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Driver compliance with, and understanding of, level crossing controls

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Abstract

Since the early 1970s, in an effort to improve road safety, Australian railway authorities have made a concerted effort to reduce the number of level road-rail crossings, particularly those controlled by passive devices such as ‘give way’ or ‘stop’ signs. Despite this effort, approximately 1400 passive-controlled level crossings in Victoria remain in operation. To improve this situation, passive level crossings are often ‘upgraded’ with active traffic controls devices. Consequently, the question arises as to which of the available options represents the most effective active traffic control device at level crossings.

The main objective of the present study was to compare the efficacy, and drivers’ subjective perception, of different traffic control devices at level crossings. Twenty-five fully-licensed drivers aged between 20 and 50 years participated in a high fidelity driving simulator study that compared three level crossing traffic control devices. A stop sign-controlled level crossing served as the passive referent, while two different active level crossing traffic control devices were also assessed: flashing lights and standard traffic lights.

Because traffic lights are believed to be more recognisable and to convey more salient information to drivers than flashing lights, it was hypothesised that drivers would report a preference for traffic lights over flashing lights at level crossings, and that this preference would correlate with safer driving behaviour. In fact, however, the majority (56%) of drivers reported preferring flashing lights to traffic lights, and were less likely to commit a crossing violation at one equipped with flashing lights than one with traffic lights.

Forty per cent of participants made violations at the stop sign-controlled level crossing. Collectively, results indicate that the installation of traffic lights at real-world level crossings may not offer safety benefits over and above those provided by flashing lights. Furthermore, the high rate of violations at passively controlled crossings strongly supports the continued practice of upgrading level crossings with active traffic control devices.

Keywords

Driving simulator, Driver behaviour, Subjective data, Road safety

Introduction

Road-rail level crossings exist within all road categories and can be either of two types: those controlled by active devices (i.e., that provide a signal to vehicle drivers of an approaching train), or those that are controlled by passive devices (referred to as ‘passive’ level crossings). The latter are characterised by signage only (usually a ‘give-way’ or ‘stop’ sign) and, as their name suggests, do not provide any active indication to drivers of the presence or absence of oncoming trains.

While the overall number of level crossings in Victoria has decreased by about 30% from the early 1970s to the year 2000, there has been, in the same period, a much larger reduction of 73% in the number of collisions and an even larger reduction of 85% in the number of deaths at railway level crossings [1]. This is likely due, at least in part, to the upgrading of many level crossings from passive, to active, controls. For example, while there was a 48% decrease in the number of passive level crossings from 1969-1974 to 1996-2000, there was a corollary increase of 46% in the number of crossings controlled by flashing lights, and a 295% increase in the number controlled by flashing lights with boom barriers [1]. Despite these changes, however, safety at railway level crossings remains one of the top concerns amongst road and rail authorities.

Understanding why drivers cross against active level crossing controls is important in order to devise appropriate countermeasures. An investigation of 87 fatal level crossing crashes by the Australian body responsible for investigating fatal transport accidents [2] found that unintentional error was a more common causal factor in level crossing crashes than in other fatal road crashes. It is likely that the saliency, or conspicuity, of a level crossing control is strongly implicated in this unintentional driver error. Although typical level crossing controls may be designed to be physically obvious to users, they do not always convey the intended urgency. In fact, Green [3] noted that level crossing control design is not typically based on human factors knowledge regarding the most effective means of conveying information to the driver.

In an effort to make them more conspicuous, current railway level crossing controls such as flashing lights were intentionally designed to be dissimilar to common road warnings [4]. It is possible that this design philosophy may have inadvertently reduced the controls' effectiveness by making them more difficult for drivers to understand. Using standard traffic lights at level crossings instead of red flashing lights may improve drivers' decision making ability and improve the level of warning compliance.

The rationale behind this proposal involves the hypothesis that drivers will be more likely to comply with traffic lights because they represent stimuli associated with a well-learned response, i.e., a sequence of behaviours that ultimately concludes with the driver bringing his or her vehicle to a full stop. In addition, failing to stop at a traffic light is a well-known, prosecutable offence, while failing to stop at a level crossing equipped with active flashing lights may not be regarded as seriously. In addition, the use of standard traffic lights at railway level crossings will provide an additional warning phase (the amber phase) that may allow drivers to make safer judgements regarding whether to stop or to continue through a level crossing.

To date, only one published evaluation of traffic lights at level crossings has been conducted [5]. Two months of data were collected before and after the installation of traffic lights at a level crossing previously equipped with flashing lights. Compared to the number of vehicles crossing when the flashing lights were active, the number of vehicles crossing during the red traffic light phase was lower by 80 per cent.

The present study assessed driver compliance to, and subjective perceptions of, two active level railway crossing controls: Flashing lights vs. traffic lights. It was hypothesised that drivers would report a preference for traffic lights over flashing lights at level crossings and that this preference would correlate with safer driving behaviour in terms of fewer level crossing violations.

Methods

Twenty-five fully licensed drivers (19 males, 6 females) aged 20-50 years (mean = 33.7 [SD = 9.2]) took part in the study. Participants were recruited by means of notices posted within the local community, the MUARC potential participant database and advertisements in a local community newspaper, and were compensated $20 for their participation. The study was approved by the Monash University human ethics committee. A within-subjects design with level crossing control (three levels) as a factor was used for both groups.

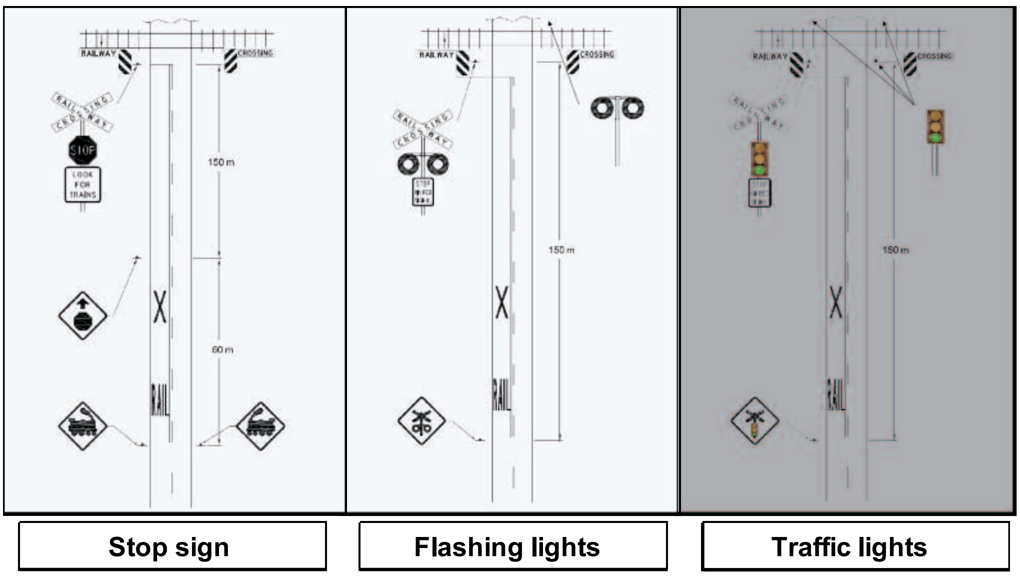

Figure 1. Schematic diagrams of simulated level crossing conditions

Equipment

Driver testing was carried out using the MUARC advanced driving simulator, which consists of a GM Holden VE Commodore sedan mounted on a three degrees-of-freedom motion base and a curved projection screen (located in front of the vehicle) that provides a 180° horizontal and 40° vertical field of view. Forward vision was produced by three image generators using seamless blended projection onto a cylindrical screen, while rear vision was provided by a separate projection screen at the rear of the vehicle. An experimenter controlled all driving simulations remotely from a control room.

Design of the simulated level crossing conditions was informed by examination of level crossing data provided to the investigators by VicTrack, as well as the relevant Australian standards. Figure 1 presents schematic diagrams of the three simulated level crossing conditions.

In relation to the subject vehicle, an approaching train was programmed to arrive at each level crossing at the same time (i.e., approximately 20 seconds after the arrival of the subject vehicle). This was done to ensure that a participant's decision to stop safely or to proceed through the crossing was based upon the crossing characteristics and not confounded by potential detection of the oncoming train itself. In all conditions, a train horn sounded just prior to the train arriving at a level crossing.

When activated, the Flashing light-controlled level crossing (Figure 1, centre panel) showed red lights flashing alternately at a rate of 45 per minute, accompanied by audible warning bells (60 dB) ringing at a rate of 60 bells per minute. Activation of the flashing light controls was dependent on the speed of the subject vehicle and occurred at the same relative time point across participants. The lights would continue to flash and the bells would continue to ring until approximately three seconds after the train cleared the level crossing. The entire sequence took 37 seconds.

In accordance with instructions from VicRoads signal engineers and Victrack, the Traffic light-controlled level crossing (Figure 1, right panel) comprised two primary sets of traffic lights on the left and right hand sides of the road on the approach side of the level crossing, and two additional sets of traffic lights on both sides of the departure side of the crossing. When activated, the traffic lights cycled from green to amber for a duration of 4.5 seconds, and then to red. Audible warning bells (60dB) accompanied the amber and red traffic lights. Like the Flashing light-controlled level crossing condition, activation of the traffic light controls was dependent on the speed of the subject vehicle and occurred at the same relative time point across participants. The traffic light would remain red and the bells would continue to ring until approximately three seconds after the train cleared the level crossing, at which point the traffic light changed to green. The entire sequence took 37 seconds.

Procedure

Upon their arrival at the simulator laboratory, participants signed an informed consent form and filled out demographics and general driving questionnaires. Participants were told that the study 'was looking at how people respond to traffic controls, such as road signs, signals and road markings', but were not informed that the focus of the study was level crossing controls. The first exposure to the driving simulator was a 10-minute *familiarisation drive*. This drive allowed participants to experience the virtual driving environment and the control dynamics of the simulated vehicle. Participants were instructed to practise accelerating and braking gently, and to practise driving at a consistent speed of 80 km/h.

After the *familiarisation drive*, the simulator was configured for the first of two 15-minute test drives. Each *test drive* consisted of a two-lane highway with gentle curves and dips. Scenario road geometry was designed according to the VicRoads Traffic Engineering Manual [6] as well as from video data of typical Victorian roads. Each participant encountered a total of four level crossing scenarios during the test trial, two in each *test drive*. The final level crossing encountered had an activated warning device (either flashing lights or traffic lights), but was not associated with the arrival of a train (i.e., the level crossing was in 'failure' mode). Data from that level crossing exposure are not described in this report.

The order of presentation of the level crossings, with the exception of the failure mode crossing, was counterbalanced across participants to limit any potential confounding due to order effects. Each level crossing type was presented first, second or third within the experimental trial, an equal number of times across drivers. On average, participants encountered a level crossing approximately every 7.5 minutes. In addition, drivers encountered three other road-road intersections during each *test drive* – one controlled by traffic lights, and two with stop signs on the secondary road. Oncoming traffic (approximately 3-4 vehicles per km, on average) was present during each *test drive*, but was not present at any of the level crossings. In between the two *test drives*, participants were given the opportunity to take a short break.

Upon completion of the second *test drive*, the experimenter brought participants to the simulator control room where they completed a face-to-face *post-drive interview*. Interview questions were designed to investigate participants' subjective perceptions of the different level crossing controls used in the study, as well as the acceptability and perceived convenience of each. Questions also related to the participants' typical behaviour at traffic control devices, and what they believed to be the appropriate behaviour at various level crossing and traffic controls. The *post-drive interview* took approximately 10 minutes to complete.

Results

Number of violations

The simulated oncoming train associated with each level crossing type was triggered according to the approach speed of the subject vehicle, which meant that the train arrived at approximately the same time point (20 seconds after the arrival of the subject vehicle) for all drivers. To determine whether a driver violated a level crossing control (i.e., drove through the crossing before the oncoming train arrived), two sources of data were consulted. First, minimum speed within the 50 metres before each level crossing was determined. If this speed was less than 10 km/h, then the driver was deemed to have stopped before that particular crossing. If the minimum speed was above 10 km/h, the driver was deemed to have driven through that particular crossing and this was defined as a violation.

These data were then compared to the experimenter's notes taken during testing and, in cases where there was a discrepancy between the two, further investigation took place. Only two cases were identified where a violation had occurred, even though the minimum speed was less than 10 km/h (both cases were at Stop sign-controlled crossings, where the subject vehicle slowed and then continued across the tracks despite the presence of an oncoming train). Percentage of completed stops vs. violations across each of the three level crossing controls is depicted in Figure 2. Chi-square analysis revealed a significant effect of level crossing type on proportion of violations, $\chi(2) = 7.36$, $p < .05$.

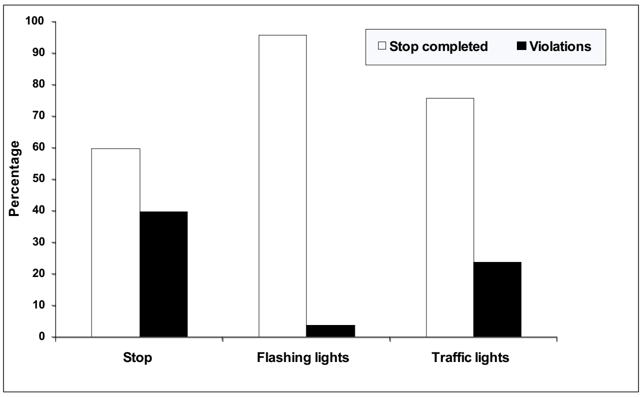

Figure 2. Proportion of drivers who violated the level crossing across conditions

Subjective data

Preferred level crossing control

In response to the question 'What do you think is the best form of traffic control device for level crossings—flashing lights or traffic lights?', 14 participants (56%) reported preferring flashing lights, while 11 (44%) reported that they preferred traffic lights.

Reasons offered for the preference of flashing lights included:

- The flashing lights represent trains, while traffic lights represent intersections ('historical presence')
- They 'grab your attention', are more 'obvious', offer better visibility, are more 'salient'
- They indicate danger more 'actively'
- They 'always mean stop'.

Reasons offered for preferring traffic lights included:

- They always mean the same thing
- Their purpose is more clear (than red flashing lights—these may just indicate a warning)
- They provide a warning phase (amber light)
- People are 'more used to them', and can be certain that they are working.

Confusion regarding level crossing controls

Participants were asked whether there were 'any railway crossings in the simulated drives at which they were confused about what to do'. Five drivers (20%) reported confusion at the Stop sign-controlled crossing; the most common reason provided for this confusion was that they could not adequately identify the stop sign in sufficient time to respond. Only two drivers reported confusion at the Flashing light-controlled level crossing.

Five drivers (20%) reported some confusion at the Traffic light-controlled level crossing. One reported that they felt confused until they saw the amber light change to red. Another reported that the traffic lights made sense, but seemed to be 'out of context'. This driver also stated that he did not expect to see a Traffic light-controlled level crossing out in the country, and that he thought this situation could be potentially dangerous. Other reasons offered for the confusion at the Traffic light-controlled level crossing included that the red light was not visible or 'didn't look red', that its activation was 'too late', and that the bells seemed quieter (than bells that sounded at the other controls).

Understanding of level crossing controls

Participants were asked to indicate what they believed to be the appropriate driving behaviour when approaching level crossings with various types of controls. For the Flashing light-controlled level crossing, all but one driver reported that the correct behaviour is to stop if approaching a level crossing where the red lights were flashing and bells were operating. When asked about the appropriate driving behaviour when approaching a level crossing with lights off and no bells ringing, 14 participants reported that the correct behaviour was to slow down and/or look and check for trains before proceeding. Three participants reported that it was correct to stop completely before proceeding, and five reported that it was correct to 'proceed with caution'. Three participants simply reported that it was correct to proceed and did not make any further comments.

When asked about approaching a level crossing controlled only by stop signs, 14 participants reported that the correct behaviour was to slow down and/or look for trains. Seven participants correctly reported that it was obligatory to come to a complete stop before looking and proceeding across the level crossing. One participant simply reported that it was correct to 'obey the signs'. Three participants reported that the correct behaviour was to 'proceed with caution'.

For Traffic light-controlled level crossings, 13 participants reported that the correct driving behaviour was to proceed through a regular traffic light showing green, and did not make any further comments. The remaining 12 participants reported that the correct driving behaviour at a green traffic signal was to proceed with caution, either slowing down, checking for trains or both. All participants reported that the correct driving behaviour when approaching a level crossing with a normal traffic light showing red was to stop.

When questioned regarding what to do if the traffic light was showing amber, 12 participants reported that the correct driving behaviour was to stop, while 11 reported that the correct driving behaviour was to stop if it was safe to do so and, if not (such as when the drivers considered themselves to be too close to the crossing), to proceed across the level crossing. One participant reported that the correct driving behaviour at an amber level crossing traffic light was to slow down, and one reported that the correct behaviour was to proceed.

Discussion

Drivers made fewer violations of level crossings controlled by flashing lights than of those controlled by traffic lights. When questioned, 56% of the same drivers reported preferring flashing lights to traffic lights as an active level crossing control. Reasons offered for this preference related primarily to the saliency of flashing lights, their ability to indicate danger more actively, and their strong association with rail level crossings (i.e., their historical presence). Some drivers expressed confusion regarding encountering traffic lights at a level crossing because they had not had prior exposure to this situation.

The observed violation data are in contrast to previous real-world results [5] that showed 80 per cent fewer drivers crossing during the red traffic light compared to during active flashing lights. The contrasting results may have been due to methodological differences between the two studies. For example, in the present study, only driver responses to active level crossing treatments where an immediate decision was required to brake and stop safely or to proceed through the crossing were examined. This design was deliberate, and while representative of safety-critical situations where an immediate decision to cross/not to cross was required, represents only a restricted set of level crossing experiences. It is unclear whether the proportion of violations would decrease in the active warning conditions if the active level crossing treatments had been activated several seconds earlier.

It is possible that the proportion of drivers who, in this study, did not comply with the red traffic light at a level crossing did this because they were not expecting to encounter such a level crossing control. If the use of traffic lights as level crossing controls was more common in the real world, or if the simulated traffic light control in the present study had been situated in an environment where drivers might be more likely to expect to see one, such as an urban environment, the relatively high number of violations might not have been observed.

Compliance at passively controlled level crossings was unexpectedly low. Forty per cent of drivers made violations of the Stop sign-controlled level crossing. When questioned, only 28% of drivers correctly stated that 'coming to a complete stop' was the required behaviour at this type of crossing, while 68% incorrectly reported the appropriate response to 'slow down and look for trains'.

Participants' understanding and interpretation of the correct behaviour when encountering level crossing controls in a variety of states of activation was quite varied. Of particular concern is the finding that over half of participants believed that the correct behaviour at a Stop sign-controlled level crossing is to slow down, and not to stop completely. This misunderstanding would be expected to have serious consequences at a real road-rail crossing equipped with a stop sign, as these crossings are designed to allow for a minimal driver line-of-sight to an approaching train when a vehicle is in a stopped position.

Previous field studies of level crossing violations [2], as well as road-rail collision statistics, illustrate why the safety of level crossings remains a priority among road and rail safety authorities. The present study assessed driver behaviour at, and understanding of, two different level crossing controls, and raised some subjective possibilities as to why drivers may react differently to different controls. In order to better understand this critical compliance issue, it is important that complementary real-world research also be conducted.

Simulators are excellent tools with which to investigate variables or factors that influence driving behaviour at the operational level; however, it is very difficult, if not impossible, to measure or address higher-order influences, such as motivation and drive, that shapes realistic human behaviour. Another limitation of the present study and of simulator studies in general is that participants were briefed on the general nature of the study beforehand. It is possible that they behaved differently compared to how they might in the real world because they knew they were being observed.

Another critical avenue for future research related to level crossing controls includes their assessment in urban environments. Lower speed limits, as well as increased visual clutter and greater potential for distraction in urban environments, may all impact driver behaviour. Drivers may also be more used to experiencing traffic lights in urban environments and, therefore, the confusion indicated in this study by some participants at the presence of traffic lights at a level crossing may be reduced.

Further, the extent to which a driver is distracted when they encounter a level crossing may interact with the saliency of certain level crossing controls. Given that the saliency of flashing lights was one of the reasons commonly given for the preference of flashing lights over traffic lights, it is important that future studies look at the effect of driver distraction on level crossing control saliency to determine whether crossing controls deemed salient and effective at low levels of distraction remain effective at high levels of distraction. Also relating to the issue of distraction, future studies could examine the potential benefits of in-vehicle train warnings at level crossings

In conclusion, although the present study was limited in that it only assessed driver compliance to level crossing controls situated in a rural environment and under very specific circumstances where an immediate decision was required to brake and stop safely or to proceed through the crossing, the finding that drivers made more violations of Traffic light-controlled level crossings than Flashing light-controlled level crossings suggests that the use of traffic lights in this capacity in real-world situations may not result in any additional safety benefits over and above those provided by flashing lights.

The subjective data provides further support for this notion. However, the reader is cautioned that more research on the issue is necessary before reliable conclusions can be made and on which related policy decisions should be based. Finally, the large number of violations seen with the stop sign condition underscores the importance of continuing to upgrade current passive level crossings to active status.

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An analysis of road signage and advertising from a pragmatic visual communication perspective: Case study of the M1 Motorway between the Gold Coast and Brisbane

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Abstract

This paper analyses examples of road signage and billboard advertising along the M1 Motorway between the Gold Coast and Brisbane from a pragmatic visual communication perspective. Such a perspective requires that two studies be conducted simultaneously. One study examines how people use designs while the other examines how features of designs meet people's needs.

For this research, the first study consisted of a literature review aimed at determining how people use road signage and advertising. Results indicate that drivers attend to signs differently depending upon personal variables such as driving experience, environmental variables such as traffic density, and sign variables such as the message and visual design.

The second part of the research involved comparing all types of signs along the M1 to best practice in the visual design of roadway information. In this paper, designs that follow best practice were considered to be those that follow principles of positive guidance. As part of this research, the author took photographs of signs in August and September 2008.

Results indicate that research could be conducted on a few types of sign designs. For road signage, it would be useful to study the effectiveness of educational messages placed on variable message signs and whether M1 drivers would find it