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## Are train horns improving road safety? Road users' perspective

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### ABSTRACT

Train horns are used as a control at railway level crossing for safety. Despite their wide use, limited information exists on their actual safety benefits. This study used focus groups with road users to understand their perceptions of the usefulness of train horns. This study showed that the message heard by road users is very simple and contrasts with the amount of information train drivers want to convey. The perceived benefits of the train horn were: (i) an additional layer of protection at active crossings; (ii) an important safety feature at rural/passive crossings; (iii) an increased safety benefit for vulnerable road users; and (iv) a greater safety benefit at night. The disadvantages of the use of train horns were perceived as outweighed by the safety benefits. This study highlights that reducing train horns, if safe to do so, could face resistance from road users and the rail industry.

### PRACTITIONER SUMMARY

The safety benefits of train horns at railway level crossings are not well-researched, despite their negative effects on health. This focus group study investigated road users' perceptions of the usefulness of train horns. It showed that reducing the use of train horns could face resistance from road users.

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Road safety; rail safety; railway level crossings; warning

## Introduction

Collisions at railway level crossings is a global issue, with continued concerns throughout the rail industry and transport agencies. Although major progress has been achieved in increasing safety at level crossings since the 1970s, the number of collisions tends to plateau in developed countries such as the US and Australia. Although such collisions are less likely than other road crashes, their effects are often catastrophic due to the difference in weight between the train and road users, the lack of possibility to steer the train away from the crossing and the long distance required to stop the train. In the U.S. between 2013 and 2022, an average of 2137 collisions occurred every year at railway crossings, resulting in 251 fatalities and 847 injuries every year (Federal Highway Administration 2023). In Australia, there were an average of 41 collisions at railway crossings every year between 2016 and 2021, resulting in 4 fatalities and 12 serious injuries per year (Office of the National Rail Safety Regulator 2023). Therefore, collisions at railway crossings remain a significant risk for rail operators.

Level crossings are composed of a superposition of safety components to ensure the safe traversal of traffic at crossings. Train horns are used to communicate train movements, such as arrivals and departures, and alert road users of a potentially dangerous situation (Queensland Rail 2020). As such, they are one of the safety mechanisms designed to alert road users to the approach of a train to produce more safety-compliant behaviours and reduce rail-related incidences, particularly around railway level crossings. Research has shown that train horn loudness negatively affects residents living near rail lines. As a result, research analysing the impacts of train horns has primarily focused on noise disturbance (Bellinger 2006; Bunn and Zannin 2016; Trombetta Zannin and Bunn 2014; World Health Organization 2018) and decreases in property prices (Bellinger 2006; Clark 2006; Cushing-Daniels and Murray 2005; Strand and Vågenes 2001; Walker 2016) rather than safety benefits (Coleman and Stewart 1990; Rapoza, Raslear, and Rickley 1999), and therefore little is known about the safety benefits of train horns.

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The greatest single contributing factor in collisions between road users and trains is driver error (Office of the National Rail Safety Regulator 2022). While some collisions result due to negligence on behalf of train operators, road vehicle drivers commonly contribute some level of responsibility, largely as a function of the inability for trains to engage in evasive action (Edquist, Stephan, and Wigglesworth 2009). The most common driver errors at railway level crossings are unintentional errors rather than lapses in attention or deliberate violations (Abraham, Datta, and Datta 1998). As such, there has been a considerable amount of human factors research into road user behaviour at railway crossings. However, the current literature fails to consider train horns, making it difficult to assess their safety benefits, above and beyond other railway crossings' safety components. A couple of recent studies provide new insights into the use of train horns in Australia. Larue et al. (2021) observed the use of train horns at railway crossings and found that there was a large variability in train horn usage by train drivers in terms of number, loudness, duration and timing, as well as the less common use of train horns at passively protected crossings (crossings equipped with a stop sign or give way sign). The study by Naweed et al. (2021) considered train horn use from a train driver's perspective and showed that the messages train drivers attempt to communicate using a train horn appear to be broader and more complex than simply signally the presence of a train.

With the development of technological alternatives to the use of train horns, such as wayside horns (i.e. horns located at the crossing and activated on train approach), there could be opportunities to reduce the use of train horns without compromising safety. However, a good understanding of train horn safety benefits is necessary for such a process to be undertaken by railway organisations. Given the ways that train drivers do provide messages with train horns and the potential interpretation that road users may have of a warning which sounds very different at a crossing compared to within the train cabin, it is essential to consider how train horns are actually being perceived by differing road users to understand the safety benefits and future utility of train horns.

## Background

### *Train horn negative effects have been extensively researched*

Despite the intended safety benefits of train horns, most literature has focused on negative aspects and disadvantages.

Internationally, research into the negative effects of train horns has extensively surrounded decreased property value. Studies have analysed property values considering the distance from train lines and exposure to rail noise pollution and consistently found significant monetary decreases in property values (Bellinger 2006; Clark 2006; Strand and Vågnes 2001; Walker 2016). Cushing-Daniels and Murray (2005) considered property values and rail crossing safety in a cost-benefit analysis and found costs associated with train horn use outweighed the safety benefits. However, safety benefits were measured as lives saved and did not consider other beneficial safety outcomes such as reduced collisions. While these studies provide insights, they do not necessarily reflect varied residential settings whereby the population density and further environmental, social and economic factors may influence the variability of property prices and their exposure to train horns. They also disregard the potential safety benefits of train horns.

The World Health Organization (2018) has stated noise pollution to be a growing global public health concern. Within this concern, railway noise pollution has been reported to contribute to health and wellbeing issues associated with annoyance and sleep disturbance, with some evidence for contributions to hypertension and hearing impairment (World Health Organization 2018). Trombetta Zannin and Bunn (2014) surveyed residents in Brazil and noted participants overall felt strongly affected by railway noise and that it led to headaches, poor concentration, irritation and insomnia Bellinger's (2006) research provided insights into circumstances where perceptions of noise disturbance from train horns and associated annoyance may vary. The results indicated that annoyance was greater for those residing closer to a rail crossing, for the sound of train horns over general train movements, for residents who lived close to rail crossings for a few years, at night and reflective of an individual's perception of train horn volume (Bellinger 2006). These findings suggest that noise pollution from rail in general and train horns in particular may be influenced by individual differences and salient experiences that contribute to perceptions of annoyance and disturbance.

Furthermore, although the studies mentioned analysed sleep-wake disturbances associated with railway noise, train horns were not isolated and specifically tested concerning the impact on sleep quality, resulting in confounding effects of general rail noise and train horns.

### *Safety benefits of train horns*

Studies analysing the safety benefits of train horns primarily reflected practices in the United States and

were linked to the trial of *horn bans*. When horn bans were implemented, railway crossing collisions were found to increase; this number decreased when the ban was rescinded (Rapoza, Raslear, and Rickley 1999). Train horns were found to lead to a 38–69% reduction in train-vehicle crashes, depending on railway crossing type, location, the train horn type used, train speed and background noise. This research has also found that crashes decrease as the probability of signal detection increases (Rapoza, Raslear, and Rickley 1999). Coleman and Stewart (1990) found similar results when analysing the effect of train horns on reducing collisions at active crossings in Florida, USA. They found whistle bans were associated with a tripling of level crossing collision rates at gated crossings.

Research analysing rail level crossing systems revealed that road users use various information sources to become aware of a rail level crossing to inform their behaviour. Although visual and audible cues, including train horns, alerted some road users of a rail level crossing, others noted environmental triggers or other road users' behaviour as critical indicators (Salmon et al. 2015). This indicates variability in how road users seek and attend to information that could alert them to the presence of a rail level crossing and a train. Perhaps it is unnecessary for most road users to selectively attend to train horns to ensure safety-compliant behaviour at rail level crossings. However, if other road users were absent or environmental factors varied, the need to attend to audible signals, like train horns, may need consideration.

The analysis of rail level crossing behaviour among a broader range of road users, including pedestrians, cyclists, drivers and motorcyclists, suggested auditory information and warnings were more beneficial in alerting vulnerable road users (Beanland et al. 2016; Salmon et al. 2013). On the other hand, drivers rarely relied on auditory information due to audibility being too low to be salient and were more reliant on visual cues (Beanland et al. 2016). These findings indicate that different modes of delivering information and warnings at rail level crossings are attended to in variation by different types of road users, with pedestrians and cyclists benefiting more from auditory information at rail level crossings to encourage safety-compliant behaviour.

Pedestrians as a cohort of road users are typically more vulnerable; therefore, understanding how safety warning mechanisms, including train horns, are perceived and interpreted is essential, particularly since the vast majority of research on railway level crossings disregards train horns (Larue et al. 2021). Though pedestrians may benefit more from auditory warnings

at level crossings (Beanland et al. 2016), perhaps these mechanisms do not function as intended for these users. Indeed, the timing of the warning is designed for road users responding the slowest (heavy vehicles) and does not consider increasing pedestrian distraction from mobile devices and headsets (Larue and Watling 2022). The current design may lead to increased non-safety compliant behaviours at rail level crossing among pedestrians due to perceptions of warnings giving pedestrians more time than necessary to cross safely. Even though pedestrians may rely more on auditory information at rail level crossings (Beanland et al. 2016; Salmon et al. 2013), these mechanisms may have been designed, arguably unsuccessfully, to meet drivers' needs and contribute to pedestrians engaging in unsafe behaviours (Mulvihill et al. 2016). Overall, train horns as a safety mechanism layer for various road users have not been thoroughly and recently researched.

### *Train horn use in Australia*

Larue et al. (2021) conducted observations at 54 railway crossings in four states in Australia. This study found that train horns were not always used, particularly at passively protected level crossings, despite the higher risk at such crossings. Further, this study identified a large variability in how train horns are used in terms of number, loudness, duration, and timing. Differences were also observed based on crossing type, remoteness, and train driver. Indeed, Australian standards and guidelines used by the rail industry are mostly open to individual interpretation with regard to train horns. This results in train drivers using train horns based on their perceptions of risk, experience, previous knowledge of level crossings and inclination to reduce noise pollution, as shown by Naweed et al. (2021).

Naweed et al. (2021) conducted focus groups with Australian train drivers to examine how and why train drivers used train horns and what message they intend to convey to road users. The focus groups used the Scenario Invention Task Technique (Naweed 2013) to identify critical themes associated with level crossing risks using concrete examples: participants were required to invent and interrogate their own railway level crossing scenarios and how train horns would be used. It was found that train drivers primarily viewed the train horn as a communication tool and a way to interact with other road users to inform of an approaching train and alert them to potential dangers. The train horn was widely used at least once as an informative tool with the intent to inform road users that the train

is approaching the level crossing. Some train drivers also used their horn as an attentive tool, attempting to help drivers to notice other dangers in the rail environment that they may not have noticed (e.g. another approaching train). Often, it was sounded multiple times to reinforce the imminence of train arrival at the crossing (Naweed et al. 2021). Train drivers also tend to respond to a likely situation rather than a particular situation (automatic cue-response links; i.e. the approach of the crossing automatically triggers train drivers to sound the train horn, independent of the current environmental conditions at the crossing), as they have limited opportunities to avoid a collision when they detect an emergency (Naweed et al. 2021). These insights highlighted that Australian train drivers viewed the train horn as an essential tool to inform and alert road users to ensure safety at rail level crossings.

All this reflects a disconnect between the expected and imagined use of the train horn, and the way it is performed in practice, with warning inconsistencies, standardisation issues, and a substantial portion of train horns blasts being of insufficient volume to warn road users (Larue et al. 2021). This raises questions on how road users interpret the complex message that train drivers attempt to convey.

Research on the negative effects and disadvantages of train horns has received greater attention in the literature than the positive impacts and safety benefits of train horns. Furthermore, varied road users' perspectives and interpretations of train horns are not widely understood nor comprehensively explored. To fill this gap identified in the research, the current study aims to describe the issue that limited insights are currently known about the safety benefits of train horns, particularly for road users that may be considered more vulnerable, including pedestrians. In addition, the current study aims to explore the notion that train horns are used very differently by different train drivers with different intentions, which raises questions about how train horns are perceived and interpreted by varied types of road users. Overall, providing valuable insights into the positive aspects and perceived safety benefits of train horns in Australia, considering road users' perspectives.

## Method

### Study design

The study consisted of focus groups with a wide range of road users (e.g. motorists, riders, cyclists, pedestrians) to investigate the perceptions of road users of the usefulness of train horns as a safety device.

The research team followed a semi-structured interview guide which contains a list of probe questions designed to explore participants' perceptions and experiences of train horns at level crossings, namely their (i) regular experiences of train horns at level crossings (e.g. *'When was the last time you heard a train horn?'*); (ii) perceptions of the purpose of a train horn (e.g. *'In your opinion, when you hear a train horn, what is the horn indicating?'*); (iii) initial reactions towards train horns/related feelings and behaviours (e.g. *'What is your initial reaction towards the sound of train horns?'*); (iv) perceived benefits and disadvantages of train horns at level crossings; and (v) influences of near-miss situations on feelings and behaviours related to train horns (e.g. *'Has this experience influenced your approach to level crossings since the event?'*). The questions were developed taking into consideration previous literature and the broader issues associated with rail procedures and safety.

### Participants

A total of twenty-nine participants aged between 19 and 77 years ( $M=42.1$ ;  $SD = 14.0$ ; 51.7% males) took part in the study. Nine focus groups were conducted with 2–4 participants per group ( $n=25$ ), as well as four individual interviews with participants who were unable to attend the groups. Table 1 illustrates the type of road users included in this study, with some participants identifying as a combination of various road users (e.g. cyclists and pedestrians). Around half of the sample of participants (51.6%) use level crossings with a unique mode of transport; 41.5% traverse level crossings regularly using two different modes of transport, and 6.9% with three different modes. Almost half of the sample (48.3%) also reported hearing train horns from their residence. To diversify the sample, participants were recruited using a range of methods, mainly snowball sampling, university emails, study advertisements posted in Facebook groups (e.g. motorcycle clubs) and local noticeboards, as well as approaching potential participants at urban level crossings in Brisbane.

### Procedure

Participants completed a 5-minute online demographic survey prior to commencement of the groups/interviews, with questions including participants' age, gender, type of road user, etc. The focus groups and interviews took approximately 40–70 min to complete and, due to enforced Queensland Government COVID-19 restrictions, were conducted online via Zoom. Three



**Table 1.** Type of road user when approaching a level crossing.

Road user/combination of road user	<i>N</i>	%
Motorist only	7	24.1
Pedestrian only	4	13.8
Motorcyclist only	2	6.9
Cyclist only	1	3.4
Scooter Driver only	1	3.4
Motorist + Cyclist	6	20.7
Cyclist + Pedestrian	3	10.3
Motorist + Pedestrian	2	6.9
Motorist + Cyclist + Pedestrian	2	6.9
Motorcyclist + Motorist	1	3.4

members of the research team were involved in data collection (AK, SN, DV); however, only two were present in each focus group, with one adopting the role of principal focus group facilitator and one adopting the role of secondary facilitator/note-taker. The individual interviews were conducted with one principal facilitator. The research team sought verbal consent from participants before commencing the discussions.

The focus groups and interviews were audio-recorded and transcribed by the research team. This study was approved by the Human Research Ethics Committee of Queensland University of Technology (Approval Number: 2021000305).

### Data analysis

The data from the focus groups and interviews were analysed through a step-by-step guide to thematic analysis outlined by Braun and Clarke (2006). Specifically, the research team (i) familiarised themselves with the data, (ii) generated initial codes, (iii) searched for themes, (iv) reviewed themes, (v) defined and named themes, and (vi) produced a write-up of the results. Transcripts were divided between the research team to analyse separately in the first instance and then come together to discuss and collate similar themes that emerged from their respective analyses.

### Results

The results from the analysis will be outlined in the following sections, namely, (i) overall safety aspects of train horns; (ii) benefits of train horns; (iii) disadvantages of train horns; and (iv) considerations of how the benefits outweigh the disadvantages.

#### Overall safety aspects of train horn sound

With regards to urban crossings, participants noted that the train horns relayed a warning to road users

about an approaching train. Specifically, there is a sense of urgency in the sound, with participants stating that the train drivers are reminding road users to remain cautious and look out for their safety by staying out of the way and not crossing the rail tracks. These safety aspects were also emphasised for rural crossings. Several participants noted that the horns provided an added indication and warning of an approaching train at crossings that lack other cues (e.g. boom gates).

Additionally, participants revealed that the warnings could influence different behaviours from various road users. For instance, vulnerable road users (i.e. cyclists, motorbike riders, and pedestrians) would be cautious and vigilant when approaching a crossing after the sounding of a train horn. Although, for the most part, they seem to engage in this cautious behaviour regardless of whether they heard a train horn or not. Drivers, on the other hand, are more likely to feel safer at crossings in general as they are more protected inside their vehicles. Nonetheless, the horn acts as an additional indication of an approaching train.

A handful of participants have witnessed a near-miss situation first-hand at a level crossing. Examples of these situations have involved pedestrians walking or running through crossings after the boom gates have lowered, as well as motorists driving around boom gates. Other participants have witnessed or learned about near-miss situations through other media sources such as YouTube, cinema, and news stories. Overall, most participants who witnessed or learned about these events, either in-person or through media, reported that the events have influenced their behaviour by making them more alert and cautious when approaching level crossings. Two participants mentioned that the events made them feel anxious, distressed, and uncomfortable near crossings, highlighting the potential risk with illegal crossing behaviours. However, a few participants revealed that the events did not necessarily change their behaviours. Overall, the participants' knowledge of near misses associated with train horns was limited.

#### Benefits of train horns

##### Theme: increased safety

Many focus group participants stated they support the use of train horns at level crossings while considering varied environmental characteristics (rural/urban, day/night, passive/active crossings) and types of road users (cyclists, pedestrians, motorists, motorcyclists). These positive views towards train horn use indicated

perceptions of warning of an approaching train, therefore, alerting road users to alter their behaviour, benefiting increased road user safety. This main theme indicates benefits of train horns at level crossings to increase safety comprised four primary sub-themes: (i) additional safety mechanism at active crossings; (ii) increased safety benefit at rural/passive crossings; (iii) increased safety benefit for vulnerable road users, and (iv) more beneficial at night.

**Subtheme 1: additional safety mechanism at active crossings.** Train horns used as an additional safety mechanism at active level crossings in urban settings was the strongest sub-theme among road users, indicating the auditory warning to complement, as well as possibly reduce potential hazards that could result from visual warning systems malfunction.

The train horn helps to warn you, even when the boom gates go down. It definitely gives you that feeling that you have to stop. (Male, 26, cyclist and pedestrian)

I think it's always good to have you know multiple levels of safety, like for example, in case of failure for example the gate doesn't go down...it's another barrier for safety for motorist and people crossing and all that. (Female, 38, motorist and pedestrian)

**Subtheme 2: increased safety benefit at rural/passive crossings.** Many road users perceived further increased safety benefits of train horns to warn of the presence of a train in a rural setting or at passive level crossing, reflecting the lack of other visual warning systems such as lights, boom gates and road markings. Although this sub-theme was strong, the majority of these perceptions were related to hypothetical or infrequent use of passive level crossings or in relation to rural settings rather than frequent experiences.

In a rural context I find them really useful. Because you don't necessarily have all the other cues that you have in the urban content in terms of flashing lights and boom gates and things like that. So sometimes that might be the only kind of warning you have before you really approach the level crossing. (Female, 33, motorcyclist)

I think there would be more benefits for the passive rural crossings. Probably again because of the lack of indication that the train is coming from just the stop sign in the railway crossing symbol sign rather than [the ones] that don't have the lights and the boom gate. (Male, 19, motorist and cyclist)

I'm just thinking about going on road trips...and going to country towns which have passive crossings,

even if there is not a train there, there is a real sense that the horns would be the first thing rather than lights or a barrier, well there is no barrier. And I can remember having feelings there and thinking how important it is to be alerted to the fact that they may be trains coming when you are in a scenario like that, which actually seems a bit threatening at times. (Female, 62, motorist and cyclist)

**Subtheme 3: increased safety benefit for vulnerable road users.** Several respondents indicated particular types of road users (pedestrians, cyclists, motorcyclists) to be more vulnerable to hazards at a level crossing than others (motorists), indicating increased perceived safety benefits of train horns to alert vulnerable road users to increase behaviours that exercise caution. This was identified to be related to the lack of 'barriers' between the vulnerable road user and a train.

I think it's more of a warning for people who are walking or on a motorcycle or on a bicycle. Because I think when you are in the car you feel more safe because you are covered, but people who are a pedestrian you don't have the covering so they are more listening and looking at safety cues. So, I think it's more of a warning to the pedestrians and to the motorcyclists and cyclists. (Female, 38, motorist and pedestrian)

I don't feel very comfortable to be honest. Especially as a pedestrian and a cyclist because I am not in a four-wheel drive or protected. I'm all by myself. Like I said the speed with which the train and the driver is coming in and the honk is louder, I won't say I get nervous but I am extremely cautious about it. (Male, 38, pedestrian, motorist, cyclist)

**Subtheme 4: more beneficial at night.** Several road users identified train horn use at level crossings to be more beneficial for inducing increased safety-compliant behaviours from road users at night compared to during the day. These perceptions reflected a need for additional audible cues for trains due to reduced visibility and awareness at night, irrespective of urban or rural settings or type of road user.

I think it's more beneficial at night when people may be less aware of what is going on around them. (Male, 61, motorist and cyclist)

It's giving a warning during the hours of darkness, when visibility might be reduced. It's not just sounded for fun, it's a very necessary part of railway life. (Male, 65, motorist and pedestrian)

The majority of the road users who participated in the focus groups reported train horns are a safety benefit and their use leads to increased safety at level crossings, however, one road user indicated perceiving no benefits. Although this road user stated this, it was

met with passive acceptance reflective of a conditional need for train horns to increase safety-compliant behaviours.

I think it[hearing a train horn]'s of no benefit for me at all. But when I'm with my daughter it's really for safety reminder. But I still think that the benefit is much more smaller than the bad impact brought to me. (Female, 36, scooter rider)

## Disadvantages of train horns

### Theme 1: noise pollution

Several focus group participants outlined the main theme related to the disadvantages of train horns at level crossings to be associated with noise pollution and feelings of irritation. These perspectives appeared to be reflective of individual experiences and hypothetical scenario interpretations related to the distance of a level crossing from a residence, as well as varied road user demographic characteristics and related disturbances. Responses related to noise pollution as a disadvantage of train horn use at level crossing contained two primary sub-themes, being residential disturbances and hearing discomfort.

**Subtheme 1: residential disturbance.** For people residing in close proximity to level crossings, train horn use was indicated to lead to feelings of irritation and disturbance, particularly at night. This was the strongest sub-theme and the most frequently described disadvantage of train horns presented by road users when considering experiences and hypothetical scenarios and at times reflecting road users' choices to reside near a level crossing.

Some of the particularly loud ones are when the trains are returning to base after midnight, so it can be 12.30 am, I've even heard them as late as 1.30 am. I've been woken up by ones around 1.30 am, those ones can be really loud. (Male, 63, motorist)

I think the additional noise could be quite irritating if you live right next to it. As a person who doesn't live next to a train station, I don't have that problem. (Female, 33, motorcyclist)

Maybe for people living close the rail lines at night, they may be kept awake. (Male, 65, motorist)

**Subtheme 2: hearing discomfort.** Several road users identified specific scenarios whereby the sound of hearing a train horn at a level crossing, resulted in hearing discomfort; this aspect was perceived as a disadvantage of train horn use. This was often associated with road users, including pedestrians and

people who experience sensitivity to sounds, becoming irritated and in some instances adjusting behaviours to accommodate the anticipated feeling.

I think my only negative feedback would be the scenario at the train station near me where it is, the train station is right next to the pedestrian access. They blast the horn right next to your ear...It's quite deafening. So, we kind of stand away and stand back... That's a pretty a negative experience. (Female, 39, motorist, cyclist and pedestrian)

This isn't speaking from my own personal experience. But I would assume there could be some disadvantages for some populations of people, perhaps if you were hard of hearing or overly sensitive to loud noises or potentially like a child on the autism spectrum who didn't deal well with those types of noises. I think there could be some disadvantages for those other groups of people. (Female, 33, motorcyclist)

**Theme 2: habituation.** The additional theme of habituation emerged in responses from a few road users as a perceived disadvantage of train horn use at level crossings. This perception surrounded familiarisation of train horn sounds and was further associated with elements of selective attention in that decreased awareness of train horn use was noted. This was further implied to lead to interpretations of train horn sounds being determined as irrelevant by some road users.

The only disadvantage I can see is because they come so regularly and systematically, it could become like white noise. Because I hear them so often I may not really notice them anymore. (Male, 39, cyclist and motorist)

I'm pretty much desensitised completely, I notice it consciously. (Male, 26, cyclist and pedestrian)

**Theme 3: perception of distance.** A further additional theme noted by a few road users indicated confusion in perceptions of train distance from the level crossing after hearing a train horn blast. This was presented as a disadvantage due to road users feeling confused and uncertain of how to behave to ensure their safety, irrespective of road user type. While a couple of road users indicated hearing a train horn at varied times at an active crossing, either before or after the boom gates had gone down, another indicated the physical distance, in general, made it difficult to perceive after hearing a train horn, impacting their subsequent hesitant behaviour.

not knowing what is the distance from the train. You will be like oh maybe it's very very far, and you start crossing but it's actually not that far. (Female, 27, pedestrian)



Maybe the timing of the horn can confuse people. I think [participant 1] was saying that the boom gates come down first and then you hear the horn? If you hear the horn first and you're looking around for a horn that's not there, you're like a confused motorist or a confused pedestrian. (Male, 43, motorcyclist and motorist)

### *Counter theme: safety benefits outweigh disadvantages*

Several focus group participants supported a counter theme to the main perceived disadvantages of train horn use at level crossings. This counter theme indicated some road users perceive the benefits of train horns to increase safety and outweigh any perceived disadvantages. These perceptions were presented in two sub-themes indicating strong and clear support or passive acceptance for train horns as a safety mechanism.

**Subtheme 1: passive acceptance.** Within the counter theme, passive acceptance of train horns was the strongest sub-theme with many participants indicating perceived disadvantages related to feelings of disturbance and irritation, however, immediately followed by expressions of understanding and awareness of the perceived safety benefits of an audible warning to gain the attention of road users to alter their behaviour.

I mean it brings stress and tension to my life. But that being said, I don't think they are harmful. There should be horns, and they should caution people. And people should be very very careful around it, even if they are multiple. But to me, they also bring some discomfort. (Male, 38, motorist, cyclist and pedestrian)

**Subtheme 2: no disadvantages, a safety necessity.** For the few road users who did not report disadvantages to train horns at level crossings, they valued safety even above the noted disadvantages such as noise pollution.

Even though there may be the concern for noise pollution, the benefits of the train horn outweigh the disadvantages [of noise]. Safety comes first. In rural setting we do need the train horn more, because it is quieter and there are no other 'active warnings' (passive only). (Male, 44, motorist)

The negatives would be for people who live close to the line. But I think overall the positive would outweigh the negatives. (Male, 26, cyclist and pedestrian)

## Discussion

While the train horn is the primary means through which train drivers communicate with road users, this control is not the primary layer of protection at railway crossings and is perceived, rightly so, by road users as

an additional layer of protection. While this study showed that road users see value in the use of train horns for safety as a contingency cue, they also reported that it has limited effect on their behaviour, and hence their perceptions contrast with that of train drivers. Indeed, Naweed et al. (2021) identified that train drivers consider the train horn as an essential tool, mechanism or control to ensure safety at level crossings. Road users, particularly when driving, rely principally on visual cues and therefore consider train horns more relevant when there is limited information about the train approaching (passive crossings) or reduced visibility (night) or for specific road users (e.g. pedestrians).

Despite this, the study showed that participants saw the most value in train horns being used at crossings equipped with all levels of protection (flashing lights, boom gates, bells) as a way to manage the risk of failing equipment. However, they fail to realise how unlikely such an event is (Wullems 2011), and that train drivers have means of detecting failing flashing lights in their approach, resulting in other mitigation strategies in place. Indeed, white or red side lights are provided at the crossing for train drivers, in conjunction with the flashing light signals for road users, to indicate that the level crossing apparatus is working (Australian Rail Track Corporation Limited 2023). On the other hand, such perceptions also highlight the fact that road users are aware of the high road and rail traffic at railway crossings equipped with all levels of protection, reflecting the high risk of conflict between road and rail users without such protections. Overall, there is still a discrepancy between perceived and actual risk as active crossings are orders of magnitude safer than passive crossings, when exposure is taken into consideration (Wullems 2011). This discrepancy in risk perception is also evident from participants' perception that a car provides a good level of protection during a crash with a train. It is important to note that such discrepancy does not only apply to road users but also to train drivers, as they tend to use their train horns more at actively protected crossing than at passively protected, despite the lack of other information about the approach of the train (Larue et al. 2021). As a result, both road users and train drivers see value in using train horns at level crossings independent of the objective risk at the level crossing.

This study has also shown that road users understand the meaning of train horns in a simple yet effective way which aligns with the intention to draw road users' attention towards the approach of the train and the necessity to stop before the crossing. Despite the limited amount of information that can be conveyed

by train horns, participants have identified conditions that lead to confusion with the message being provided, such as the repetition of the use of the horn, or the perception of train distance. Given that focus groups conducted with train drivers (Naweed et al. 2021) identified that train drivers attempt to convey complex messages to road users with their horns (Naweed et al. 2021), this study suggests that confusion with the train horn message could be a broader issue that could limit their safety benefits, for instance through habituation. Indeed, for train drivers, one blast can be informative about the approach of a train and ask road users to prepare for the train's arrival, but it can also be used to warn of other dangers such as another train (Naweed et al. 2021). However, road users mainly link train horns with the presence of the train.

The train horn message is only moderated through the loudness of the horn, with louder horns being perceived as being emitted by a train closer to the road user, and hence more urgent. This can also be problematic as train drivers moderate the loudness of their horns (Naweed et al. 2021), resulting in the loudness at the level crossing being not directly related to the distance of the train (Larue et al. 2021). This may lead road users to underestimate the closeness of the train and risk, particularly since humans are unable to accurately estimate the distance and speed of large objects such as trains (Clark, Perrone, and Isler 2013; Larue, Filtness, et al. 2018).

Overall, a large part of the message that train drivers want to convey is lost. Perhaps more importantly, this study showed that the repetition of train horn usage can result in road user confusion and habituation to the warning, which can be reinforced by the variability in train horn use when approaching a crossing (Larue et al. 2021). If confusing, participants reported that this warning may then be perceived as unreliable and reduce their likelihood to react as intended to train horns, limiting their effectiveness as it may favour errors in the road user decision-making processes or delays in reactions, particularly in emergency situations. Such effects of confusion are well-researched in the literature, for instance by Cummings et al. (2007). Indeed, avoiding a collision at railway crossings largely relies on the intervention of the road user, trains being unable to swerve and taking a long time to slow down. If habituated road users may also disregard the train horn warning and become more complacent at railway crossings. They may also be more prone to take risks at the level crossings, which was identified by participants, through their experience, as an issue leading to near-miss incidents.

Complacency and risk-taking are well-known effects in rail level crossing safety research, particularly when passively protected (Davey et al. 2008; Larue, Wullems, et al. 2018) or congested (Larue, Naweed, et al. 2018). Habituation to the sound of train horns specifically is a new dimension found in this study on the habituation and complacency issues at railway level crossings. This is of concern as it can potentially reduce the net safety effects of the various mechanisms implemented at railway crossings. This suggests that standardisation of practice is essential for ensuring that road users understand the train horn message, and that there is a clear demarcation between the use of train horns for informing road users of the approach of the train and emergency situations. It is suggested that this demarcation could be based on the loudness and duration of the train horn blast. This study also raises questions about the safety benefits of regular train horn use when approaching crossings at fully protected crossings. Indeed, train horn use may not change road user behaviour, whether compliant (attentive anyway and using it as an additional cue) or risk taker (actively decided to disregard the closure of the level crossing).

Given the potential confusion of road users, this study highlights that the use of train horns should be limited to cases that are proven to provide safety benefits. Further, attempts to reduce train horns should be investigated in cases where safety benefits might be limited. Indeed, there are several opportunities to reduce the use of train horns at crossings. For instance, train horns could only be used once on the approach of the crossing (not considering emergency situations), while practice has been shown to often involve multiple uses (Larue et al. 2021). While removing the use of train horns for actively protected crossings with boom gates would be unlikely to significantly affect safety, this study and the literature suggest that a number of factors would lead to resistance to the limitation of train horn use making such a change unlikely in the foreseeable future: (i) road users perceive train horns as a necessary tool for safety that outweigh their negative effects, (ii) insufficient scientific knowledge on the safety benefits of train horns and risks when removing them, and (iii) train drivers perceptions of train horns as an essential contributor to level crossing safety in all conditions. Therefore education campaigns based on sound scientific evidence would be necessary to ensure that such reductions would be accepted by level crossing users. As train horns are often used multiple times during the approach of a crossing (Larue et al. 2021), a first step towards making the train horn message more relevant to road users and reducing habituation could be to only use it once

when informing of the approach of the train, particularly since train horns are highly likely to be heard by road users (Larue et al. 2022; Mortimer 1994). This approach would significantly reduce the number of train horn blasts, be aligned with current train horn guidelines, improve message consistency and would not impact safety. This is also justified by the fact that using multiple warnings may not be necessary for eliciting road users' reactions, as reaction times are similar in single versus multiple warning approaches (Cummings et al. 2007; Ho and Cummings 2005). Another approach could be to replace train horns with an alternative technology. The TrackSAFE Foundation (2017) conducted a review of railway level crossing technologies in the USA and the UK and identified an alternative to train horns: wayside horns. Wayside horns are horns located at the crossing and automatically activated on the train approach. Such an approach would allow a reduction of the negative effects on nearby residents while potentially keeping the likely benefits of train horns. However, their effects have not been assessed yet, and trials would be necessary to ensure their effectiveness in warning road users, reducing disturbance to nearby residents, and measuring acceptance by train drivers.

Train horns are seen by road users to be more important for vulnerable road users. This aligns with the Australian Level Crossing Assessment Model (Australian Level Crossing Assessment Model (ALCAM) Technical Committee 2016), which estimates the risk of level crossings based on their characteristics. In this model, train horns reduce risk through the *infrastructure factor* that is used to model collision probability per year. The factor used is different based on road users using the crossing, with a higher reduction for pedestrians. In this model, train horns reduce risks for pedestrians but not for drivers. This suggests that there could be opportunities to reduce the use of train horns, which is an aim of the rail industry (Rail Industry Safety and Standards Board 2022) given the known negative impacts of train horns. For instance, there may be limited benefits in using train horns on the approach of trains at actively protected crossings with boom gates at crossings not used by pedestrians. The number of train horn uses could also be reduced by avoiding multiple uses on the approach of a crossing.

Despite the benefits being principally for vulnerable road users, some concerns were noted about perceiving a train horn blast when wearing a helmet. Similar concerns were reported when inside a vehicle with softer train horns. This suggests that the effectiveness of train horns may be reduced for a subgroup of vulnerable road users (riders), and particular attention

should be put towards this group when evaluating the safety benefits of train horns in future research.

The disadvantages of the use of train horns were related to noise pollution, with residential disturbance (e.g. noise irritation) and hearing discomfort (i.e. sensitivity to sound). While these two aspects are related, the former is well-documented in the literature while the latter has not been identified before this study. It is also of note that the second aspect does not only apply to people living near rail lines and exposed to train horns over extended periods but also to railway level crossing and railway station users. This suggests that future research should investigate how hearing sensitivity can modulate the negative effects of train horns. Further, the negative effects of train horns related to noise are therefore the most acute at times (night) when train horns are perceived as having the most benefits by road users, highlighting the complexities inherent to determining rules for the use of train horns.

The findings from this study on road users' safety perceptions of train horn, combined with the current knowledge of train horn practice (Larue et al. 2021), and train drivers' intentions (Naweed et al. 2021) raise questions about the requirement to use train horns at all level crossings to inform road users of the approach of the train, particularly since limiting such changes in the use of train horn would not affect their use in emergency situations. However, there is significant support for the use of train horns from both train drivers and road users, suggesting that any changes in the requirement to use train horns would need to be scientifically justified and not reduce safety. The current research has largely focused on the negative effects of train horns, and their benefits are largely assumed by the rail industry and road users. It is essential that research is conducted to confirm the actual benefits of train horns, so that accurate cost-benefit analyses can be conducted. Further, there could be resistance to such change, and a significant amount of information would be required for such an approach to be accepted by both train drivers and road users.

This study provides important insights into the understanding and safety perceptions of train horns by road users, given the variability and complexity of the message provided by train drivers. While the research design employed in this study was comprehensive, there are invariably some limitations to the study that need to be acknowledged.

First, the sample of participants was composed of people living near a city (Brisbane). This led to participants reflecting on level crossings that they encounter not often: level crossings located in regional or remote

locations. Despite this, participants reflected on the limited cues available at passive crossings and saw the importance of using train horns at such crossings. Nevertheless, it may be beneficial to extend this research to road users who traverse such crossings regularly.

Further, this study focused on the more frequent use of train horns, i.e. informing road users of the approach of a train. Researchers did not prime participants towards the emergency use of train horns, and such use was not discussed extensively. It is therefore not possible to infer whether road users' perceptions of the safety benefits of train horns vary based on the type of train horn used. This should be further investigated.

## Conclusion

This focus group study aimed to understand the perceptions of the usefulness of train horns as a safety device, including the benefits and disadvantages of the use of train horns. Participants reported a simple interpretation of the train horn being an alert-based mechanism, which contrasts with the complex message that train drivers attempt to provide. They noted several advantages (e.g. an additional layer of protection, important safety features at rural/passive crossings and with vulnerable road users, a greater safety benefit at night) and several disadvantages (e.g. noise pollution with residential disturbance, sound sensitivity, habituation). On the whole, train horns were acknowledged as an important safety mechanism but with some well-known issues, the safety benefits outweighing their disadvantages.

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