact (either psychological or physical) on another driver, for example, tail-gating, horn-honking, and obscene gestures [20]. The prevalence of aggressive driving was highlighted in a recent Australian survey of 3,740 drivers aged 18 years and over. Half of the participants admitted to yelling or swearing at another motorist, 38% admitted to giving an obscene gesture, and 18% admitted to tailgating [1].

Deffenbacher, Oetting, and Lynch [10] developed the Driving Anger Scale (DAS) to measure trait driving anger. However, it was later acknowledged that, despite feeling the same level of aggression, drivers may express their aggression quite differently thereby having a differential impact on crash risk. For example, a driver who mumbles something to themself is unlikely to negatively affect other road-users. However, a driver who tries to run another car off the road places themselves, their passengers, and the other car occupants at a much higher crash risk [8]. To encompass and acknowledge these differential risk factors, the Driving Anger Expression Inventory [9] was developed. (See materials section for a more detailed description and example items from the DAX). This inventory measures driving anger expression, defined as a situation-specific (i.e., driving) form of trait anger [10]. The DAS and the DAX are positively correlated in that drivers who score high on the DAS are also likely to score high on the DAX. That is, those with high driving anger also have a high level of driving anger expression and engage in more aggressive driving behaviours [7, 11].

Aggressive driving is commonly associated with other risky driving behaviours, such as speeding, erratic driving, and failure to obey traffic signs [3]. In a review of the published scientific literature, the AAA Foundation for Traffic Safety attempted to quantify the contribution of aggressive driver actions to fatal crashes and reported that 56% of fatal crashes in the United States from 2003 to 2007 involved at least one driver action that is typically associated with driver aggression. The most common action, reported in one third of these fatalities, was speeding [3]. In addition, simulator studies have found that those with high driving anger, as measured by the DAS [10] tend to select higher speeds for driving situations, such as speed departing from an open gate, and driving faster and more erratically on open road simulations [7, 27].

Young drivers

Young drivers aged 17 to 25 years old are represented in over 20% of deaths in road crash fatalities in Australia [12] yet constitute only 12.4% of the population [4]. Despite this over-representation in road crash statistics, younger drivers aged 18 to 24 years are more likely to use a mobile phone while driving [2]. As they are more likely to use their mobile phones and they lack driving experience, young drivers represent a particularly vulnerable group as their attentional resources are more heavily compromised and their resulting crash risk is increased. Indeed, Neyens and Boyle [23] analysed data on teenaged drivers from the US National crash database and found that teenaged drivers and their passengers were most likely to be severely injured when distracted by a mobile phone. Haque, Washington, Ohlhauser, and Boyle's simulator study [17] found the risk of yellow-light running while using a mobile phone was greatest for drivers aged 16 to 25 years. Additionally, a recent simulator study investigating reaction times of young drivers found 50% longer reaction times to detect an event that originated in the driver's peripheral vision, such as a pedestrian entering a zebra crossing, when using a mobile phone compared to when they were not [16].

In addition to young drivers' risky use of mobile phones, research typically shows younger drivers are often involved in aggressive driving incidents or self-reported aggressive driving behaviours which may also contribute to their over representation in the road crash statistics [20, 24]. A recent Australian survey found that 31% of young drivers aged 18 to 24 years admitted to tailgating other vehicles, representing the group most likely to engage in this behaviour. In addition, 50% admitted to having yelled or sworn at another driver, and 43% have gestured rudely at another driver [2]. Similar to their older counterparts, aggressive young drivers are more likely to engage in risky behaviours such as speeding than non-aggressive young drivers [12]. However younger drivers may be at even greater risk when they speed as they lack driving experience and do not always correctly evaluate a given situation [12].

The current study

As aggressive driving is commonly associated with engagement in other risky driving behaviours such as speeding [3], it is possible that aggressive drivers are more likely to engage in mobile phone use as it, too, represents a risky driving behaviour. Indeed, Chen [6] carried out a survey study and found that aggressive drivers were more likely than non-aggressive drivers to use their mobile phone while driving. Despite this result, little is known about the extent to which aggressive driving and mobile phone use may function independently and in combination to influence speed selection behaviour. Although not specifically targeting young drivers, a study that has investigated the combined effect of aggression and mobile phone use in on-road driving performance found that, when approaching traffic signals at intersections, the aggressive drivers tended to drive faster than non-aggressive drivers regardless of whether they were using a mobile phone or not [21].

In order to address this gap in the literature, the current simulator study explored the impact of driving anger expression (categorised as low and high, measured by the Total Aggressive Expressive Index from the DAX [9]) and mobile phone use condition (baseline, hands-free, and hand-held) on speed selection by young drivers aged 18 to 26 years. The overarching, exploratory aim of the current study, therefore, was to investigate whether average speed selection for each of the mobile phone conditions was different for young drivers scoring low or high in driving anger expression. The current study also investigated mean deviation from the speed limit as a dependent variable; a closely related concept to speed selection. The specific hypotheses were as follows:

H1: It was predicted that speed selection for each of the mobile phone conditions will be different for drivers with low and high driving anger expression. That is, there will be a significant interaction effect.

H2: In support of previous literature[12], it was hypothesised that young drivers high in driving anger expression would drive at a higher speed across each of the mobile phone conditions than young drivers low in driving anger expression. That is, there will be a significant main effect for driving anger expression.

H3: In support of previous literature [29, 30], it was predicted that all drivers would have the highest speed selection for the baseline condition (where no additional attentional resources are required) and select the lowest speed for the hand-held mode (where additional physical and cognitive resources are required). That is, there will be a significant main effect for mobile phone use condition.

Methodology

Participants

Participants (N = 32, 16 males, 16 females) were recruited by flyers distributed through university student email addresses, university Facebook portals, and by posting in a few university locations (e.g., library, refectory). All participants were aged between 18 and 26 years (M = 21.5, SD = 2.0); held either a provisional (n = 11) or open (n = 21) Queensland driver's licence; did not have a history of motion sickness; and were not pregnant. The average driving experience was 4.20 (SD = 1.89) years. Current amount of driving and mobile phone usage while driving are reported in Table 1.

Driving Simulator

The CARRS-Q Advanced Driving Simulator located at the Queensland University of Technology (QUT) was used for this study. This high fidelity simulator consists of a complete car with working controls and instruments surrounded by three front-view projectors providing 180-degree high resolution field view to drivers. LCD monitors replaced the car's wing mirrors and rear view mirror to simulate rear view mirror images. Road images and interactive traffic were continuously updated on front-view projectors, wing mirrors and the rear view mirror at 60 Hz to provide a photorealistic virtual environment. The car used in this experiment was a complete Holden Commodore vehicle with an automatic transmission. Driving performances data such as position, speed, acceleration and braking were recorded at rates up to 20 Hz.

The simulator driving route for the current study was approximately 7km long and included a detailed simulation of a suburban route of approximately 5km with various 'normal' traffic events such as following lead cars, free flow with no other cars in sight and free flow along curve with opposing traffic. The speed limit for the selected segments in this study was 60 kph. Three route starting points were designed to reduce learning effects and allow driving under the three different phone conditions. All three routes had the same geometry and road layout but the locations of traffic events were randomised across the routes. The driving conditions were counterbalanced across participants to control for carry-over effects. Participants were instructed to drive as they normally would, to obey the posted speed limits, and to follow the directional signs towards the airport, that is, participants had a navigational task.

Procedure

After ethics approval was received and informed consent was obtained, participants completed a self-report questionnaire that included driver demographics, driving history, general mobile phone usage history, usage of mobile phones while driving, and driver behaviour related to aggressiveness (i.e., the DAX [9]). For experimental drives in the hands-free and hand-held phone conditions, the experimenter called the participant before the start of the drive and there was a single continuous call until the end of the drive. The participants talked through a Bluetooth headset in the hands-free condition, and were required to hold the phone to their ear for the duration of

Table 1. Reported distance driven and frequency and type of mobile phone use while driving

	km	% of participants
Distance driven in a typical year	< 10,000	44
	10,000 – 20,000	47
	> 20,000	9
Frequency of mobile phone use (including talking and texting) while driving	At least once per day	34
	1 – 2 times per week	47
	1 – 2 times per month	19
Type of mobile phone used while driving	Hands-free	22
	Hand-held	78

the conversation in the hand-held condition. The phone conversation dialogues used in both phone conditions was cognitive in nature and modified from Burns, Parkes, Burton, Smith, and Burkes' 2002 study on the impact of mobile phone use while driving [5]. The dialogues required the participant to provide an appropriate response after hearing a complete question (e.g., 'Jack left a dinner in his microwave for Jim to heat up when he returned home. Who was the dinner for?'), solve a verbal puzzle (e.g., 'Felix is darker than Alex. Who is lighter of the two?'), or solve a simple arithmetic problem (e.g., 'If three wine bottles cost 93 dollars, what is the cost of one wine bottle?'). These types of questions required simultaneous storage and processing of information, and thus distracted drivers by increasing their cognitive load.

When a participant reached the route starting point, after a closed loop drive the scenario automatically ended. Participants took brief breaks while remaining in the vehicle between each experimental drive while the scenarios were loaded onto the simulator display system. All data not collected in the simulator were self-report. Participants were reimbursed for their time upon completion of the study.

Measures

Driving Anger Expression Inventory (DAX)

The DAX [9] is a validated measure [18, 26] of how drivers express their anger in the driving context. The DAX breaks down into two general dimensions, a 34-item hostile/aggressive expression dimension (comprising three subscales) and a 15 item adaptive/constructive expression dimension (comprising one subscale). Items in each scale are rated on a 4-point likert scale (1 = *almost never*, 4 = *almost always*). The hostile/aggressive expression dimension correlates positively with measures of driving-related anger, aggression, and risky behaviour [9, 7]. The three subscales comprising this dimension are:

1. Verbal Aggressive Expression (12 items) assesses verbal means of anger expression (e.g., "I make negative comments about the other driver") and formed a reliable subscale in the current study (Cronbach's α = .88);

2. Physical Aggressive Expression (11 items) assesses the physical forms of expressing anger (e.g., "I try to get out of the car and tell the other driver off"). The reliability of the subscale in the current study was Cronbach's α = .57;

3. Use the Vehicle to Express Anger (11 items) assesses the way drivers use their vehicles to express anger (e.g., "I try to cut in front of the other driver") and formed a reliable subscale in the current study (Cronbach's α = .89).

When added together, these three subscales form the Total Aggressive Expression Index. This Index formed a reliable scale in the current study (Cronbach's α = .89). For the purpose of this study, and consistent with the previously acknowledged definition of driver aggression as causing another driver harm, the fourth subscale measuring Adaptive/Constructive Aggression (e.g., "I try to think of positive solutions to deal with the situation") was not included in the analysis.

Note that while it is acknowledged that the reliability of the Physical Aggressive Expression subscale is low, it was retained to maintain the factor structure of the Total Aggressive Expression Index in the DAX. In addition, with the relatively small sample size (N = 32) it was beyond the scope of the present study to carry out a factor analysis.

Results

A 2 X 3 mixed factorial ANOVA was conducted to assess the impact of level of driving anger expression (low, high) and mobile phone use condition (baseline, hands-free, hand-held) for both speed selection and deviation from the speed limit. For the purpose of the current study, participants were divided into low and high levels of driving anger expression determined by a median split on the Total Aggressive Expressive Index to generate a dichotomous categorical variable. Young drivers were categorised as having a high level of driving anger expression if they scored over 56 (n = 16) and a low level of driving anger expression if they scored below 56 (n = 16).

Results showed that, for mean speed selection as the dependent variable, there was no significant interaction between level of driving anger expression and mobile phone use condition, Wilks' Lambda = .92, $F(2,29)$ = 1.27, p = .30, η^2 = .08. This result indicated that the speed selected in each phone use condition did not differ between drivers with low and high levels of anger expression. There was, however, a significant main effect for mobile phone use condition, Wilks' Lambda = .47, F (2, 29) = 16.65, p < .001, η^2= .54. Inspection of the mean speed selections showed that young drivers with both low and high levels of anger expression used the highest average speed for the baseline condition and the lowest for the hand-held condition (see Table 2). The main effect for level of driving anger expression was not significant, F (1, 30) = .43, p = .52, η^2= .01, indicating that there were no significant differences between speed selection for drivers with low and high levels of anger expression.

For mean deviation from the speed limit as the dependent variable, results showed a similar pattern to speed selection. Deviation from the speed limit was calculated as 60kmph minus average speed selected for each phone use condition for low and high driving anger expression. There was no significant interaction between level of driving anger expression and mobile phone condition, Wilks' Lambda = .92, $F(2, 29)$ = 1.34, p= .30, η^2= .08 indicating that the deviation from the speed limit in each phone use condition did not differ between drivers with low and high levels of anger expression. There was a significant main effect for mobile phone use condition, however, Wilks' Lambda = .45, F (2, 29) = 17.84, p < .001, η^2= .55. Inspection of the mean deviations from the speed limit indicated that young drivers with both low and high levels of anger expression

Table 2. Mean speed selection and mean deviation from speed limit for low aggression drivers for each of the mobile phone conditions

Mobile phone use condition	Level of driving anger expression	Mean speed selection (kmph) (SD)	Mean deviation from speed limit (kmph) (SD)
Baseline	Low	56.39 (3.04)	3.61 (3.04)
	High	56.83 (1.79)	3.17 (1.79)
	High and low	56.61(2.46)	3.40 (2.46)
Hands-free	Low	54.34 (3.99)	5.50 (3.44)
	High	53.38 (3.88)	6.36 (3.74)
	High and low	53.86 (3.90)	5.90 (3.56)
Hand-held	Low	53.98 (4.70)	6.03 (4.69)
	High	52.44 (3.78)	7.56 (3.78)
	High and low	53.21 (4.27)	6.80 (4.26)

Note: The higher the score on mean deviation from the speed limit indicates a lower speed selection.

had the greatest deviation from the mean in the hand-held condition and the lowest deviation for the baseline condition (see Table 2). The main effect for level of driving anger expression was not significant, $F(1, 30) = .40$, $p = .53$, $\eta^2 = .01$, indicating that there were no significant differences between mean deviation from speed limit for drivers with low and high levels of anger expression.

Discussion

The main aim of this study was to provide an initial investigation into whether mean speed selection for each of the mobile phone conditions (i.e., baseline, hands-free, and hand-held) was different for drivers with low and high anger expression. Our exploratory hypothesis was not supported as no significant interaction effect was found for this combination of factors. This suggests that the combined effect of level of driving anger expression and mobile phone use condition does not result in significantly different speed selections.

A significant difference was found, however, for mean speed selection for mobile phone use condition such that drivers, regardless of their level of driving anger expression, selected the highest speed for the baseline condition and the lowest speed for the hand-held condition. This result was predicted and supports previous studies in which drivers reduced their speed more when using a mobile phone in hand-held mode than in hands-free mode[29, 30]. While the use of both hand-held and hands-free modes presents a cognitive distraction, the hand-held mode is riskier as it also presents a physical distraction. Drivers may reduce their speed in order to maintain a constant level of risk perception and attempt to compensate for divided attention and increased mental workload [21, 29, 30]. Despite being illegal in Australia, in the current study, 78% of the young drivers reported typically using a hand-held (rather than hands-free) mobile phone while driving. This finding represents a challenge for law enforcement and public education. While selecting a lower speed may decrease crash risk [15], the public could be made aware that attention being diverted from the primary task of driving probably outweighs the small reduction in risk that results from selecting a lower speed.

The current study found no significant difference for speed selection between levels of driving anger expression, regardless of phone use condition. This finding does not support our hypothesis or previous literature, the latter of which has shown that high aggressive young drivers select higher speeds than low aggressive young drivers [12]. It is possible, however, that as young driver aggression may increase speed selection and mobile phone use while driving typically results in reduced speed selection [29, 30], in the current study, they may have functioned to cancel each other out and the net effect was negligible. Indeed, a recent review of simulator studies showed that the increase in reaction time combined with the reduction in speed selection (two behaviours often associated with mobile phone use while driving) sometimes had the effect of cancelling each other out, so the overall impact on crash risk appeared quite minor [15]. As mean speed selection and mean deviation from the speed limit are closely related measures, the discussion can also refer to mean deviation from the speed limit.

The main strength of the current study is that it is, to our knowledge, the first to investigate the combined influence of mobile phone use and level of driving anger expression on speed selection among a sample of young drivers. However there are also limitations. While it is acknowledged that the internal reliability of the Physical Aggressive Expression subscale was low (Cronbach's $\alpha = .57$), it was retained in order to maintain the factor structure of the Total Aggressive Expression Index in the DAX. The study's sample size was relatively small ($N = 32$) and comprised university students who may not be representative of the population of young drivers. Future studies should continue to investigate this combination of variables and address these limitations by recruiting a larger sample size from the broader community of young drivers.

Conclusion

Driver aggression and mobile phone use are both prevalent and risky behaviours among young drivers, who are already over-represented in road crash statistics. The current simulator study investigated the impact of level of driving anger expression and mobile phone use condition on speed selection by young drivers aged 18 to 26 years. While no significant interaction effect was found between these two variables, results showed that mobile phone use (regardless of level of driving anger expression) had a significant effect on speed selection among the young drivers in the current study. Future studies should further investigate this risky combination of variables and their impact on young driver behaviour and subsequent crash risk.

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Contributed Articles

Australia's Naturalistic Driving Study

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The Australian Naturalist Driving Study (ANDS) is being carried out by a Transport and Road Safety (TARS) team led by Professors Raphael Grzebieta and Ann Williamson. Drivers will be observed within and around their vehicles using the so-called Naturalistic Driving Study research method. The ANDS team will be instrumenting around 400 cars in Sydney and Melbourne to continuously record data from within and outside the vehicles on driver and road user behaviour, in normal and safety-critical situations. They will then analyse this data to develop new and novel countermeasures for reducing road deaths and serious injuries on Australian roads. This is the first study of this magnitude and sophistication being carried out in Australia.

Researchers

The team comprises researches from a number of areas including: co-Chief Investigators Associate Professor Teresa Senserrick from TARS; Professors Narelle Haworth and Andry Rakatonirainy from CARRSQ in Brisbane; and Professor Stevenson, Associate Professor Judith Charlton and Doctor Kristie Young from MUARC in Melbourne; and Doctor Jeremy Woolley from CASR in Adelaide.

After successfully securing around $3 million funding from the Australian Research Council and Partner Organisations, an Integrated Facility is being built and an extensive research project has been planned to carry out this ground breaking research to observe Australian drivers in New South Wales and Victoria. The Partner Investigators joining the team are Ben Barnes and John Wall from the New South Wales Centre for Road Safety (Transport for New South Wales); Samantha Cockfield from the Transport Accident Commission in Victoria; Antonietta Cavallo and David Healy from VicRoads; and Jack Haley from NRMA Limited in New South Wales. Other Partner Organisations and people involved are Iain Cameron from the Office of Road Safety from Main Roads Western Australia and Ben Tufnell from the Motor Accidents Commission of SA.
The ANDS team will be partnering with the Virginia Tech Transportation Institute in the USA who will be assisting with the installation of the vehicle instrumentation and data capture.