The psychological underpinnings of young pedestrians' deliberate rule-breaking behaviour at pedestrian railway crossings: A cross-sectional study utilising the Theory of Planned Behaviour

Millie Darvell, James Freeman and Andry Rakotonirainy

Abstract

School children continue to be disproportionally represented in train–pedestrian collisions. Although this is often thought to be the result of deliberate rule violations, scant research has been conducted into the determinants of rule-breaking behaviour at pedestrian railway crossings among this cohort. The current study used a Theory of Planned Behaviour model, including a sensation-seeking construct, to investigate the underpinnings of young pedestrians' railway violations. In total, 119 participants under the age of 18 completed a questionnaire assessing the standard Theory of Planned Behaviour constructs (attitude, subjective norm and perceived behavioural control), demographic variables (age and gender), sensation-seeking tendencies and deliberate violations at level crossings. In an attempt to gain further insight into the origins of rule breaking, an additional question was incorporated about whether participants had ever made a mistake at a railway level crossing. Regression analyses revealed support for the Theory of Planned Behaviour in predicting intention, in that subjective norm and attitude, but not perceived behavioural control, significantly predicted intention to violate railway pedestrian rules. Gender (being male) was also found to significantly predict intention, although age and sensation seeking did not. Overall, the final model accounted for 65% of the variance in intentions to deliberately break the rules at railway pedestrian crossings. Results also provided preliminary support for the notion that young pedestrians are more likely to deliberately violate the rules rather than make errors while using railway level crossings. Overall, findings suggest that intentional rule breaking is influenced by attitudinal and normative factors and is most problematic among males. Directions for future research as well as remedial efforts to discourage intentional violations are discussed.

Peer reviewed paper

This paper has been critically reviewed by at least two recognised experts in the relevant field.

Originally submitted: March 2015

INTRODUCTION

Train–pedestrian collisions are a significant problem both nationally and internationally (Silla & Luoma 2009). In Australia, between January 2001 and December 2010 there were 392 rail accidents involving pedestrians that resulted in fatal and serious injuries, excluding suicides (Australian Transpor t Safety Bureau 2011). Such incidents have a high likelihood of death, with survival rates at approximately one in three (Lobb, Harre & Terry 2003). In addition to the emotional cost of these collisions, an earlier estimate by the Australian Bureau of Transport and Regional Economics (2002) documented the financial cost of each fatality at $1.9 million, and $27 000 for a serious injury. Although the precise contribution of pedestrian violations to collisions remains unknown, a substantial proportion of pedestrians and cyclists have been observed to violate crossing rules, with a large 72% of those crossing the track after the alarm had been activated (Knutton 2004). Despite these figures, scientific research into the origins of pedestrians' behaviour at railway level crossings has been scarce to date, therefore limiting the development of corresponding effective and targeted interventions for high-risk groups. The literature has instead tended to focus on understanding and promoting safe railway crossing behaviour among drivers (Railway Safety Regulators' Panel 2008).

Analyses based on serious injury and fatality data indicate that certain groups are at a disproportionate risk of train–pedestrian collisions (Clancy et al. 2007). Males are consistently over-represented in incidents at level crossings (Searle, Di Milia & Dawson 2012; Henley & Harrison 2009; Silla & Luoma 2012), consistent with the notion that male pedestrians are also more likely to violate road intersection rules (Keegan & O'Mahony 2003). Although there are limited investigations into why males are disproportionately represented in level crossing incidents, a Victorian study showed that 40% of males, compared with only 12% of females, reported that they would ignore activated warning signs and cross a train line when a train was not in sight (Lloyd's Rail Register 2007). Younger persons, including school children, have also been reported to be at an increased risk (Khattak & Luo 2011; Lobb et al. 2003; Spicer 2008). Research based on video surveillance data in the US has indicated that children aged 8 years or younger were involved in 25% more gate-related violations at a grade crossing compared to older pedestrians (Khattak & Luo 2011). Though there is limited research into the origins of why school children are at an increased risk (Searle et al. 2012), preliminary findings indicate this may be due to poor scanning behaviours, underdeveloped cognitive and risk-perception abilities, impulsiveness (Searle et al. 2012), sensation seeking (Freeman et al. 2013) and intentional risk taking (Clancy et al. 2007). Non-compliance among younger pedestrians may also be heightened in the absence of pedestrians who model appropriate crossing behaviour, as research has indicated that gate-related violations among young children are greatest in the absence of older crossing users (Khattak & Luo 2011). Risk taking more broadly may also be an expression of sensation seeking, which has been associated with a wide range of behaviours, including both risky (Jonah 1997; Zuckerman 2007) and aggressive (Jonah, Thiessen, & Au-Yeung 2001) driving habits. Although previous research has neglected to consider the influence of sensation-seeking traits on risky pedestrian crossing behaviour, there appears to be some merit in exploring whether those who are more inclined to take physical risks are also more likely to violate crossing rules. Thus, in an exploratory manner this study aims to incorporate a sensation-seeking construct to determine whether, and to what extent, this influences safety behaviour at railway level crossings.

Rule-breaking behaviours at railway pedestrian crossings can be categorised into two separate behaviours: 'deliberate violations', which constitute intentional rule breaking, and 'errors', in which the rules are broken in an accidental manner. Deliberate violations are thought to be far more prevalent than errors (Clancy et al. 2007), although the factors contributing to such violations are largely unknown. Observational studies have reported that pedestrians are most likely to be non-compliant during peak morning and afternoon transportation periods, with non-compliant behaviours involving crossing against both activated warning signs and barriers (Arup 2005). Although not specific to pedestrians, research conducted in the US has indicated that drivers engage in more risky crossing behaviour when warning signals extended beyond 30–40 seconds (Richards & Heathington 1990). This increase in risk-taking propensity is believed to stem from the driver losing confidence in the warning system once it exceeds a desirable waiting time (Richards & Heathington 1990). Violations also tend to be influenced by the presence of other pedestrians, with research indicating an inverse relationship between gate-related violations and the number of nearby pedestrians (Khattak & Luo 2011). Similar to the above findings, observational studies conducted at various Perth-based level crossings revealed that the typical non-compliant

pedestrian was male, adult, crossing alone and in a hurry (Edquist, Hughes, & Rudin-Brown 2011). One of the few studies to explore the etiology of such behaviour among younger adults (18–25) revealed that the three main reasons for violations were being in a hurry, warning factors (e.g. suspecting faulty warnings) and making errors (e.g. being unaware of a second train) (Clancy et al. 2007). This study provided further support for the notion that non-compliant crossing behaviour can be attributed to both deliberate and unintentional violations.

Although distraction and inattention have been speculated as contributing factors of accidental violations (Caird et al. 2002), observational research has indicated that only a small proportion of non-compliant crossing incidents can be attributed to distraction, and that even non-distracted pedestrians fail to look for approaching trains before crossing (Edquist et al. 2001). An additional factor that may increase error making at pedestrian railway crossings is poor knowledge of level crossing procedures (Richards & Heathington 1990) and of the penalties associated with breaching crossing rules (Wallace 2008). One of the few studies to investigate pedestrians' knowledge of penalties revealed that approximately half of a sampled group did not believe, or were unaware, that it was illegal to cross when a train was approaching (Clancy et al. 2007). The same study reported that 18% of the survey sample acknowledged unintentionally being caught on train tracks when a train was approaching.

The examination of psycho-social problems such as pedestrian risk-taking is often enhanced through the use of well-validated models that offer explanation for the relationship between attitudes and behaviours. Thus, the current study employs the Theory of Planned Behaviour (TPB) (Ajzen 1991) to gain insight into young pedestrians' deliberate violations at railway level crossings. This model was chosen given its efficacy in predicting deliberate behaviour and its utility in both understanding and promoting responsible behaviour in the field of injury prevention. The TPB posits that intentions are the most proximal determinants of behaviour (Ajzen 1991). Intention is influenced by three constructs: attitudes, an individual's favourable or unfavourable evaluation of the behaviour; subjective norms, an individual's perception of whether significant others will approve or disapprove of the behaviour; and perceived behavioural control (also held to directly predict behaviour), an individual's perceived degree of control over performing the behaviour (Ajzen 1991). The TPB has been successfully used to predict various intentions and behaviours, including intentions to cross roads in risky situations (Holland & Hill 2007), violate traffic regulations (Diaz 2002) drink and drive (Moan & Rise 2011) and ride motorcycles at inappropriate speeds (Chorlton, Conner & Jamson 2012), as well as intentions to exceed the speed limit, and subsequent objectively measured speeding behaviour (Conner et al. 2007). On average, the model has been shown to account for 39% of the variance in intention, as indicated in an earlier meta-analysis (Armitage & Conner 2001). To the authors' knowledge, the validity of the TPB in predicting deliberate violations at railway level crossings has not been empirically tested.

In line with the aforementioned lack of research in the context of pedestrian railway crossings, the present study aimed to examine the psychological underpinnings of younger pedestrians' crossing behaviour, by:

a. utilising a TPB model incorporating additional demographic and sensation-seeking factors to investigate the underpinnings of this group's crossing violations; and

b. providing preliminary insight into whether a younger cohort is more likely to make deliberate violations versus errors at crossings.

METHOD

Participants

Ethical approval was granted by the Queensland University of Technology's Human Research Ethics Committee (approval #1200000078). In total, 119 participants under the age of 18 years completed the questionnaire. A purposive sampling technique was employed wherein participants aged 10 to 17 years (M = 15.1, SD = 1.43) were recruited from two Brisbane metropolitan schools selected on the basis of their close proximity to a railway crossing. Participants were predominantly male (N = 99; 83.2%), with 16.8% of the sample comprising females (N = 20). All participants reported using a level crossing at least once in the past six months, with 28.3% indicating that they used crossings on most days of the week. Participation was voluntary and anonymous, and a signed parental consent sheet was returned to teachers before the questionnaire was distributed. The authors attended the schools to distribute and collect questionnaires, as previously approved by teachers. A pen and paper version of the questionnaire was completed by participants while at school, and was collected by a teacher upon completion. A movie voucher was provided to each participant as an incentive.

Measures

Target behaviour: Prior to data collection, a pilot study was conducted using a sample of 9 participants (6 male and 3 female, aged 14–17 [M = 15.22]) to assist in ascertaining minors' understanding of, and engagement in, intentional rule-breaking behaviour, as well as their exposure to railway level crossings. Based on pilot study findings, and the low frequency of self-reported violations within a six-month period, the target behaviour was operationalised in the main questionnaire as 'intentionally breaking the rules at a railway pedestrian crossing in the next six months'. To increase specificity, participants were reminded of the various types of rule-breaking behaviours identified in the pilot study, such as jumping the fence, running across the tracks when a warning is activated and disobeying signs in general.

Main questionnaire: Most items were positively worded, although some items were negatively worded to reduce response bias. Aside from demographic variables (age and gender), all items were scored on Likert scales or semantic differential scales, as specified below.

Deliberate violations and errors. Deliberate violations were assessed via three items asking participants if they had ever crossed at a railway pedestrian crossing when the lights were flashing or the gate was closed, or whether they had deliberately ignored a warning signal. A corresponding item examined whether participants were more likely to cross after the train had passed. Participants were also asked whether they had ever made a mistake at a railway level crossing. Responses were in a yes or no format.

Theory of planned behaviour variables. Three items assessed *intention* to perform the target behaviour (e.g. 'I intend [1]/do not intend [7] to intentionally break the rules at a railway pedestrian crossing in the next 6 months'). Items were averaged to obtain an overall measure of intention, which was moderately reliable (α = 0.64). *Attitude* was assessed by four 7-point semantic differential scales (e.g. 'For me, intentionally breaking the rules at a railway pedestrian crossing in the next 6 months would be good [1]/ bad [7]'). Items were averaged to produce an overall measure of attitude, which was reliable (α = 0.84). *Subjective norm* was assessed using four items (e.g. 'Many people like me would also intentionally break the rules at a railway pedestrian crossing in the next 6 months'; strongly disagree [1] to strongly agree [7]). Items were averaged to obtain an overall measure of subjective norm, which was moderately reliable (α = 0.64). Due to very low scale reliability, one *perceived behavioural control* item was removed, leaving two items to comprise the measure of perceived behavioural control (e.g. 'It is up to me whether or not I intentionally break the rules at a railway pedestrian crossing in the next 6 months'; strongly disagree [1] to strongly agree [7]). The scale was moderately reliable (α = 0.64).

Sensation seeking. Sensation seeking was measured using the Brief Sensation Seeking Scale, which comprises 8 items evaluating an individual's propensity to seek varied and novel sensations and engage in risky behaviours (Zuckerman 1979) (e.g. 'I get restless when I spend too much time at home; strongly disagree [1] to strongly agree [5]). The scale was reliable (α = 0.81).

RESULTS

Deliberate violations and errors

The first aim of the study was to investigate the frequency of making deliberate violations at pedestrian crossings versus errors. For any of the intentional violation questions (e.g. lights flashing, gates closed or deliberately ignoring a signal), 42 participants (35.3%) reported having intentionally violated the rules at level crossings in at least one of these ways. Participants were provided with an opportunity to explain the reasons for their behaviour, with the overwhelming majority indicating they were 'in a rush' or 'running late'. Males were significantly more likely to break the rules compared to females (40 versus 2), X^2 (1, N = 119) = 6.34, p = 0.009. A corresponding question regarding crossing when the lights were flashing (measured on a 7-point Likert scale) revealed that participants were statistically more likely to violate the rules after the train has passed (M = 3.09) than before the train has passed (M = 2.31) [t (116) = −5.46, p < 0.001].

In contrast, errors were not as common an occurrence, with only 5% (N = 6) of participants reporting this event. Although there was a tendency for males to report a greater number of errors compared to females (4 versus 2), the difference was not statistically significant X^2 (1, N = 119) = 1.23, p = 0.267. Only 4 participants (2.6%) reported making the error of crossing after a train had passed without realising a second train was approaching. Due to the small numbers involved, statistical analyses could not be undertaken to determine if these differences were statistically significant or

Table 1
Means, standard deviations and bivariate correlations for attitude, subjective norm, perceived behavioural control, intention and sensation seeking

Variable	M	SD	1	2	3	4	5
Attitude	2.25	1.30		0.57*	−0.28*	0.71*	0.22†
Subjective norm	2.70	1.17			−0.32*	0.77*	0.24†
Perceived behavioural control	5.36	1.47				−0.31*	0.09
Intention	2.42	1.37					0.30*
Sensation seeking	3.10	0.84					–

Means scores for the TPB variables are based on 7-point scales, while the mean score for sensation seeking is based on a 5-point scale.
* $p < 0.01$
† $p < 0.05$

expected by chance. Deliberate violations did not have a significant effect on errors made at level crossings X^2 (1, N = 119) = 2.72, p = 0.09.

Bivariate analyses

The means, standard deviations and bivariate correlations for the TPB and sensation-seeking variables are presented in *Table 1*. Significant modest to strong correlations were found among the TPB predictors, with the strongest positive correlation found between subjective norm and intention (r = 0.77, $p < 0.01$). This indicated that the stronger the value placed on others' approval of rule breaking, the stronger the intention to deliberately break the rules at a railway level crossing. Similarly, the strong positive correlation (r = 0.71, $p < 0.01$) between attitude and intention indicated that the more favourable the attitude towards deliberately breaking the rules at a railway level crossing, the stronger the intention to engage in such behaviour. The modest negative correlation between perceived behavioural control and intention (r = −0.31, $p < 0.01$) indicated that the less control participants thought they had over intentionally breaking railway crossing rules, the stronger their intentions.

On average, participants' attitudes towards breaking the rules at a railway level crossing were unfavourable (M = 2.25), they did not perceive that others would approve of such behaviour (M = 2.70), and their intentions to engage in deliberate rule violations were weak (M = 2.42). However, participants reported a high level (M = 5.36) of control (perceived behavioural control), indicating that it would not be difficult for them to deliberately violate the rules at a railway level crossing. The group as a whole exhibited neutral sensation-seeking tendencies, which correlated with all TPB variables except perceived behavioural control.

Multivariate prediction

A hierarchical multiple regression analysis was undertaken to examine the contribution of demographic, TPB and sensation-seeking variables to deliberate rule-breaking intentions among the current sample (*Table 2*). Intention was the dependent variable, while age, gender, the TPB variables (attitude, subjective norm and perceived behavioural control) and sensation seeking were the independent variables.

Age and gender were entered at step 1 to control for (and explore) the contribution of demographics to the model, which contributed significantly to the variance in intention F (2, 92) = 6.71, $p < 0.01$. Entered at step 2, the TPB constructs of attitude, subjective norm and perceived behavioural control significantly accounted for a further 52% of the variance in rule-breaking intentions, F (3, 89) = 32.16, $p < 0.001$. Inclusion of sensation seeking at step 3 did not significantly add to the model, F (1, 88) = 26.90, p = 0.36.

Overall, the final model accounted for 65% of the variance in intentions to deliberately violate railway pedestrian rules in the future. Gender (being male), subjective norm and attitude independently contributed to the prediction of intention, with subjective norm emerging as the strongest predictor (β = 0.48, $p < 0.001$). Age, perceived behavioural control and sensation seeking did not significantly predict intention.

DISCUSSION

The present study endeavoured to investigate the determinants of young pedestrians' intentions to deliberately violate rules, by using a TPB model with the inclusion of sensation-seeking and demographic variables. Additionally, the study explored the

Table 2
Hierarchical multiple regression analyses predicting intention to deliberately break the rules at a railway pedestrian in the next 6 months

Variable	*B*	β	R^2	*Adj.* R^2
Step 1				
Gender	−0.40	−0.14‡	0.13†	0.11†
Age	−0.03	−0.05		
Step 2				
Attitude	0.35	0.39*	0.64*	0.62*
Subjective norm	0.47	0.48*		
Perceived behavioural control	−0.03	−0.05		
Step 3				
Sensation seeking	0.08	0.06	0.65	0.62

Note: Weights provided are those revealed in the final step of the analysis.

* $p < 0.001$

† $p < 0.01$

‡ $p < 0.05$

contribution of deliberate violations versus errors to younger pedestrians' crossing behaviours.

Participants were more likely to report deliberate rule breaking than making errors (35.3% versus 5%), with more than a third of the sample admitting to previously breaking crossing rules at a given time. This finding supports the hypothesis that pedestrians at level crossings are more likely to ignore warning signals than make mistakes (Freeman et al. 2013; Searle et al. 2012), which is an issue that has remained unexplored among younger pedestrians. A corresponding preliminary analysis revealed that the reasons for ignoring warning signals were most closely associated with being 'in a rush' or 'running late'. This finding is consistent with one of the only prior studies to examine this issue, albeit in the context of young adults (Clancy et al. 2007). Further research is required to determine whether pedestrians make calculated risks before crossing or if such behaviour is more impulsive in nature. Further research is also warranted to investigate other factors that influence pedestrians' decisions to ignore or undervalue rules, such as an individual's perceived credibility and accuracy of warnings, and the influence of optimism bias (the belief that risks are more likely to apply to others rather than oneself). Complementary studies that examine the utility of specific interventions designed to limit intentional violations would also be of value, and may involve the use of physical barriers, enforcement or education-based signs. Even with the implementation of well-designed education and enforcement campaigns, it is noteworthy that pedestrians may still be capable of bypassing the physical barriers that currently exist at many pedestrian railway crossings. For example, it was noted by participants in this study (during the pilot phase) that jumping the fence constituted a popular form of rule-breaking behaviour. Similarly, other research has indicated that it is not uncommon for pedestrians to jump the fence, push open the gate while it is closing, or hold the gate open for others to go through (Edquist et al. 2011).

The TPB was utilised to investigate the determinants of young pedestrians' intentions to deliberately violate rules. Overall, participants' attitudes towards breaking the rules at railway level crossings were unfavourable. It is possible that this finding was influenced by self-report or selection bias, or that some disparity existed between stated intentions and actual behaviours, since a sizeable proportion of the sample admitted to deliberately violating crossing rules. As a whole, the current sample perceived that others would not approve of such behaviour, and they did not possess strong intentions to engage in deliberate rule violations. The former result is encouraging as it indicates that school children do not generally perceive their peers as strong supporters of violating railway crossing rules. This may serve as an informal deterrent, similar to that found in prior research indicating that peer disapproval can reduce the likelihood of engagement in some offending behaviours (Freeman & Watson 2009; Homel 1988). Consistent with the aforementioned limits to physical barriers at level crossings, the high average level of control

(perceived behavioural control) participants reported suggests that it would not be difficult for this cohort to deliberately violate the rules at railway level crossings. This raises concern as it implies that school-aged pedestrians have an entirely voluntary conscious choice as to whether they break crossing rules.

The overall TPB variables accounted for 52% of the variance in young pedestrians' intention to deliberately violate railway level crossing rules. Compared to the average amount of variance explained by the TPB (39% (Armitage & Conner 2001)), the current model accounted for a much greater proportion of variance in intentions. This provides preliminary support for the utility of the TPB in investigating and explaining railway crossing violations. However, only attitude and subjective norm significantly predicted intentions; perceived behavioural control did not. Thus, pedestrians who had more favourable attitudes towards rule-breaking behaviour, and who perceived that important others would support rule-breaking behaviour, were more likely to intend to violate rules at railway pedestrian crossings in the next six months. The failure of perceived behavioural control to predict intentions stands in contrast to the model's premise that perceived behavioural control affects behavioural intentions (Ajzen 1991). However, such a finding is not uncommon, as approximately one third of TPB studies fail to find a significant effect of perceived behavioural control on intentions (Sutton, McVey & Glanz 1999). This finding also corresponds with the assumption that the influence of perceived behavioural control on intention declines as an individual's volitional control over a behaviour increases (Ajzen 1991). It would seem that younger pedestrians perceive they have high volitional control over whether or not they violate level crossings rules, therefore reducing the significance of perceived behavioural control on intentions in railway contexts. This is also consistent with the assumption that pedestrians are more likely to commit deliberate violations at crossings rather than make errors (Freeman et al. 2013). It is worth noting that such a high perceived behavioural control mean has also been reported in previous research concerning motorcyclists' intention to speed, indicating a high degree of control over whether or not to engage in the behaviour (Chorlton et al. 2012). The finding has direct implications for the development of countermeasures, as rail crossing designs that maximise a physically impermeable effect (e.g. locking gates or high barriers) may prove most effective at reducing violations. Again, given the tendency for humans to circumvent environmentally based rail countermeasures (Silla & Luoma 2009), effective countermeasures may need to be multi-modal and include environmental, enforcement and educational approaches.

Of the non-TPB variables, only gender emerged as a significant additional predictor in the model, while age and sensation seeking did not predict intentions. The finding that males were more likely to intend to violate crossing rules is consistent with previous research concerning pedestrian behaviours at public railway crossings (Clancy et al. 2007) as well as with Australian statistics indicating that 84% of train–pedestrian fatalities involve males, and that males are generally overrepresented in general pedestrian accident rates (Australian Transport Safety Bureau 2004). Unfortunately, the current findings and previous research do not offer an explanation for why males are at a greater risk and are more likely to violate pedestrian rules. Qualitative work might be required to explore this issue from the perspective of male pedestrians. Given the small variance in participants' ages (with most being adolescents), it is perhaps to be expected that age did not prove predictive in the current study. With a more heterogeneous sample including children under the age of 10, these results may differ and be more aligned with research showing that younger pedestrians are at an increased risk of being involved in train–pedestrian collisions (Searle et al. 2012). The finding that sensation seeking did not predict intentions in the current study may be due to a number of factors, including the sensation-seeking construct itself and the nature of railway crossing violations. As noted in the current study and in previous research, intentional rule breaking at level crossings appears more related to time pressures than the seeking out of novel experiences. As such, sensation seeking may have a limited impact on intentional violations in such a context due to being negated by other overriding factors such as being in a hurry. An argument also exists for the differentiation between impulsive, unsocialised sensation seeking and non-impulsive, socialised sensation seeking (Glicksohn & Abulafia 1998), with the latter being associated with a higher degree of self-control and less disinhibition (Suranyi et al. 2013). Future research might therefore consider investigating the role of non-impulsive sensation seeking, impulsivity more broadly, or other motivational factors as opposed to sensation seeking, in the context of railway level crossing violations.

Given the strength of subjective norm towards intentions, one approach to counteracting deliberate railway violations may be to emphasise

that important others would disapprove of deliberate rule-breaking behaviour. Highlighting, also, the general consensus regarding the inappropriateness and dangers of rule breaking at crossings may prove to have some efficacy in reducing risks resulting from violations. A similar approach that aims to maximise safety culture has demonstrated the potential to improve traffic safety at a group level (Banks, Freeman, & Davey 2014; Edwards et al. 2014). However, research has yet to identify the most effective manner to improve and sustain increased perceptions of safety at a group or population level (Guldenmund 2000). This may prove to be a particularly difficult task for younger cohorts, as a series of competing forces including personal, social and situational factors are likely to influence impulsive decisions to violate crossing rules on any one occasion. Currently, few evaluations have been undertaken to determine whether education campaigns that highlight the physical threat of breaking crossing rules are effective at modifying behaviour. One of the few studies targeting school children revealed that railway safety awareness-raising approaches were unlikely to be effective unless complemented with enforcement techniques (Lobb et al. 2003). Promising results have been reported in a 16-month Illinois study, which examined a combined education and enforcement campaign in which a 76% decrease was reported in rates of pedestrians circumventing a closed barrier (Sposato, Bien-Aime & Chaudhary 2006). Consistent with other injury-prevention domains, interventions have outpaced corresponding evaluations and there is a need to conduct applied evaluative research to determine the efficacy of different approaches to reduce level crossing injuries.

Limitations and conclusions

The study's limitations should be borne in mind when interpreting the results. First, participants were not randomly selected and, as such, questions remain regarding the representativeness of the sample. Second, the sample was small, and further research should replicate the design with a larger sample. This is particularly important given that only six participants (5% of the current sample) reported making errors at railway pedestrian crossings, and thus the comparisons made between errors and intentional violations are not definitive. Third, the study only contained self-reported data, and there may be some discrepancy between stated behaviour and actual events, particularly when responses focused on breaking rules. Despite this, self-report bias (in particular, impression management) has not been demonstrated to have spurious effects on admissions of aberrant behaviours among adults (Sullman & Taylor 2010). Fourth, from a TPB point of view, the definition of the target behaviour could be considered quite vague ('breaking the rules at a railway pedestrian crossing in the next six months') and a different pattern of results may be found with an alternative, more specific definition. Finally, it is important to note that the study's primary focus on intentional rule-breaking behaviour necessarily has not taken into account the many other factors that may influence safe and unsafe behaviour at railway level crossings. The study highlights the psychological underpinnings of rule-breaking behaviour based on the assumption that rule compliance should increase safety, though it is noted that many other interventions may also improve safety at railway level crossings.

Notwithstanding these limitations, this study is one of the first to clarify that a large proportion of deliberate violations constitute aberrant behaviours at level crossings for younger cohorts. It also provides initial support for the utility of the TPB in predicting intentions to deliberately violate railway crossing rules, highlighting the effect of attitudes and normative influences on young individuals' intentions. In contrast, the study failed to demonstrate the influence of sensation seeking on rule-breaking behaviour. These findings are, however, only preliminary, as this study represents one of the only known studies to examine the psychological factors that influence level crossing behaviours among this high-risk group. Given the ongoing personal and social impact of pedestrian–train collisions, there is a clear need for further research to not only illuminate the psychological underpinnings of rule breaking at level crossings among younger cohorts but also design and evaluate evidence-based interventions to improve pedestrian crossing behaviours.

REFERENCES

Ajzen, I 1991, 'The theory of planned behaviour', *Organisational Behaviour and Human Decision Processes*, vol. 50, pp. 179–211.

Armitage, CJ & Conner, M 2001, 'Efficacy of the theory of planned behaviour: A meta-analytic review', *British Journal of Social Psychology*, vol. 40, pp. 471–99.

Arup 2005, *Platform Access at Bentleigh, Carnegie and McKinnon Stations: Survey and Assessment*, report by Arup for VicTrack, Department of Infrastructure, Melbourne.

Australian Bureau of Transport and Regional Economics 2002, *Rail Accident Costs in Australia*, Report 108, Bureau of Transport and Regional Economics, Canberra, Australia.

Australian Transport Safety Bureau 2004, *Level Crossing Accident Fatalities*, Australian Transport Safety Bureau.

http://www/atsb.gov.au/publications/2004/lev_crossfat.aspx.

Australian Transport Safety Bureau 2011, *Australian Rail Safety Occurrence Data 1 January 2001 to 31 December 2010*, ATSB Transport Safety Report Rail Statistics RR-2011-004, Australian Transport Safety Bureau, Canberra, Australia.

Banks, T, Freeman J & Davey J. 2014, 'The influence of fleet safety culture on occupational driver behaviours and traffic incidents', *Proceedings 2nd Occupational Safety in Transport Conference*, Gold Coast, Australia, http://ositconference.com/program/2014-proceedings/.

Caird, JK, Creaser, JI, Edwards, CJ & Dewar, RE 2002, *A Human Factors Analysis of Highway-Railway Grade Crossing Accidents in Canada*, Montreal, Canada, Transport Canada.

Chorlton, K, Conner, M & Jamson, S 2012, 'Identifying the psychological determinants of risky riding: An application of an extended Theory of Planned Behaviour', *Accident Analysis and Prevention*, vol. 49, pp.142–53.

Clancy, J, Duck, NJ, Grey, E, Knightly, I, Misa, R & Scott, M 2007, *Study of Pedestrian Behaviours at Public Railway Crossings*, Victoria: Lloyd's Register Rail for Public Transport Safety.

Conner, M, Lawnton, R, Parker, D, Chorlton, K, Manstead, ASR & Stradling S 2007, 'Application of the theory of planned behaviour to the prediction of objectively assessed breaking of posted speed limits', *British Journal of Psychology*, vol. 98, pp. 429–53.

Diaz, EM 2002, 'Theory of planned behaviour and pedestrians' intention to violate traffic regulations', *Transportation Research Part F – Traffic Psychology*, vol. 5, no. 3, pp. 169–75.

Edquist, J, Hughes, B & Rudin-Brown, CM 2011, *Pedestrian Non-Compliance at Level Crossing Gates*, Curtin-Monash Accident Research Centre.

Edwards, J, Freeman, J, Soole, D & Watson, B 2014, 'A framework for conceptualising traffic safety culture', Transportation Research P*art F – Traffic Psychology*, volume 26, part B, pp. 293–302.

Freeman, JE, Rakotonirainy, A, Teodora, S & McMaster, M 2013, 'Understanding pedestrian behaviour at railway level crossings: is there a need for more research?', *Road & Transportation Research*, vol. 22, no. 3, pp. 29–39.

Freeman, JE & Watson, B 2009 'Drink driving deterrents and self-reported offending behaviours in a sample of Queensland motorists', *Journal of Safety Research*, vol. 40, no. 2, pp. 113–20.

Glicksohn, J & Abulafia, J 1998, 'Embedding sensation seeking within the big three', *Personality and Individual Differences*, vol. 25, pp. 1085–99.

Guldenmund, F 2000, 'The nature of safety culture: a review of theory and research', *Safety Science*, vol. 34, pp. 215–7.

Henley, G & Harrison, JE 2009, *Serious Injury Due to Transport Accidents Involving a Railway Train, Australia, 2002-03 to 2006-07*, Australian Institute of Health and Welfare, Canberra

Holland, C & Hill, R 2007, 'The effect of age, gender and driver status on pedestrians'' intentions to cross the road in risky situations', *Accident Analysis and Prevention*, vol. 39, pp. 224–37.

Homel, RJ 1988, *Policing and Punishing the Drinking Driver. A Study of Specific and General Deterrence*, New York, Springer-Verlag.

Jonah, BA 1997, 'Sensation seeking and risky driving: A review and synthesis of the literature', *Accident Analysis and Prevention*, vol. 29, no. 5, pp. 651–65.

Jonah, BA, Thiessen, R & Au-Yeung, E 2001, 'Sensation seeking, risky driving and behavioural adaptation, *Accident Analysis and Prevention*, vol. 33, no, 5, pp. 679–84.

Keegan, O & O'Mahony, M 2003, 'Modifying pedestrian behavior', *Transportation Research Part A – Policy and Practice*, vol. 37, pp. 889–901.

Khattak, A & Luo, Z 2011, 'Pedestrian and bicyclist violations at highway-rail grade crossings', *Transportation Research Record*, no. 2250, pp. 76–82.

Knutton, M 2004, 'The best level crossing is one that doesn't exist', *International Railway Journal and Rapid Transit Review*, vol. 44, no. 4, pp. 26.

Lloyd's Rail Register 2007, *Study of Pedestrian Behaviour at Public Railway Crossings*, Public Transport Safety Victoria, Melbourne.

Lobb, B, Harre, N & Terry, N 2003, 'An evaluation of four types of railway pedestrian crossing safety interventions', *Accident Analysis and Prevention*, vol. 35, no. 4, pp. 487–94.

Moan, IS & Rise, J 2011, 'Predicting intentions not to 'drink and drive' using an extended version of the theory of planned behaviour', *Accident Analysis and Prevention*, vol. 43, pp. 1378–84.

Railway Safety Regulators' Panel 2008, *Review of National Level Crossing Statistics*, retrieved from http://www.rsrp.asn.au/files/publications/14_32.pdf.

Richards, SH & Heathington, KW 1990, 'Assessment of warning time needs at railroad-highway grade crossings with active traffic control', *Transportation Research Record*, no. 1254, pp. 72–84.

Searle, A, Di Milia, L & Dawson, D 2012, *An Investigation of Risk Takers at Railway Level Crossings*, CRC Project # R2.114, Cooperative Research Centre for Rail Innovation, Brisbane.

Silla, A & Luoma, J 2009, 'Trespassing on Finnish railways: Identification of problem sites and characteristics of trespassing behaviour', *European Transport Research Review*, vol. 1, no. 1, pp. 47–53.

Silla, A & Luoma, J 2012, 'Main characteristics of train pedestrian fatalities on Finnish roads', *Accident Analysis and Prevention*, vol. 45, pp. 61–6.

Spicer, T 2008, 'A railway pedestrian crossing case study', paper presented at the *10th World Level Crossing Symposium: Safety and Trespass Prevention*, Paris, France.

Sposato, S, Bien-Aime, PP & Chaudhary, M 2006, '*Safety of Highway-rail grade crossings: Public education and enforcement research study*', Final Report, US Dept. of Transportation, Federal Railroad Administration, Office of Research

and Development, Report No. DOT/FRA/ORD-06/27, Washington, DC.

Sullman, M & Taylor, J 2010, 'Social desirability and self-reported driving behaviours: Should we be worried?' *Transportation Research Part F – Traffic Psychology*, vol. 13, pp. 215–21.

Suranyi, Z, Hitchcock, DB, Hittner, JB, Vargha, A & Urban, R 2013, 'Different types of sensation-seeking: A person-oriented approach in sensation-seeking research', *International Journal of Behavioural Development*, vol. 37, no. 3, pp. 274–85.

Sutton, S, McVey, D & Glanz, A 1999, 'A comparative test of the theory of reasoned action and theory of planned behaviour in the prediction of condom use intentions in a national sample of English young people', *Health Psychology*, vol. 18, no. 1, pp. 72–81.

Wallace, A 2008, *Motorists Behaviour at Railway Level Crossings: The Present Context in Australia*, unpublished PhD thesis, Queensland University of Technology, Brisbane, Australia.

Zuckerman, M 1979, *Sensation Seeking: Beyond the Optimal Level of Arousal*, Hillsdale, New Jersey, Erlbaum,

Zuckerman, M 2007, *Sensation Seeking and Risky Behaviour*, Washington, DC, American Psychological Association.

Millie Darvell

Millie is a research officer at the Centre for Accident Research and Road Safety – Queensland in the Faculty of Health. She is also a project officer at Metro North Hospital and Health Service, a registered psychologist and a member of the Australian Psychological Society. Her current research interests include social psychology, drug and alcohol-related risks and accidents, cyberpsychology, web-based interventions, and technology addictions.

James Freeman

James is an Associate Professor at the Centre for Accident Research and Road Safety – Queensland in the Faculty of Health. James' current research interests include method effects, human machine interfaces, deterrence, perceptions of risk, drug driving, drink driving, prevention of alcohol-related violence, risk assessment and offender rehabilitation. He is also a registered psychologist, a member of the Australian Psychological Society and an Executive Member of the College of Forensic Psychologists (National Committee & Queensland Chapter).

Andry Rakotonirainy

Professor Andry Rakotonirainy directs the Intelligent Transport System human factor research program within the Centre for Accident Research and Road Safety – Queensland. He is also a program leader for operations Safety in the CRC for Rail Innovation (RailCRC). He has 25 years of research experience in computer science and brings advanced expertise in road safety and context-aware systems. He is a regular visiting Professor to the French institute of sciences and technology for transport, development and networks (IFSTTAR).

CONTACT

Millie Darvell
Centre for Accident Research and Road Safety – Qld (CARRS-Q)
Queensland University of Technology (QUT)
Kelvin Grove, Qld. 4059
Email: millie.darvell@qut.edu.au

ACKNOWLEDGEMENTS

The authors would like to acknowledge the funding of this research by the Cooperative Research Centre (CRC) for Rail Innovation.