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To stop or not to stop: Contrasting compliant and non-compliant driver behaviour at rural rail level crossings

Vanessa Beanland[a,b,*], Paul M. Salmon[a,b], Ashleigh J. Filtness[b,c], Michael G. Lenné[b], Neville A. Stanton[a,d]

[a] Centre for Human Factors and Sociotechnical Systems, University of the Sunshine Coast, Sippy Downs, QLD, Australia
[b] Monash University Accident Research Centre, Monash University, Clayton, VIC, Australia
[c] Loughborough Design School, Loughborough University, Loughborough, United Kingdom
[d] Transportation Research Group, Civil, Maritime, Environmental Engineering & Science Unit, University of Southampton, Southampton, United Kingdom

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ABSTRACT

Many rail level crossings (RLXs) have only passive protection, such as static signs instructing road users to stop, yield, or look for trains. Stop signs have been suggested as a low-cost option to improve safety at passive RLXs, as requiring drivers to stop should encourage safe behaviour. However, field observations have noted high rates of non-compliance at stop-controlled RLXs. To explore this further, we conducted an on-road study to identify factors that influence compliance at stop-controlled RLXs. Twenty-two drivers drove a 30.5 km route in rural Australia, encompassing three stop-controlled RLXs. In over half of all cases (59%) drivers stopped completely at the RLX; on 27% of crossings drivers executed a rolling stop, and on 14% of crossings drivers violated the stop controls. Rolling stops were defined as a continuous deceleration to < 10 km/h, but remaining above 0 km/h, before accelerating to > 10 km/h. Behavioural patterns, including visual checks and decision-making, were similar when comparing drivers who made complete versus rolling stops. Non-compliant drivers did not differ from compliant drivers in approach speeds, but spent less time visually checking for trains. Post-drive interviews revealed some drivers wilfully disregarded the stop sign, whereas others did not notice the stop sign. Those who intentionally violated noted trains were infrequent and suggested sight distance was good enough (even though all crossings had been formally assessed as having inadequate sight distance). Overall the results suggest most drivers exhibit safe behaviour at passive RLXs, but a notable minority disregard or fail to notice signs. Potential avenues for redesigning passive RLXs to improve safety are discussed.

1. Introduction

Safety issues are prevalent at rail level crossings (RLXs) worldwide (Evans, 2011; Mulvihill et al., 2016; Pyrgidis et al., 2016). Accordingly, a range of active and passive traffic control devices are used to guide road user decision-making at RLXs. *Active RLXs* incorporate warnings (e.g., flashing lights, bells) and/or barriers that activate when a train is approaching, whereas *passive RLXs* have only static signs and road markings. Crash analyses indicate that active RLXs, especially those with barriers or gates, have superior safety performance (Austin and Carson, 2002; McCollister and Pflaum, 2007; Raub, 2009; Saccomanno et al., 2007). However, passive RLXs predominate in many countries, constituting approximately two-thirds of Australia's public RLXs (ATSB, 2008). Although upgrading to active controls is a government priority it remains cost-prohibitive, with a low benefit-cost ratio (Cairney et al., 2002). This has prompted researchers and practitioners to seek cost-effective ways of improving safety at passive RLXs (Read et al., 2017).

One low-cost option could be passive signs that promote safer decision-making. The prototypical sign at passive RLXs is a crossbuck, sometimes with the instruction to yield, slow or look for trains (Yeh and Multer, 2007). These configurations place the onus on individuals to decide whether to stop. An alternative is to add stop signs, which should reduce decision uncertainty by legally obliging road users to stop. At stop-controlled RLXs, it is common to have a stop sign placed immediately at the RLX, usually with a crossbuck to indicate the presence of an RLX. Some stop-controlled RLXs include additional signage (e.g., advance warning signs that signal an upcoming passive RLX and/or the need to stop ahead) and road markings, such as a painted stop line (see Fig. 1).

* Corresponding author at:
E-mail address: vbeanlan@usc.edu.au (V. Beanland).

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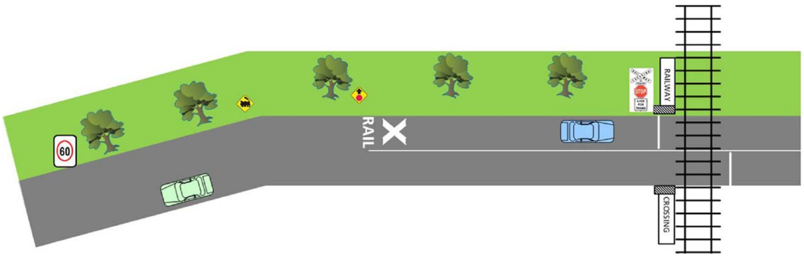

Fig. 1. Example configuration for a stop-controlled rail level crossing in Australia. Signs at the crossing include a crossbuck, stop sign, a sign that says "look for trains" and signs flanking the road saying "railway" and "crossing". Signs on approach include an icon of a steam train (indicating a passive rail level crossing ahead) and a sign indicating a stop sign ahead.

Table 1
Summary of previous research findings on compliance at stop-controlled rail level crossings.

Study	Location	Study type	Compliance
Russell et al. (2007)	Kansas, USA	Field observation	12%
Tey et al. (2011)	Queensland, Australia	Field observation	41%
Kasalica et al. (2012)	Čapljinac, Serbia	Field observation	43%[a]
Rudin-Brown et al. (2012)	Victoria, Australia	Simulator	44%[a]
Lenné et al. (2011)	Victoria, Australia	Simulator	60%[a]
Tey et al. (2013)	Queensland, Australia	Simulator	67–74%

[a] Denotes studies that only collected data when a train was approaching, so non-compliant drivers crossed in front of an oncoming train. All other studies represent a mix of train-present and train-absent encounters.

1.1. Driver compliance at stop-controlled RLXs

Stop controls theoretically encourage all drivers to make safe, consistent decisions at passive RLXs (Ward and Wilde, 1996). Supporting this, a recent simulator study found that stop signs increased both stopping and looking behaviour at passive RLXs (Liu et al., 2016). Despite this, there is evidence that many drivers violate RLX stop signs (Kasalica et al., 2012; Lenné et al., 2011; Rudin-Brown et al., 2012; Russell et al., 2007; Tey et al., 2011, 2013). As summarised in Table 1, compliance rates vary greatly, with field observations in USA, Australia and Serbia revealing real-world compliance rates from 12% and 43% (Kasalica et al., 2012; Russell et al., 2007; Tey et al., 2011).

Compliance at stop-controlled RLXs tends to be higher in simulator studies, ranging from 44% to 74% (Lenné et al., 2011; Rudin-Brown et al., 2012; Tey et al., 2013), but is still well below the compliance rates for active controls: the same simulator studies found 76–80% compliance at traffic lights (Lenné et al., 2011; Rudin-Brown et al., 2012) and 96–100% compliance with flashing lights (Lenné et al., 2011; Tey et al., 2013). Two simulator studies incorporated interviews that explored drivers' interpretations of traffic controls. Strikingly, 29% of participants in Queensland, Australia, and 88% of participants in Victorian, Australia, suggested the correct response at a stop-controlled RLX is to "look for a train" and/or "slow down" (Rudin-Brown et al., 2012; Tey et al., 2013).

1.2. Reasons for noncompliance

A key limitation is that previous research has not identified the reasons underlying noncompliance. Although some simulator studies have explored this, there remains limited understanding of why some drivers disregard stop signs at RLXs. This is particularly so for RLX encounters in naturalistic settings. This is a significant knowledge gap, as understanding the factors driving non-compliance should inform the design of interventions to prevent it.

Researchers have suggested that noncompliance in US studies stems from "indiscriminate" application of stop signs at RLXs (Raub, 2009; Russell et al., 2007). US regulations permit installation of stop signs at any RLX with at least two trains per day. This means stop signs are used at very low-volume RLXs, whereas elsewhere in the road network they are installed at relatively busy non-RLX intersections (Raub, 2009). The consequence is that whereas drivers often encounter traffic at *road* intersections with stop signs, they rarely encounter trains at stop-controlled RLXs, meaning the RLX environment deviates from the prototypical stop-controlled intersection.

Other jurisdictions have more stringent regulations regarding the use of stop controls. In Australia, stop signs are only installed at RLXs with restricted visibility on approach (Standards Australia, 2007). Specifically, stop signs must be used at passive crossings if approaching road users would not have enough time to stop safely from the point at which they can first see far enough down the tracks to detect an oncoming train. Ideally, such strict regulation should foster greater compliance; however, this presupposes that drivers recognise and agree with the reasons for installing stop controls. This is questionable given that Australian research found many drivers declare "slowing down" is the appropriate response to a stop sign (Rudin-Brown et al., 2012; Tey et al., 2013).

One avenue for understanding drivers' behaviour is through Neisser's (1976) perceptual cycle model, which posits that our perception of the world is a constructive, iterative process that originates from our schemata, or mental models of what we expect to encounter. The content of our schemata is based on our past knowledge and experience, and guide our exploration or information-seeking within our environment. The information we sample through this process is then used to update the relevant schema, so our future understanding of situations will be strongly influenced by what we have encountered in the past. The perceptual cycle model and schema theory have been applied to various topics within human factors and ergonomics (Plant and Stanton, 2013a,b; Stanton et al., 2009), including RLX safety (Salmon et al., 2013b). It has been argued that inappropriate decisions and actions at RLXs can be explained as schema-driven failures; for instance, if a driver has encountered a specific RLX multiple times without seeing a train, they may form a strong expectation that they will *never* see a train there. This type of faulty schemata can have tragic consequences, as in the 2007 collision near Kerang, Victoria, Australia, in which a truck driver failed to detect that flashing lights were activated and a train was approaching. In the Kerang collision, the truck driver had extensive experience with the RLX in an inactive state, which contributed to him making a "looked-but-failed-to-see" error and not realising the RLX signals were active (Salmon et al., 2013b). Inappropriate schema activation can also occur (Norman, 1981). Here the RLX environment may inadvertently trigger the wrong schemata in drivers; for example, drivers may activate the schemata for a standard active RLX if they do not possess relevant schema for stop-controlled RLXs, which in turn may lead to the driver failing to stop and/or adequately scan for trains.

At stop-controlled RLXs, different drivers may possess vastly different schemata that guide their actions. Drivers who have extensive experience at passive RLXs may possess schema that indicate stop signs are unnecessary (e.g., as in the US example, where stop signs are used indiscriminately, or in Australia if drivers do not appreciate the potential risks), which could lead them to violate the warnings. Alternatively, drivers in Australia may possess schemata that a stop sign signals a specific subtype of RLX (i.e., no active warnings, restricted