ARTICLE IN PRESS

Accident Analysis and Prevention xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

The impact of texting on driver behaviour at rail level crossings

Kristie L. Young[a,*], Michael G. Lenné[a], Paul M. Salmon[b], Neville A. Stanton[c]

[a] Monash University Accident Research Centre, Monash University, Melbourne, Australia
[b] University of the Sunshine Coast Accident Research, Maroochydore, QLD, Australia
[c] University of Southampton, Highfield, Southampton, UK

ARTICLE INFO

Keywords:
Mobile (cell) phone
Text messaging
Driver distraction
Rail level crossings

ABSTRACT

A driver text messaging in the vicinity of a rail level crossing represents the merging of a high-risk, high-workload driving environment with a highly distracting secondary task. In this simulator study, we examined how texting impacts driver behaviour on approach to actively controlled urban rail level crossings. Twenty-eight participants drove a series of simulated urban routes containing rail level crossings, while sending text messages and while driving without performing a secondary task. At half of the crossings, drivers were required to respond to the crossing warnings as a train approached. Results revealed that texting on approach to rail level crossings had a detrimental impact on a range of driver behaviour measures. Specifically, texting more than doubled the amount of time spent with eyes off the forward roadway, resulting in drivers spending more than half of their approach time to rail level crossings looking away from the road. This lack of visual attention to the roadway was associated with a range of decrements in driving that may be indicative of a loss of situation awareness, including increased brake reaction time to the crossing warnings and a reduction in lateral position control. The findings have safety implications, not only for urban level crossings, but also for passive level crossings where no warnings are present to re-orient the distracted driver's attention toward an approaching train.

1. Introduction

Sending and receiving text messages (texting) is a high-workload task that competes for many of the same cognitive resources required for driving. Research has shown that texting while driving substantially increases the amount of time drivers spend with their eyes off the forward roadway, and degrades the ability to maintain lateral position, control speed and headway and respond to roadway events (Caird et al., 2014; Drews et al., 2009; Hosking et al., 2009; Owens et al., 2011; Rudin-Brown et al., 2013; Yannis et al., 2014). These degradations in driving performance translate into an increased crash risk (Dingus et al., 2016; Simmons et al., 2016; Simons-Morton et al., 2014). In the US in 2015, there were 442 fatal crashes that involved the use of mobile phones (National Center for Statistics and Analysis, 2017). Moreover, in 2013 the National Safety Council estimated that 341,000 crashes involved a driver text messaging (National Safety Council, 2015).

Despite the risks, a large proportion of drivers admit to texting when driving. In Australia, the prevalence of sending and receiving text messages while driving is high, particularly among the young driver population (Petroulias, 2014; Young and Lenné, 2010). A 2013 Australian survey of community attitudes to road safety found that 32 percent of drivers reported reading text messages and 18 percent reported sending text messages while driving (Petroulias, 2014). In certain driver populations the incidence of texting while driving is even higher, with 92 percent of college students reporting that they read text messages when driving (Atchley et al., 2011).

The crash risk associated with engaging in secondary tasks while driving varies as a function of the attentional demands of driving and the distribution of drivers' attention across the driving and secondary tasks (Lee et al., 2009). Like other sources of distraction, texting becomes particularly risky when there is a temporal overlap between driver engagement in texting and a high workload segment of driving. Risk is increased because the additional attention demanded by the roadway exceeds the amount of attention that the driver is devoting to it, placing them at greater risk of a distraction-related incident. One such high-demand and high-risk scenario occurs when a driver traverses a rail level crossing (RLX). The high level of demand associated with RLXs is exacerbated by the fact that, in urban areas at least, they are often located in busy segments of the road network, such as strip shopping areas (e.g., Salmon et al., 2013a; Young et al., 2015). As a result, the implications of text messaging while driving are likely to be heightened in the vicinity of RLXs, particularly as the consequences of a RLX collision are frequently catastrophic.

In Australia between 2002 and 2012, there were 601 collisions

* Corresponding author at: 21 Alliance Lane, Clayton, VIC, 3800, Australia.
E-mail address: kristie.young@monash.edu (K.L. Young).

https://doi.org/10.1016/j.aap.2018.05.002
Received 9 November 2017; Received in revised form 18 March 2018; Accepted 3 May 2018
0001-4575/

between trains and vehicles at RLXs, making these collisions the largest cause of loss of life on the rail network (ATSB, 2012). Similar figures are observed in other countries. The US experienced 263 fatalities and 832 injuries at RLXs in 2016 (FRA, 2017), while RLX collisions represented more than one quarter of all railway crashes occurring on the EU railway system, with 604 fatalities and casualties during 2011 (European Railway Agency, 2013). RLX crashes also have massive associated economic costs, since they result in wide scale disruption to both the rail and road networks. The annual cost of level crossing crashes to society was estimated in 2010 as approximately $116 million (Tooth & Balmford, 2010).

Driver behaviour on approach to RLXs has been found to play a key role in RLX crashes (Berg & Oppenlander, 1969; Caird et al., 2002; Green, 2002). In particular, diminished situation awareness (Stanton et al., 2017), driver inattention and distraction (Parnell et al., 2016) are key contributors to unintentional non-compliance at RLXs (Caird et al., 2002; Salmon et al., 2013b) and, as such, are likely casual factors in RLX crashes. A number of studies have examined driver behaviour on approach to RLXs and have found that drivers' attention is often diverted elsewhere (Salmon et al., 2013a, 2013b; Young et al., 2015). Two studies from the US used field operational test data to examine the behaviour of light and heavy vehicle drivers' behaviour at or on the approach to RLXs (Ngamdung and daSilva, 2012, 2013). They found that while traversing RLXs, the drivers of both light and heavy vehicles were engaged in secondary tasks for 46.7 percent and 20.8 percent of the approach time, respectively. For light vehicle drivers, the most frequently observed secondary task was conversing with a passenger (15.5 percent), followed by talking on or listening to a mobile phone (6.6 percent). The most commonly observed secondary behaviour engaged in by heavy vehicle drivers was talking on or listening to a mobile phone (6.5 percent). Another study conducted in Nebraska using video recordings at RLXs found that approximately one third of the drivers observed at RLXs were distracted (Tung and Khattak, 2015). Drivers were most commonly distracted by talking to front seat passengers, looking to the side and using a mobile phone.

Most recently, a study investigating the impact of driver inattention on the severity of driver's injuries sustained in crashes at or near RLXs found that the probability of being injured in a single-vehicle crash increased by 9.7 percent when the driver was inattentive (Zhao et al., In press). Moreover, the study found that the impact of inattention on driver injury outcomes were not statistically different to the influence of drink driving or aggres sive driving.

Clearly, distracted driving and, in particular, the use of mobile phones in the vicinity of RLXs is a significant safety concern. Indeed, there are a number of high profile fatal RLX crashes where the driver of the vehicle was found to be using a mobile phone at the time of the collision. For example, on 5 June 2006, a passenger car drove into the path of an on-coming passenger train on the outskirts of Albury, Australia fatally injuring a 19 year old male driver. An investigation into the collision found that the driver's mobile phone probably rang at or around the time that the car was approaching the RLX and, while records indicate that he did not answer the call, the ringing phone could have distracted him from the driving task at a critical moment (ATSB, 2007). Almost a decade later, on 11 September 2015, a Canadian National train struck an ambulance at a RLX, injuring the two paramedics and killing the patient who was being transported. The investigation identified that, in addition to the complex design of the crossing, distraction from a mobile phone use likely decreased the ambulance driver's ability to detect warning stimuli in the environment while traversing the crossing (Transportation Safety Board of Canada, 2017).

The two case studies cited highlight specific scenarios where the diversion of attention from the road to mobile phone use can increase the risk of a collision at rail level crossings. It is unclear, however, the extent to which texting on approach to this critical part of the road environment specifically impacts driver behaviour. Much of the previous literature on texting has examined its impact on driver behaviour when driving in low-risk areas, such as mid-section segments of urban and rural roads or freeways/motorways. It is not known how texting affects behaviour at the intersection of the road and rail network, or whether drivers will adjust their driving behaviour or their attention allocation strategies to compensate for the greater risk present at this location. Research in a somewhat analogous yellow light running scenario suggests that drivers do engage risk compensation strategies when engaged in a phone conversation while traversing signalised intersections (Haque et al., 2016; Ohlhauser et al., 2011). Haque et al., for example, found a reduced propensity for young and middle-aged drivers to run yellow traffic lights while talking on a phone, indicating an attempt at risk reduction by adopting more conservative stopping behaviour. It is not clear if similar results would be found with the more highly demanding task of texting or at RLXs, which are encountered less often on the road network than signalised intersections and appear to be associated with different schema and set of expectancies (Yeh and Multer, 2008). Indeed, even when not engaged in a secondary activity, noncompliance with active RLX warnings is relatively common and drivers have a low level of situation awareness in relation to the crossing (Cooper and Ragland, 2008; Salmon et al., 2013a,b). These factors combined suggest that the consequences of texting on approach to RLX may be greater than at other parts of the road network.

In the current simulator study, we examined driver behaviour on approach to active urban RLXs while drivers sent text messages on a smartphone and while they drove undistracted. At half of the RLXs, drivers were required to respond to the active crossing warnings as a train approached. Measures of lateral and longitudinal control, reaction time and eye glance behaviour were examined. Because texting competes with a range of cognitive resources required for safe driving (Parnell et al., 2016, 2017), we predicted that sending the text messages would negatively impact a range of driving measures. It was predicted that texting would result in significantly greater eyes off road time, increase reaction time to the RLX warnings, increase lane position variability and reduced average approach speeds. Based on a previous finding that drivers took longer and more frequent glances to several off-road areas when a train was present at an RLX, possibly due to the associated reduced speeds (Young et al., 2015), it was also expected that, due to the slower approach speeds, drivers would take more frequent and longer duration glances to the mobile phone when a train was present and, as a result, that the impact of texting on the driving performance measures on approach to the activated RLX would be increased.

2. Method

2.1. Experimental design

The study used a two-way (2 × 2) repeated measures design with the factors of condition (baseline and text messaging) and train presence (train and no train). The dependant variables included those related to the primary (driving) and secondary (texting) tasks. To assess driving performance, these included distance from RLX when the brake pedal was first pressed, brake reaction time from the activation of the RLX warning signals, standard deviation of lateral position (SDLP), and mean speed at distances of 100 m, 50 m and 20 m from the RLX. All driving data, apart from SDLP, were examined for the 100 m approach to the RLX. SDLP, a measure of lane weaving defined as the standard deviation of the mean distance of the centre of the front axle to the centre line, was examined for a 400 m straight section approaching the RLX. Eye glance measures extracted from the faceLAB™ 5.0 eye tracking system included percentage of eyes off road time and frequency and mean duration of glances to the phone (during the text messaging tasks). To assess drivers' performance on the text messaging tasks, and therefore gain insight into potential performance trade-offs, the number of correct and incorrect texts composed was examined.