Driver Heterogeneity in Rubbernecking Behaviour at an Incident Site

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Abstract Incidents can reduce roadway capacity due to lanes blockages, and in some cases, also affect the flow in non-incident direction. This paper provides insights into change of driving behaviour while passing an incident site in attempt to assess rubbernecking activity. We use empirical trajectory data obtained from a helicopter-mounted video camera. By assessing the points where acceleration changes on speeds profiles over distance of individual vehicle, the behavioural changes of driver passing in the opposite direction of the freeway incident can be determined. Results show that the variations in speed in the upstream of incident location are substantially higher within passenger car drivers then within the truck drivers. The passenger cars in the median lane reduce the speed further upstream, mostly with sharp deceleration while passenger cars in the shoulder lane reduce the speed closer to the incident scene. Truck drivers, on the other hand, tend to decelerate earlier and farther upstream, more than 125 m from the incident site. Some drivers did not exhibit rubbernecking behavior, passing the incident with a steady speed. This study emphasizes the difference between passenger car and truck driving behaviour while passing an incident location. The results provide a better understanding of rubbernecking behaviour and useful for modeling driver behaviour under incident conditions.

1 Introduction

Most of traffic incidents such as crashes, spilled load, or temporary road maintenance that happens on a roadway can affects traffic due to physical reductions (lane blockages). However, traffic incidents also can cause a phenomenon, which significantly affects the traffic flow referred to as rubbernecking. Rubbernecking term is widely used in incident study to describe the breakdown of traffic in the opposite direction of the incident resulted by non-physical bottlenecks. It is caused by change in driver behaviour when passing an incident. Knoop et al. [1, 2] have

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M. Chraibi et al. (eds.), *Traffic and Granular Flow '13*,
DOI 10.1007/978-3-319-10629-8_59

shown that rubbernecking may reduce the capacity per available lane by about 50 %. According to that study, the behavioural changes of drivers (lower speed, increase in time headway and increase in reaction time) during incident conditions lead to a 25–40 % reduction of normal queue discharge rates [3]. It has been reported in [4] that about 10 % of accidents caused rubbernecking in the opposite direction.

To the best of our knowledge, only average rubbernecking effects have been analyzed but in depth the heterogeneity in the behavioural change has never been look into. In this paper, heterogeneity not only focuses on the behavioural difference between passenger cars and trucks but defined as difference in individual driver behaviour when passing an incident. In this study, acceleration changes while approaching the incident scene are attributed to a rubbernecking behaviour, due to driver attention shift to the incident. The main goal of this paper is to improve understanding on the heterogeneity in rubbernecking behaviour. Therefore, the main question addressed in this paper is: is there a variation on driver behaviour between vehicle groups and within vehicle groups when passing an incident? We do so by identifying differences in speed changes between passenger cars and trucks while passing an incident site. The findings of this paper will be useful in considering the heterogeneity in modeling microscopic driver behaviour under incident conditions.

2 Data Extraction and Handling

2.1 Incident Description

The incident site is located on Motorway A1, near the city of Apeldoorn, The Netherlands. The incident type is a rolled over van, ended in the median (unpaved area which separates opposing lanes of the motorway), and happened around 9:15 a.m. on 6 June 2007, at the eastbound direction. There are two main lanes and one shoulder lane in each direction of the motorway, and no gradient. The speed limit on the motorway is 120 km/h. The weather condition during the incident was clear. Emergency vehicles were presence during the collection of data and blocked one lane in the incident direction.

2.2 Data Collection and Description

The empirical trajectory data in the opposite direction of the incident location have been collected using a digital camera mounted under a helicopter. Microscopic data was obtained over a length of 230 m, starting approximately 125 m upstream of the incident site. A total of 199 vehicle trajectories were observed and collected on both lanes, consisting of 123 passenger cars in the median (left/fast) lane, 35 trucks and 41 passenger cars in the shoulder (right/slow) lane. The trajectories have undergone

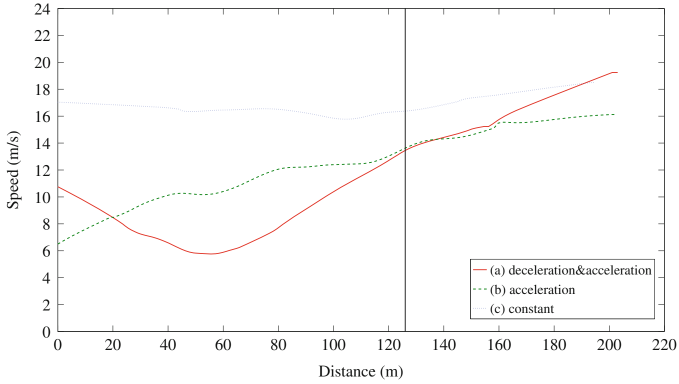

Fig. 1 The examples of speed patterns of individual vehicles

several processes before proceeding with the analysis. For further explanation, we refer to [5].

2.3 Overview of the Collected Data

The speed data were separated into three vehicle groups: passenger cars in the median lane, trucks, and passenger cars in the shoulder lane. In order to determine the changes in speed due to rubbernecking behaviour, we plot the speed (calculated with 0.1 s intervals) over incremental distances for each individual vehicle. Analysis of the individual vehicle speed profiles show that there are three distinct speed patterns as shown in Fig. 1. The black vertical line on the graph represents the location of the incident.

3 Data Analysis and Results

3.1 Analysis on Difference in Speed at a Location

We analyzed the speed data for different parts along the road. We focus on the variation in vehicle speeds and the statistical difference in speed between each vehicle class and within vehicle class, spatially split the roadway in segments of 10 m. In each segment, there are speeds for vehicles in all groups. Using a t-test, we test whether differences in mean speed between the vehicle groups are significant. In the remainder of the paper, the distance along the roadway is denoted by x.

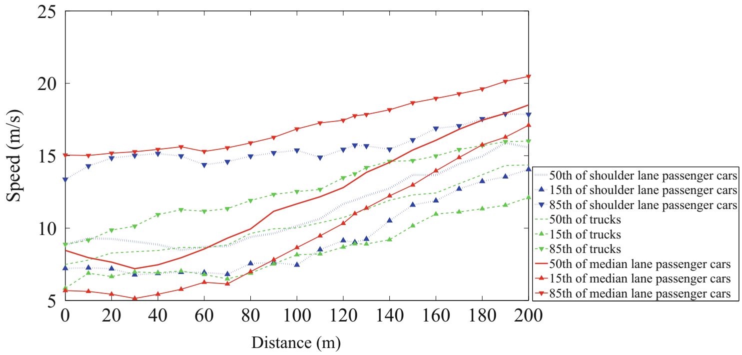

Fig. 2 Speed distributions (15th percentile, median and 85th percentile)

3.2 Statistical Analysis on Speed Data

This section presents the statistical analysis on driver speed passing the incident site. Figure 2 shows the spread in speed for each vehicle group. We can observe that there are wide variations of speed of passenger car drivers at the beginning of study section, especially the one in the median lane. From the observation of individual speed profiles, all of the passenger cars show the three reaction patterns. Measurement of central tendency suggest that most of the passenger cars in the median lane reduce the speed between $x = 20$ and 40 m, while in the right lane they reduce speed between $x = 50$ and 70 m. Since this is the point where the average speed drops, it can be assumed that the points are the rubbernecking zone, where most of the drivers reduce their speed. However, there is no speed drop for truck drivers, suggesting that most of the truck drivers continue to accelerate when passing the incident location, as conform to the speed profiles of truck drivers where majority show acceleration pattern within the study area.

Figure 3 shows the difference of mean speed between each vehicle group and the results of independent t-test. There are three sets of pairs in this test: (1) Trucks in the shoulder lane and passenger cars in the shoulder lane, (2) Trucks in the shoulder lane and passenger cars in the median lane and (3) Passenger cars in the median and passenger cars in the shoulder lane. The plots show large differences in speed between the first pair, even though both vehicle groups are in the same lane. The passenger car drivers start with a higher speed than truck drivers, but the wide difference in speed between them is closer towards the incident site, hence there is no statistical difference in speed between the two groups between $x = 90$ and 120 m. After passing the incident, the difference continues to increase with a slow rate, due to trucks capability to accelerate.

As for the second pair, the approaching mean speed of passenger cars in the median lane is higher than trucks drivers but the difference decreased until there is no significant difference between $x = 30$ and 40 m. This is believed to be where the

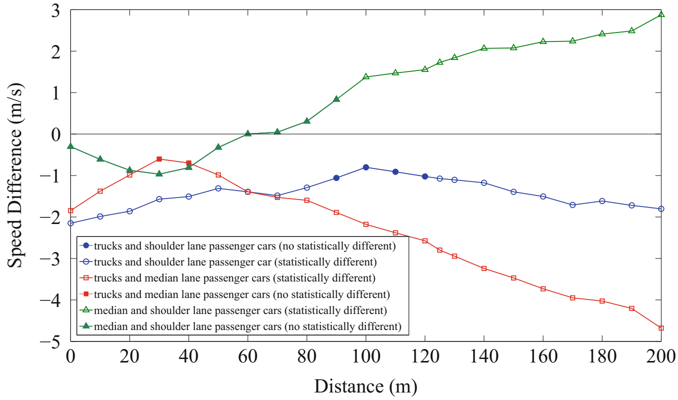

Fig. 3 Mean speed difference and independent t-test

drivers drive at the lowest speed to look on the incident. After passing this point, the passenger cars continue to speed up and resulting a large difference in mean speed.

Between the passenger cars, shoulder lane drivers approaching the incident location with a slightly higher speed than median lane drivers, but there is no significant difference in speed. At $x = 60$–80 m, the difference in mean speed between this vehicle groups is nil. After this point, the median lane passenger cars accelerate and increase the difference between these two vehicles.

4 Discussion

This study provides the insight into heterogeneity of vehicle speed in rubbernecking behaviour. The analysis shows that there is a high variation in speed profiles between individual vehicles. The variation in speed of passenger cars are higher upstream of incident site and lower downstream of the incident site. It was found that the lowest speed of median lane vehicles is further upstream than shoulder lane passenger cars, within $x = 25$–70 m. On the other hand, the shoulder lane passenger cars reduce the speed when closer to the incident scene. This can be described by the location of the incident itself. Since the passenger cars in the median lane is close to median (where the incident happened), the drivers are aware of the incident earlier than drivers in the shoulder lane. In contrast, variation in speed of trucks is low and constant through out the incident area. They mainly accelerate through the section, indicating that they had to slow down for the congestion caused by the other drivers, but they anticipated and started accelerating earlier, thus the rubbernecking zone of trucks is nowhere to be found in the study section.

There is significance difference in mean speed between vehicles in median and shoulder lanes. However, the mean speed difference in the upstream of incident is lower compared to downstream, and at certain points the results show no statistical difference in mean speed between these vehicle groups. Further examination on individual speed profiles shows that passenger cars in the median lane are significantly affected by the incident, and demonstrate a sharp deceleration when approaching the incident scene. On the other hand passenger cars in the shoulder lane approach the incident with a higher speed than those in the median lane. Some drivers, however, were not affected by the existence of incident and maintain a steady speed, suggesting that not all vehicles choose to slow down the vehicles while passing an incident site.

Conclusions and Future Work

This study analyzed the rubbernecking behaviour in the opposite direction of the freeway accident, and shows that there is high variation in driver behaviour under incident conditions due to different driver reaction. Passenger cars in the median lane show a much higher variation in speed. Truck drivers, all in the shoulder lane, showed a completely different type of behaviour. Drivers of passenger car in the shoulder lane showed a more dynamic behaviour than the truck drivers, but speed variations were less than the passenger cars in the median lane. The findings show that the speed of individual vehicle varies between vehicle class, occupying lane and visibility of the incident. Vehicles in either the same or different groups react differently while passing an incident.

This study gives an insight into underlying processes that leads to a speed reduction and variation in non-incident direction. The results provide a better understanding of underlying activity in rubbernecking and can be used to establish a framework in quantifying the rubbernecking effects. In this study, we did not differentiate between speed reductions due to car-following behaviour and speed reductions due to rubbernecking. And also the variation of other parameter such as headway and reaction time, as well as lane changing behaviour. This will get more attention in future work.

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