The dangers of silent electric vehicles

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Part of the Tranzinfo Hot Topics series, this issue offers a selection of recent material on the dangers of silent electric vehicles. Electric and hybrid electric vehicles have the advantage of being more environmentally friendly and quieter than internal combustion engine vehicles. However, reduced noise can also lead to potentially dangerous situations for pedestrians when an oncoming vehicle is inaudible due to background noise. The installation of devices that produce warning sounds in vehicles to alert pedestrians has been legislated in the US, Europe, the UK and parts of Asia, and is currently being considered in Australia. Meanwhile, a similar problem is emerging for e-scooters, with research underway to develop a universal warning sound to alert pedestrians to their presence.

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The problem

Silent 'life and death' risk lurking in electric cars
Canberra Times, 18 February 2023
Australia has yet to follow international examples in mandating sound-emitting technology in EVs, leaving the technology's inclusion up to

manufacturers in a move academics and industry experts warn could lead to more road accidents.

Blind and low-vision community calling on federal government to install noise emitters on all electric vehicles
ABC News, 17 May 2023
The low-vision community is leading calls to fit EVs with noise-emitting devices called acoustic vehicle alert systems (AVAS), so pedestrians can hear them coming at low speeds, bringing Australia into line with the US, Europe and parts of Asia.

Old electric cars could become louder after US safety authority investigation
Drive, 15 February 2023
US road safety regulators could force more than 9 million old electric and hybrid cars to be fitted with hi-tech speakers to alert vision-impaired pedestrians. Since 1 September 2019, new electric and hybrid vehicles sold in the US – specifically those which don't run on engine power at up to 30km/h and weigh less than 4536kg – have been required to emit a sound between 43 and 64 decibels to warn pedestrians of their presence.

Consultation impact analysis for improving pedestrian safety – Acoustic Vehicle Alerting Systems for electric vehicles
Department of Infrastructure, Transport, Regional Development, Communications and the Arts, March 2023
This consultation Impact analysis focuses on pedestrian road trauma in Australia. Specifically, it seeks to address the increased risk that electric vehicles have for pedestrian safety, related to the difficulty pedestrians have in detecting these quiet vehicles at low speeds.

Scientists creating universal e-scooter sound to help pedestrians detect them
Hern, A, The Guardian, 1 April 2022.
A universal sound for e-scooters is being developed by scientists at the University of Salford working with the Royal National Institute for Blind People (RNIB) to help pedestrians hear the oncoming vehicles.

Work-related road safety: the impact of the low noise levels produced by electric vehicles according to experienced drivers
Pardo-Ferreira, M et al., Safety Science, vol. 121, 2020, pp. 580-88
The introduction of electric vehicles in urban areas contributes to the reduction of air and noise pollution in these environments. However, the low noise levels produced by these vehicles, previously seen as an advantage, could pose a new risk to the safety of road users. The real magnitude of this issue is, however, controversial. The present study analyses the perception of experienced electric and hybrid vehicle drivers in work situations, something which had not been studied to date.

Modeling the effect of electric vehicle adoption on pedestrian traffic safety: an agent-based approach
Karaaslan, E et al., Transportation Research Part C: Emerging Technologies, vol. 93, 2018, pp. 198-210
In this paper, the positive and negative factors associated with electric vehicle adoption and the subsequent effects on pedestrian traffic safety are investigated using an agent-based modeling approach, in which a traffic micro-simulation of a real intersection is simulated in 3D using AnyLogic software. According to the analysis, electric vehicles have a 30% higher pedestrian traffic safety risk than internal combustion engine vehicles under high ambient sound levels. At low ambient sound levels, however, electric vehicles have only a 10% higher safety risk for pedestrians. Low levels of ambient illumination also increase the number of pedestrians involved in near-crashes for both electric vehicles and combustion engine vehicles.

The impact of electric/hybrid vehicles and bicycles on pedestrians who are blind or have low vision
Liu, S et al., MUARC, 2018
This study was designed to gain a better understanding of the road safety experiences of people who are blind or have low vision. In particular, it aimed to specifically examine the challenges experienced by pedestrians who are vision impaired when navigating electric / hybrid vehicles as well as bicycles during their everyday travel. The ability to travel safely and independently has significant implications for overall health and well-being. This report documents the findings from the study and outlines a range of recommendations to enhance road safety for pedestrians who are blind or have low vision. It is likely that these same recommendations will also positively influence the safety of the broader pedestrian population.

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Research

Audible pedestrian warning system using embedded system
Nalini, T et al., Measurement: Sensors, vol. 25, Feb 2023
Despite their low emissions, hybrid electric cars have caused concerns for the safety of other road users (pedestrians, cyclists, etc.). At low speeds (below 30 km/h), electric and hybrid cars are almost quiet, which poses a risk to pedestrians. This is particularly true for those who are more susceptible to harm, such as the visually handicapped. The primary goal of this project is to create a working prototype of a vehicle (robot) equipped with a pedestrian-detecting automated signalling system and speakers aimed towards the pedestrian. This enhances the vehicle's capacity for responding to its surroundings. The alert tone must also be fine-tuned so that it is audible but not obnoxious.

On-street testing of universal sound for shared e-scooters begins in London
Intelligent Transport, 28 April 2023
On-street testing of a 'universal sound' for rental e-scooters to alert pedestrians and other road users of their approach is now taking place on London's streets. The research is being conducted by Anderson Acoustics following extended experiments at University College London's (UCL) specialist Person-Environment-Activity Research Laboratory (PEARL), together with London's other e-scooter operators, TIER Mobility, Lime and Dott.

Investigation of the external noise emitted from electric buses in New Zealand and the need for acoustic vehicle alerting systems to improve road user safety
Doran, BR et al., NZTA research report 703, 2022
This research aimed to identify the need for and applicability of Acoustic Vehicle Alerting Systems (AVAS – noises made on purpose from vehicles) for electric buses in New Zealand. It completed two studies (in Auckland and Wellington) to first, measure noise differences between electric and diesel buses in New Zealand, and secondly, to measure people's ability to detect them in urban street environments.

Audiovisual time-to-collision estimation for accelerating vehicles: the acoustic signature of electric vehicles impairs pedestrians' judgments
Wessels, M et al., Transportation Research Part F: Traffic Psychology and Behaviour, vol. 91, November 2022, pp. 191-212.
To avoid collisions, pedestrians intending to cross a road need to accurately estimate the time-to-collision (TTC) of an approaching vehicle. For TTC estimation, auditory information can be considered particularly relevant when the approaching vehicle accelerates. The sound of vehicles with internal combustion engine (ICEVs) provides characteristic auditory information about the acceleration state (increasing rotational speed and engine load). However, for electric vehicles (EVs), the acoustic signature during acceleration is less salient.

Overestimated time-to-collision for quiet vehicles: evidence from a study using a novel audiovisual virtual-reality system for traffic scenarios
Oberfeld, D et al., Accident Analysis & Prevention, vol. 175, September 2022.
To avoid collision, pedestrians intending to cross a road need to estimate the time-to-collision (TTC) of an approaching vehicle. Here, we present a novel interactive audiovisual virtual-reality system for investigating how the acoustic characteristics (loudness and engine type) of vehicles influence the TTC estimation.

Development of electric scooter alerting sounds using psychoacoustical metrics
Walton, T et al., Applied Ergonomics, vol. 201, December 2022.
In this paper, the development of an electric scooter (e-scooter) AVAS is considered by taking a perception-influenced design approach to designing alert sounds that optimise detectability and annoyance. A listening

experiment has been conducted using ambisonic soundscapes and simulated auralisations of e-scooter passes at 20 km/h, in which a detection-based task and annoyance rating task were conducted.

Effect of environmental noise, distance and warning sound on pedestrians' auditory detectability of electric vehicles
Hsieh, M et al., Int J Environ Res Public Health, Sep 2, 18(17), 9290, 2021, doi: 10.3390/ijerph18179290
In this study, the auditory detectability of the electric vehicle warning sound at different volumes, distances, and environmental noise levels was investigated.

Gear sound model for an approach of a Mechanical Acoustic Vehicle Alerting System (MAVAS) to increase EVs' detectability
Miguel Fabra-Rodriguez, M et al., Applied Accoustics, vol. 184, December 2021.
This paper details an acoustic prediction model capable of simulating the sound produced by a pair of spur dry gears used as a Mechanical Acoustic Vehicle Alerting System (MAVAS). This sound model makes it possible to characterize a proposed gear combination of the MAVAS, verifying its compliance with the European legislation.

Pedestrian assessment: is displaying automated driving mode in self-driving vehicles as relevant as emitting an engine sound in electric vehicles?
Faas, SM & Baumann, M, Applied Ergonomics, vol. 94, July 2021
Pedestrians rely on vehicle dynamics, engine sound, and driver cues. The lack of engine sound now constitutes an addressed pedestrian safety issue for (hybrid) electric vehicles ((H)EVs). Analogously, lacking driver cues may constitute a pedestrian safety issue for self-driving vehicles (SDVs). The purpose of this study was to systematically compare the relevance of substituting driver cues with an external human-machine interface among SDVs (no eHMI vs. eHMI) with the relevance of substituting engine sound with artificial sound among (H)EVs (no engine sound vs. engine sound).

Acoustic Vehicle Alerting Systems (AVAS) of electric cars and its possible influence on urban soundscape
Laib, F & Schmidt, JA, Proceedings of the 23rd International Congress on Acoustics, Aachen, Germany, 2019
Due to the frequently low speeds in urban traffic, the AVAS will play a relevant role for the future acoustics and soundscape of cities. On the one hand, electric vehicles generally induce less noise in urban traffic than vehicles with combustion engines – a chance to reduce health threatening urban environmental noise. However, since the AVAS of electric vehicles is intended to attract attention for safety reasons, it can on the other hand also generate additional noise annoyance. Considering an increasing share of electric vehicles in urban traffic in the future, the effects on urban soundscape and the quality of life are investigated.

Effect of additional warning sounds on pedestrians' detection of electric vehicles: an ecological approach
Sylvain Fleury, S et al., Accident Analysis & Prevention, vol. 97, December 2016, pp. 176-85.
Virtually silent electric vehicles (EVs) may pose a risk for pedestrians. This paper describes two studies that were conducted to assess the influence of different types of external sounds on EV detectability.

Understanding and improving methods for exterior sound quality evaluation of hybrid and electric vehicles
Singh, S, PhD thesis, University of Warwick, UK, 2016
Electric and Hybrid Electric Vehicles [(H)EVs] are harder for pedestrians to hear when moving at speeds below 20 kph. Laws require (H)EVs to emit additional exterior sounds to alert pedestrians of the vehicles' approach to prevent potential collisions. These sounds will also influence pedestrians' impression of the vehicle brand. Current methods for evaluating (H)EV exterior sounds focus on "pedestrians' safety" but overlook its influence on "vehicle brand", and do not balance experimental control, correct context along with external and ecological validity. This research addresses the question: "How should (H)EV exterior sounds be evaluated?"

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