Title:

Drinking, Texting, Eating: The influence of everyday distractions on simulated driving performance

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ABSTRACT

Objective: Driving is a complex task and distractions such as using a mobile phone for the purpose of text messaging is known to significantly impact on driving performance. Eating is a common form of distraction that has received less attention in relation to impact on driving performance. The aim of this study was to further explore and compare the effects of a variety of distraction tasks (i.e. text messaging, eating, drinking) on simulated driving performance.

Methods: Twenty-eight healthy participants (13 female) took part in a cross-over design study involving 3 experimental trials (separated by ≥ 24 hrs). In each trial, participants completed a baseline driving task (no distraction) before completing a second driving task involving one of three different distraction tasks (drinking 400ml water, drinking 400ml water and eating a 6-inch Subway® sandwich, drinking 400ml water and composing three text messages). Primary outcome measures of driving consisted of standard deviation of lateral position (SDLP) and reaction time to auditory and visual critical events. Subjective ratings of difficulty in performing the driving tasks were also collected at the end of the study to determine perceptions of distraction difficulty on driving.

Results: Driving tasks involving texting and eating were associated with significant impairment in driving performance measures for SDLP compared to baseline driving (46.0 ± 0.08 vs. 41.3 ± 0.06 cm and 44.8 ± 0.10 vs. 41.6 ± 0.07 cm respectively) and auditory reaction time compared to baseline driving (922 ± 95 vs. 889 ± 104 ms and 933 ± 101 vs. 901 ± 103 ms). No difference in SDLP (42.7 ± 0.08 vs. 42.5 ± 0.07 cm) or auditory reaction time (891 ± 98 and 885 ± 89 ms) was observed in the drive involving the drink only condition compared to the corresponding baseline drive. No difference in reaction time to visual stimuli was observed between baseline and experimental drives for any of the trial conditions. Participants' subjective ratings indicated that they perceived the texting whilst driving condition to be the most difficult despite similar magnitudes of impairment observed with the eating whilst driving condition.

Conclusions: Eating and text messaging whilst driving appear to provide a significant distraction that negatively impacts on driving performance measures of lane position control and reaction time.

These findings may have direct implications for motorists that engage in these types of distracting behaviours behind the wheel and for the safety of other road users. Greater awareness of the impact eating has on driving performance and safety is required.

Key Words: *Text messaging; Mobile phone; Eating; Distraction; Driving performance*

INTRODUCTION

Driving a motor vehicle is one of the most complex tasks performed by many individuals on a daily basis. Behind the wheel, drivers constantly receive visual, tactile and auditory information from the road and vehicle; analyse this information and react according to traffic conditions, driving regulations, capabilities and previous experience (Jackson et al. 2013). Diverting attention away from driving to other activities (i.e. using a mobile phone, eating, drinking) can lead to errors that are potentially catastrophic. According to both international and domestic (Australia) data, driver distraction is estimated to account for at least one quarter of all car crashes (Klauer et al. 2006; McEvoy et al. 2006) and contributes to a large number of accident-related serious injuries and casualties (Beanland et al. 2013).

Driving distraction occurs when the attention demand by the roadway is greater than the attention devoted to it (Lee et al. 2008). Over time, drivers may dismiss the complexity of operating a motor vehicle, and engage in alternate activities whilst behind the wheel. In fact, large proportions of drivers admit to engaging in distracting activities such as talking with passengers, using a mobile phone, eating or drinking, smoking and reading maps (Stutts et al. 2005; Stutts et al. 2001) with this behaviour becoming a growing public safety hazard (Wilson and Stimpson 2010). The increasing prevalence of distracted driving may, in part, be explained by the popularity of convenience products such as drive-thru fast food outlets, hands-free mobile phones and global positioning system (GPS) guidance devices.

While making and receiving phone calls negatively impacts on driving performance (Caird et al. 2008), sending and receiving text messages causes further decrements in driver performance (Libby and Chaparro 2009). These decrements relate particularly to eye-glance behaviour, lane position deviation, reaction time to visual stimuli and consistency in speed control whilst texting (Libby and Chaparro 2009). Of further concern is that text messaging whilst driving is becoming increasingly common (Wilson and Stimpson 2010), particularly among young drivers (Harrison 2011). Studies investigating the impact of text messaging on driving performance unanimously indicate text messaging to be a distraction which negatively impacts on one's ability to drive safely (Basacik et al.

2011; Burge and Chaparro 2012; Crandall and Chaparro 2012; Drews et al. 2009; Hosking et al. 2009; McKeever et al. 2013; Owens et al. 2011; Yager et al. 2012).

The rapid advancement in mobile phone technology may further contribute to increasing driver distraction. The majority of mobile phones currently manufactured are smart phones, which incorporate touch screen capabilities (e.g. Apple iPhone, Samsung Galaxy). In comparison to former mobile phone technology that does not incorporate touch screen interfaces; using smart phones whilst driving appears to further deteriorate performance due to an increasing need to look at the screen. This may be because of the decreased tactile feedback from the phone (Crandall and Chaparro 2012; Reimer et al. 2012). Thus, the impact of mobile phone-mediated distraction from early research may underestimate the level of distraction commonly experienced by present-day drivers.

Food and beverages are also commonly consumed whilst driving and may be a regular source of distraction (Stutts et al. 2005). While the dangers of eating and drinking whilst driving are not as highly publicised as mobile phone use, some evidence suggests a greater proportion of drivers are involved in traffic accidents as a result of distraction by eating or drinking than by talking on a mobile phone (Stutts et al. 2001). Many food and beverage franchises now incorporate drive-thru facilities, while service stations commonly contain food and beverage options that encourage drivers to eat or drink. Despite reports that upwards of 70% of individuals engage in eating and drinking activities whilst driving (Stutts et al. 2005), its effect on driving performance has only received limited attention (Alosco et al. 2012; Jenness et al. 2002; Young et al. 2008).

In a study examining the impact of eating on driving performance, Jenness et al (2002) determined that consuming a cheeseburger was as distracting as voice-activated dialling and mobile phone conversations whilst driving. However, the applicability of this study to public driving is reduced by the methodology which employed video game technology and a performance task whereby participants were instructed to drive as fast as possible around a simulated track. In a laboratory-based driving simulator study, Young et al (2008) reported a lack of effect of eating/drinking on driving performance variables including speed control, lane position and time to collision with lead vehicles. However, the authors did find that eating and drinking increased the number of crashes during critical incidents, which was attributed to increased physical rather than cognitive demands. Despite these

findings, the specified timing for eating and drinking and the relatively basic meal provided (packet of sweets) again limit the ability to generalise these findings to on-road driving behaviour, which might involve consumption of foods typically purchased from fast-food restaurant drive-thru facilities. More recently, Alosco et al (2012) indicated that eating impairs driving performance (increased collisions and centre lane crossings) with equivalent deterioration in performance observed in comparison to texting on a mobile phone. However, participants were allocated to one of three experimental conditions (eating, texting, control) in a between-groups study design. The use of a repeated-measures design would have allowed participants to act as their own control, thus controlling for intra-individual variability in natural driving performance.

The aim of this study was therefore to examine the effects of text messaging, eating and drinking on simulated driving performance in a naturalistic driving scenario using a within-subjects study design and a meal typical of fast-food consumption. It was hypothesised that compared to non-distracted driving, eating and drinking whilst driving would impair simulated driving performance in a comparable magnitude to that of text-messaging.

METHODS

Participants

Twenty-eight (13 female, 15 male) healthy participants (mean age: 28.4 ± 4.6 years, range 25-40 years) volunteered to take part in this study. Volunteers were recruited from the university campus, with eligibility criteria stipulating that they needed to be aged between 18 and 45 y, be familiar with the use of a touch screen mobile phone, hold a current provisional or full Australian driving license and be driving at least weekly. All participants were fully informed of the nature and possible risks of the study before providing written informed consent. The investigation was approved by the Universities Human Research Ethics Committee (PBH/36/12/HREC) and the procedures were conducted in accordance with the principles outlined by the agreement of Helsinki.

Experimental Design

Each participant attended the laboratory on four occasions. The initial visit incorporated obtaining participant informed consent and a familiarisation session with the driving simulator using a scenario similar to those employed in the experimental drives to minimise the impact of possible learning effects. Participants then completed three experimental trials consisting of a baseline drive followed by a drive incorporating three different forms of driving distraction. The distraction treatments involved drinking; drinking and eating; drinking and text messaging. Experimental trials were randomised via an incomplete Latin square design to ensure the order of distraction trials occurred with the same frequency.

Pre-Experimental Procedures

Participants were asked to refrain from using recreational drugs and non-prescriptive medications for the duration of the study, abstain from alcohol for 24 h, caffeine-containing substances for 12 h, and fast from all food and beverages for at least 2 h prior to each experimental trial.

Experimental Procedures

On arrival to the laboratory, compliance to pre-experimental conditions was verbally confirmed before a measure of breath alcohol concentration (Alcolizer LE Breathalyser, Alcolizer Pty Ltd) was taken to ensure no alcohol had been consumed prior to testing. A baseline blood glucose (BGL) measure was then recorded using a finger prick sample (Accucheck Advantage II®, Roche) to confirm that participants would not be completing testing in a hypoglycaemic state. Participants then completed a baseline driving test using the experimental scenario without distraction. Following the baseline drive participants were given a 5 min rest before repeating the scenario with one of the three experimental treatments. The experimental treatments (Figure 1) consisted of drinking 400 ml of water from a bottle throughout the drive and either no further distraction, eating a 6-inch Subway® sandwich, or composing three text messages on a smart phone.

In the drink only trial, participants were instructed to consume the entire contents of the water bottle by the end of the driving task, with no specified rate of drinking allocated. In the drink and texting trial, participants were instructed to consume the entire contents of the water bottle and

compose 3 specified text messages at dedicated time-points. The 3 text messages were equivalent in length (36-37 characters each), with one compiled in the first minute of driving, one in the fourth minute and one in the sixth minute of driving. The phone was situated on the participants lap during the driving task, and participants were required to unlock the phone (simple finger swipe access) prior to composing text messages. In the drink and eat trial, participants were asked to consume the entire contents of a 6-inch subway® sandwich and the 400ml bottle of water during simulated driving. Participants were given the food items at the commencement of the driving simulation test and instructed to fully consume the food at their own pace prior to the completion of the drive. There were no pre-specified times for participants to engage in eating in order to simulate real-world eating behaviour as closely as possible. In all trials involving a distraction task, participants were instructed prior to commencement of the test to drive as they normally would and to simultaneously engage in the tasks but to not allow the tasks to cause unsafe driving (i.e., participants were encouraged to drive as safely as possible). In each of the trials, participants were told when they were approximately half-way through the trial to ensure they were on track for complete consumption of the drink and sandwich. The three trials were completed in a randomised order with each separated by at least 24 hours. At the conclusion of the study, participants completed a subjective questionnaire to determine the task that was perceived to be most distractive to driving and the aspects of driving performance believed to be most affected by each of the distraction tasks.

INSERT FIGURE 1 ABOUT HERE

Driving Simulator

A computerised driving simulation task was used to measure driving performance (SCANeR studio simulation engine – v1.2r95, OKTAL, Paris, France). The driving simulator was a fixed based model with original controls from a Hyundai Getz linked to dedicated graphics computer equipment. Details of the driving simulator have been outlined elsewhere (Irwin et al. 2014). For each driving test, participants were instructed to stay in the centre of the left-hand lane (traditional for Australian motorists) and adhere to all normal road rules and speed signs. A GPS included in the scenarios

provided auditory and visual directions for the participants to follow. Crashes into other vehicles resulted in the program being reset, with the driver placed in the centre of the left lane at the point of the crash and then allowed to resume the driving task. Because simulator sickness is often an issue in driving simulator studies (Brooks et al. 2010), participants were instructed prior to each drive if they experienced any symptoms of sickness whilst driving the simulator, to immediately cease driving and inform the researcher of their condition.

Experimental Driving Scenarios

Participants drove an itinerary defined course of ~10 km, which required approximately 8 min to complete. The driving scenario was set during daylight conditions and consisted of three main sections (Table 1).

INSERT TABLE 1 ABOUT HERE

Other vehicles were present in the scenario, however only two vehicles were set to interact with the participant's vehicle. Within the first minute a parked car was programmed to pull-out from a parked position onto the road way in front of the participant's vehicle. After the first intersection, a bus was programmed to pull-out from a parked area onto the roadway and in front of the participant's vehicle. The car and bus programmed for these manoeuvres was randomly assigned from a group of parked vehicles to avoid participants predicting the event. Throughout each trial, participants engaged in critical events to assess reaction time to auditory and visual stimuli. The critical events were included at random intervals within the scenario and to reduce the predictability of the critical events, four parallel scenarios were used, with the events occurring in different sections of the driving task for each version. In addition, the four parallel versions of the driving test scenario were randomly assigned to the trials for each participant.

The experimental drives were intended to be a reflection of naturalistic driving; with the exception of the reaction time events. As such participants were given minimal instruction on how to drive,

provided with no task priorities, incentives or performance feedback. A visual depiction of the simulated driving scenario experienced from the driver's viewpoint is shown in Figure 2.

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Driving Performance Measures

Two pre-defined primary measures of driving performance (standard deviation of lane position, SDLP; reaction time, RT) were acquired during the experimental drives. Each measure was chosen on the basis that driving performance degradation in response to text messaging has been observed in previous research (Hosking et al. 2009; Libby and Chaparro 2009).

Reaction Time Events

During the experimental drive, participants were required to respond to stimuli on nine occasions in order to test reaction time. On four occasions the stimulus was an auditory sound, which comprised of a voice calling 'Stop!' On five occasions the stimulus was visual which consisted of a stop sign appearing in the right-hand centre screen. For all reaction time events participants were instructed to respond to the presentation of the stimulus by braking as quickly as possible and bringing the simulated vehicle to a complete stop before resuming the driving test.

Statistical Analysis

All statistical procedures were performed using SPSS for Windows, Version 22.0 (SPSS Inc., Chicago, IL). All measures were examined for normality and outliers. Planned comparisons were performed to test our specific hypothesis that driving whilst performing a distracting task (drinking, texting, eating) would induce greater performance decrement compared to baseline (no distraction task) drives. In this case, statistical analysis for each of the main dependent variables on the driving task were conducted using paired samples *t*-tests to compare baseline drives and task specific

distraction drives. Statistical significance was accepted at $p<0.05$. All data are reported as mean±standard deviation.

RESULTS

Participant Driving Behaviours

Twenty-eight participants completed all experimental drives with no reports of simulator sickness noted in any of the trials. Participants had a regular driving history of 8 ± 6 years and drove at least once a week, but were more likely to drive at least once per day. Almost all participants (92.9%, $n=26$) owned and regularly used touch-screen smart phones. In all experimental driving tests participants were able to safely avoid collisions with the programmed vehicles (cars and buses) that pulled-out onto the roadway from a parked position. The absence of any collision events throughout the study precluded statistical analyses for this measure. With regard to typical driving behaviours, 25 participants stated that they had previously sent a text message whilst driving, 26 participants stated that they had previously read a text message whilst driving, 27 participants had previously eaten food whilst driving, and 28 had previously consumed a beverage whilst driving, indicating that the experimental treatments were common forms of driving distraction undertaken by the participant group.

Standard Deviation of Lane Position (SDLP)

The mean SDLP performance for the three experimental conditions are shown in Figure 3. A significant increase in SDLP was observed between baseline and experimental driving tests involving texting (41.3 ± 0.06 vs. 46.0 ± 0.08 cm respectively, $p=0.009$) and eating (41.6 ± 0.07 vs. 44.8 ± 0.10 cm respectively, $p=0.038$) trials. No difference was noted between the baseline and experimental driving test involving the drink only condition (42.7 ± 0.08 vs. 42.5 ± 0.07 cm respectively, $p=0.855$).

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Auditory Reaction Time

Mean reaction time to auditory stimuli critical events for each trial is shown in Figure 4. Reaction time was significantly higher in the trials involving texting (922 ± 95 ms, $p=0.007$) and eating (933 ± 101 ms, $p=0.040$) compared to corresponding baseline drives (889 ± 104 and 901 ± 103 ms respectively). No difference in reaction time was observed between baseline and experimental drives in the drink only condition (891 ± 98 and 885 ± 89 ms respectively, $p=0.584$).

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Visual Reaction Time

Mean reaction time to visual stimuli critical events for each trial is shown in Figure 5. No difference in reaction time was observed between baseline and experimental drives for any of the trial conditions ($p>0.05$).

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Post-Study Subjective Questionnaire

Following the completion of all three experimental trials, 5 participants (17.9%) claimed that the trial involving driving and eating was the most difficult task, whilst the remaining 23 (82.1%) stated that the trial involving texting was the most difficult task. Many of the participants reported that whilst they were completing the trials involving texting or eating, their speed control diminished and lane deviation increased. Nineteen participants (68%) reported difficulty maintaining lane position and 10 participants (36%) reported difficulty with speed control during the trial involving texting. Eleven participants (39%) reported difficulty maintaining lane position and 16 participants (57%) reported difficulty with speed control in the trial involving eating. In total, 13 participants reporting decreased ability to respond appropriately to reaction time events across the three trial conditions (texting $n=6$, eating $n=5$, drink only $n=2$).

DISCUSSION

The current investigation examined the effects of common distractions including text messaging, eating and drinking on simulated driving performance. Results from the current study support our hypothesis that both texting and eating lead to measurable deteriorations in driving performance, particularly relating to driver control and responses to auditory stimuli amongst individuals with some experience in these types of distracting behaviours.

Both texting and eating were associated with similar magnitudes of performance impairment related to vehicle control (SDLP) compared to baseline driving (without distraction). SDLP is regarded as a potential index of driving safety (Verster and Roth 2011) and increases in SDLP could potentially lead to lane crossings into adjacent traffic lanes or the road shoulder that may have severe consequences. The current findings support the previous work of Alosco et al. (2012) who also noted deteriorations in vehicle control for drivers that were texting and eating, indicated by an increase in the number of centre-line crossings and road edge excursions compared to non-distracted (control group) drivers. However, the results extend on the previous work of Alosco et al. (2012) with the use of a repeated-measures design allowing participants to act as their own control, thus controlling for intra-individual variability in driving performance, and is identified as a preferred method to increase statistical power (Dawson 2011). Collectively, these results suggest that individuals undertaking distracting tasks such as eating or texting whilst driving are likely to experience deficits in control of lane position.

Reaction time to auditory stimuli was impaired during trials involving texting and eating in the present study. The ability to react quickly to the changing road environment is paramount when unexpected events occur requiring a rapid response in order to avoid potential collisions. Drivers are subjected to a variety of stimuli in the vehicle or on the road. Responding to auditory stimuli such as a car horn or directive from a vehicle passenger to avoid potential negative situations are examples of possible auditory signals. Results from the present study suggest that individuals who are distracted by texting or eating whilst driving have slower response times to auditory stimuli, which may have catastrophic effects in the real-world. Surprisingly, visual reaction time was not affected by distraction tasks in this study. Eye glances away from the road and on to a mobile phone when texting or to avoid

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spilling food/drink and the increased mental effort required to perform these tasks whilst driving increase the level of distraction (Alosco et al. 2012; Hosking et al. 2009; Owens et al. 2011; Young et al. 2008). Typically, one would then assume greater impairment in response to visual stimuli than auditory stimuli given the higher task demands and likelihood of increased eye glances away from the roadway to carry out the distracting task. Whilst the current study involved a naturalistic driving scenario, the intermittent nature of the critical event task used for visual reaction time may explain the lack of observed effects of distraction on visual reaction time performance.

The physical and attentional demands of additional tasks undertaken whilst driving are likely to influence the degree of impairment observed in driving performance (Collet et al. 2010a, 2010b; Young et al. 2008). Text messaging often requires greater cognitive and physical capacity compared to voice conversations on a mobile phone. Thus, impairment in driving performance when texting has been shown to be greater than when using voiced based systems or phone calls (Libby and Chaparro 2009; Owens et al. 2011; Terken et al. 2011). The same concept may apply to eating tasks, in that meals requiring greater physical and cognitive demand, for example in order to avoid spilling contents, remove food from packaging or containers, or handling hot foods/beverages are likely to have greater impact on deteriorations in driving performance. This may explain why no observable impairment in driving performance was detected by Young et al. (2008) when participants consumed a packet of sweets during driving. It is likely that the cognitive demand required to perform the eating task was too low to impact on driving ability and induce performance changes. In contrast, Jenness et al. (2002) and Alosco et al. (2012) both reported deficits in driving performance when consuming a cheeseburger and breakfast pastries respectively; meals that could be considered more demanding to eat given the potential for spilling contents. In the current study consuming a Subway® sandwich and drink during driving resulted in performance impairment compared to no distraction. Whilst consuming only a drink during the driving task did not impact on performance. Drinking from a water bottle could be considered a relatively low demand task, given that there is a reduced likelihood for spilling contents. Collectively, these results suggest that consuming food that requires higher levels of physical demand and cognitive capacity (typical of food purchased from drive-thru facilities) has the

potential to impact on driving performance and may have serious implications for motorists that engage in this type of behavior.

Interestingly, it appears that perceptions of the impact of different distractions do not necessarily reflect actual impairment observed in driving performance. In the current study, most participants subjectively rated the texting condition as the most difficult task to complete whilst driving, with greater numbers reporting difficulty in controlling lane position in this trial. Given the media attention associated with mobile phone use and driving impairment, it may have influenced participants' perspective as to which was the most difficult task. However, performance results in the current study reflect almost identical levels of impairment in both SDLP and auditory reaction time with the texting and eating distraction tasks compared to baseline driving. This suggests that individuals may be less receptive to the distraction imposed by eating whilst driving. Previous research indicates that drivers perceive eating to be a more acceptable behaviour and are therefore less likely to identify the associated risks or modify eating behaviours behind the wheel (Stutts et al. 2005; Stutts et al. 2001; White et al. 2004). Given the findings from previous work and that of the current study, an increase in public health messages promoting awareness of the impact of eating on driving performance and driver safety may be required.

This study has demonstrated that two common behaviours performed whilst driving (eating and texting) result in a deterioration of simulated driving performance. However, it is important to recognize the limitations of the current study in relation to on-road driving. Firstly, the driving simulator was a fixed based model, thus avoiding any of the natural forces that might occur when operating a motor vehicle. It is possible that the forces experienced whilst driving may amplify the level of concentration required to eat or drink. Hence, the results of the present study in regards to eating, drinking and driving may underestimate the real impact of these activities on driving. In addition, the study design has explored the impact of texting and eating as independent activities. Whilst the literature on driving distraction describes these activities as discrete tasks (Stutts et al. 2005; Stutts et al. 2001), it is possible that individuals may engage in multiple tasks whilst driving. The effect of multiple distractions on driving performance warrants further investigation.

In summary, eating and texting whilst driving provide a significant distraction that results in

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3 impairment related to lane position control and reaction time performance. These findings may have
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5 serious implications for motorists that engage in these types of distracting behaviours behind the
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7 wheel and for the safety of other road users around them. Greater awareness of the impact eating has
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9 on driving performance and safety is required.
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FIGURE LEGENDS

Figure 1. Experimental driving conditions.

Figure 2. Example of the driver’s visual impression in the simulated driving scenario.

Figure 3. SDLP performance comparisons between baseline and experimental driving tests. * Significant difference from baseline drive ($p<0.05$).

Figure 4. Auditory reaction time performance comparisons between baseline and experimental driving tests. * Significant difference from baseline drive ($p<0.05$).

Figure 5. Visual reaction time performance comparisons between baseline and experimental driving tests.

TABLES

Table 1. Driving simulator scenario for experimental drives

Section	Description	Length (Km)	Configuration	Critical events
1	Urban	1.03	4 lane dual carriageway, 60km/hr sign posted section. 2 intersections with traffic signals. Many buildings highly landscaped area. Moderate traffic present.	Interaction with 2 vehicles & 1 RT event
2	Highway merging section	0.72	2 lane single carriageway which reduces to 1 lane, 80km/hr sign posted section. Few buildings, lightly landscaped area. Light traffic present.	1 RT event
3	Highway	7.92	6 lane dual carriageway, 110km/hr sign posted section. No buildings, lightly landscaped. Moderate traffic present.	7 RT events

RT - Reaction time. Light traffic - may encounter 2-3 other vehicles, Moderate traffic - may encounter 6-8 other vehicles.

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422x188mm (96 x 96 DPI)

444x270mm (96 x 96 DPI)

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271x185mm (300 x 300 DPI)

276x188mm (300 x 300 DPI)

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