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How do pedestrians interact with electric and non-electric vehicles?

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Abstrakt
Previous studies conducted in Europe and in the United States have shown that electric vehicles are involved in a higher number of pedestrian crashes compared with vehicles powered by internal combustion engines. To address this problem, the Acoustic Vehicle Alerting System (AVAS) has been mandated in Europe for all new electric vehicles, starting from 1st July 2021. There is to date a lack of research investigating how pedestrians interact with electric and internal combustion engines vehicles, to shade light on possible differences that can lead to higher number of crashes.
Within this project, more than 20 hours of video data was collected in a heavily pedestrian-trafficked area in central Aalborg, on 5 different days. The videos were manually reviewed to identify interactions between pedestrians and vehicles occurring in the intersection. Overall, 106 interactions were detected in the videos and, for each interaction, several variables were annotated to perform odds ratio and binary logistic regression. Based on the statistical analysis, vehicle propulsion type (i.e., electric vs non-electric) did not affect pedestrians' likelihood of looking at vehicles approaching from the right. On the other hand, the use of a headset for pedestrians proved to be a strong predictor of reduced visual interaction with vehicles.

Introduction
According to a recent study conducted in Great Britain using crash data between 2013 and 2017, electric vehicles (EVs) and hybrid electric vehicles (HEVs) were three times more dangerous for pedestrians in urban environments, compared to internal combustion engines vehicles (Edwards et al., 2024). The British research confirms the results of an earlier study from United States of America finding that EVs and HEVs had 35% higher odds of causing a pedestrian injury in comparison to a vehicle propelled by an internal combustion engine, in the period 2000-2007 (Wu et al., 2011). There are no studies conducted in Denmark on this topic, but previous research performed in Norway showed that EVs and HEVs had 1.5 times higher crash rates with pedestrians and cyclists compared to vehicle propelled by an internal combustion engine (Liu et al., 2022).
It is plausible to assume that, in the past, EVs and HEVs had higher odds of getting into a crash with pedestrians due to their low-engine noises. To reduce this problem, the Acoustic Vehicle Alerting System (AVAS) has been mandated in Europe for all new EVs or an HEVs, starting from 1st July 2021 (European Parliament and Council, 2014). The expectation is that the introduction of AVAS will decrease the likelihood of crashes occurring between EVs/HEVs and pedestrians. However, there is lack of research conducted after the introduction of the system, and it is thus not possible to ascertain if the mandatory introduction of AVAS will solve the traffic safety concern. To shade more light on the matter, the research proposed in this

document aims to investigate how pedestrians interact with electric and internal combustion engines vehicles, using video material collected in the city of Aalborg.
The main research question that the study aims to answer is: Are pedestrians less likely to look towards EVs/HEVs than towards internal combustion engines vehicles, when they cross the road?

Methods

The data collection took place in Aalborg, at the intersection of Nytorv and Braskensgade. Figure 1 presents a top view of the intersection, along with a schematic illustration showing the camera's placement and the angle covered during the recording. This specific location was selected because of the high pedestrian traffic in the area due to the nearby entrance to the pedestrian zone, as well as the flow of vehicles accessing the parking facilities located on Braskensgade.

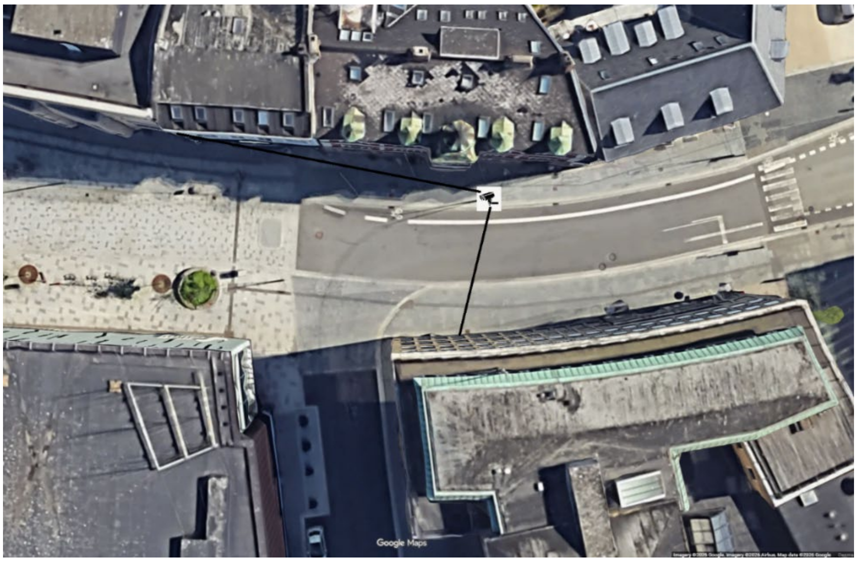

Figure 1: Top view of the data collection site, including the selected camera location and its field of view

Prior to the data collection, approval was obtained from Aalborg Municipality. A GoPro Hero 12 Black action camera was mounted on a light pole at a height of 2.60 meters using two zip ties. Data was collected on five dates during August and September 2025, between approximately 10:00 and 14:00. The final dataset consists of more than 20 hours of recordings (1223 minutes and 35 seconds), with images captured at a resolution of 3840×2160 and a frame rate of 29.97 frames per second. A screenshot from the video recording is shown in Figure 2.

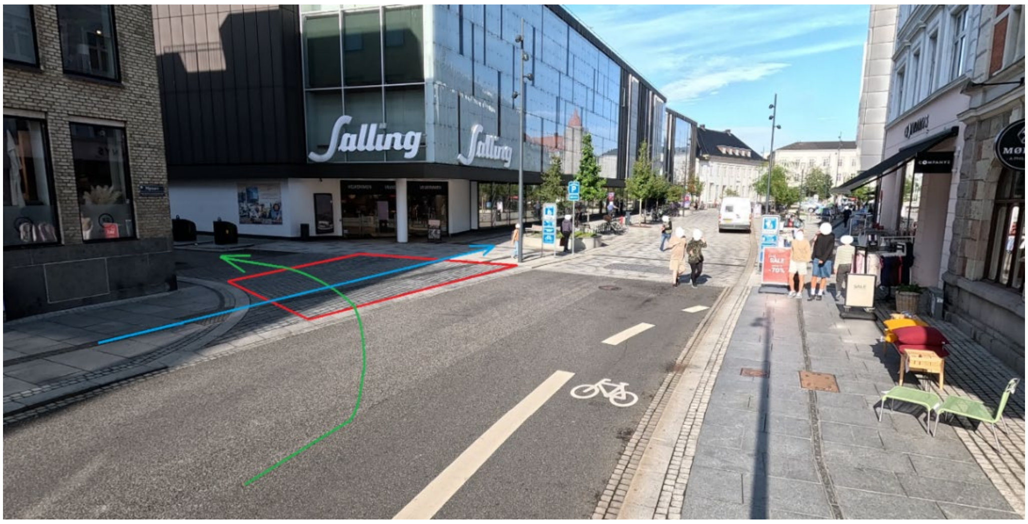

Figure 2: Screenshot from the video recording captured at the chosen location and schematic representation of the interaction area as well as the directions of pedestrians and vehicles (blue: pedestrians; green: vehicles)

All video material was carefully reviewed to identify interactions between pedestrians proceeding from Nytorv and crossing Braskensgade perpendicularly (see blue arrow in Figure 2) and vehicles coming from Nytorv and turning left into Braskensgade (see green arrow in Figure 2). Interactions between pedestrians and vehicles occurring within the area defined by the red trapezoid were considered only if they met the following criteria:

1. Either the pedestrian(s) or the vehicle yielded.
2. The vehicle or pedestrian(s) had not yielded to another vehicle or pedestrian immediately before the interaction.
3. Neither the pedestrian(s) nor the vehicle had already started crossing when the other road user (i.e. vehicle or pedestrian) appeared in the video frame.
4. Only passenger vehicles and vans were included in the analyses as vehicles. Trucks were excluded because their height obstructed the camera view.

Whenever an interaction was found, several variables were annotated to identify, among other things, the vehicle propulsion type, the vehicle type, which road user yielded, whether the pedestrian looked in the direction of the vehicle, and whether the pedestrian looked at their phone or used a headset or talked on the phone, during crossing. First, odd ratios were calculated to assesses how much more or less likely were pedestrians to look towards approaching vehicles during an interaction with an EV or HEV, compared to an interaction with an internal combustion engine vehicle. Then, a binary logistic regression was conducted to predict pedestrians' looking behaviour using the independent variable propulsion type and the independent variable assessing whether the pedestrian used a headset during crossing. All analyses were run in Python, using the software PyCharm.

Results

A total of 106 interactions were detected in the videos: 75 involved non-electric vehicles, 22 involved fully electric vehicles, 5 involved plug-in hybrids, and 4 involved conventional hybrid vehicles. Given the low speeds at which vehicles travelled along this section of road, it is reasonable to assume that both plug-in hybrids and conventional hybrids operated in electric mode. On this basis, the proportion of electric versus non-electric vehicles becomes 70.7% and 29.3%, respectively.
To examine how the variable *Vehicle propulsion* (i.e., electric vs. non-electric) influenced pedestrians' visual scanning for approaching vehicles (i.e., variable *Pedestrian looking towards approaching vehicles*), a 2×2 contingency table was constructed (Table 1).

Table 1: contingency table showing the relationship between the variables *Vehicle propulsion* and *Pedestrian looking towards approaching vehicles*

		Pedestrian looking towards approaching vehicles		
		Yes	No	**Row total**
Vehicle propulsion	Electric	20 (a)	11 (b)	**31**
	Non-electric	58 (c)	17 (d)	**75**
	Column total	**78**	**28**	**106**

Odds ratios (OR) were calculated with formula (1) below.

$$OR = \frac{a/c}{b/d} = \frac{a \cdot d}{b \cdot c} \tag{1}$$

Where the letters a, b, c, d represent the position as shown in red in Table 1. The calculation yields an OR of 0.53, indicating that participants are 0.53 times less likely (in terms of odds) to look in the direction of the vehicle when the vehicle is electric. The calculation of the confidence interval for the OR results is in the interval [0.214, 1.328]. Since the confidence interval includes value 1, the result is not statistically significant at the 0.05 level, and it is therefore not possible to rule out the possibility of no real effect.

Although the odds ratios did not yield any significant results, it remains possible that the interaction between the variable *Vehicle propulsion* and another variable, such as the variable assessing whether the pedestrian used a headset or talked on the phone (i.e., *Pedestrian used headset or talked on the phone*) could influence the scanning behaviour captured by the variable *Pedestrian looking towards approaching vehicles*. For testing this possibility, a binary logistic regression was conducted. The results for the main effects are presented in Table 2, and the results for the interaction between the variables *Vehicle propulsion* and *Pedestrian used headset or talked on the phone* are shown in Table 3. For both tables, *Pedestrian looking towards approaching vehicles* was the dependent variable (1 = Yes).

Table 2: Results of binary logistic regression predicting pedestrian pedestrians' looking behaviour using the variables *Vehicle propulsion* and *Pedestrian used headset or talked on the phone* as independent variables (main effects)

Predictor	Coefficient (β)	Std. Error	z	p	95% CI
Intercept	1.486	0.310	4.796	<0.001	[0.878, 2.093]
Headset in use / talking on the phone	–1.276	0.525	–2.431	0.015	[–2.304, –0.247]
Electric / hybrid vehicle	–0.527	0.484	–1.089	0.276	[–1.474, 0.421]

Model $\chi^2(2) = 3.80$, $p = 0.022$; Pseudo $R^2 = 0.062$; N = 106.

Table 3: Results of binary logistic regression predicting pedestrian pedestrians' looking behaviour using the variables *Vehicle propulsion* and *Pedestrian used headset or talked on the phone* as independent variables (interaction effects)

Predictor	Coefficient (β)	Std. Error	z	p	95% CI
Intercept	1.553	0.332	4.681	<0.001	[0.903, 2.204]
Headset in use	–1.553	0.666	–2.333	0.020	[–2.859, –0.248]
Headset in use / talking on the phone	–0.727	0.562	–1.294	0.196	[–1.828, 0.374]
Headset in use / talking on the phone × propulsion	0.727	1.072	0.678	0.498	[–1.374, 2.827]

Model $\chi^2(3) = 4.03$, $p = 0.045$; Pseudo-$R^2 = 0.066$; N = 106.

The main effects shown in Table 2 indicate that only the variable *Pedestrian used headset or talked on the phone* produces a statistically significant decrease in the variable *Pedestrian looking towards approaching vehicles*. In other words, pedestrians wearing a headset or talking on the phone were less likely to look toward the approaching vehicle. The overall model was statistically significant, $\chi^2(2) = 3.80$, $p = 0.022$, indicating that the included predictors improved model fit compared with the null model. However, the effect size was modest, as reflected by the pseudo R^2 value of 0.062, meaning that the model explained approximately 6% of the variance in the likelihood of pedestrians looking toward the approaching vehicle. When examining the interactions effects, the Pseudo-R^2 shows a marginal increase, while the significance of the overall model decreases. This result indicates that no meaningful improvement in predictive capability was added by the interaction between the variables *Vehicle propulsion* and *Pedestrian used headset or talked on the phone*.

Discussion and conclusions

This project was conducted to investigate pedestrians' behaviour when interacting with electric and non-electric vehicles in real-life. Over 20 hours of video data were collected in a heavily pedestrian-trafficked area in central Aalborg. The material was visually reviewed and manual annotations of selected interactions between pedestrians and vehicles were performed to extract relevant variables. Based on the statistical analysis, vehicle propulsion type (i.e., electric vs non-electric) did not affect pedestrians' likelihood of looking at vehicles approaching from the right. On the other hand, the use of a headset for pedestrians proved to be a strong predictor of reduced visual interaction with vehicles.

It is noteworthy to state the limitations of this project. First, the data were only collected and analysed for a specific scenario, where pedestrians and vehicles cross their path perpendicularly, when vehicles turn left. In the future, it would be interesting to investigate a scenario where pedestrians are walking on the sidewalk and suddenly start crossing the road, while vehicles come in parallel direction. Another limitation is associated to the limited number of cases observed. The results of the odd ratios indicate that pedestrians are less likely to look in the direction of the vehicle when the vehicle is electric, but this result was not statistically significant. A higher number of interactions, compared to the 106 included in this analysis, could have led to different results.

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Acknowledgments

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