Passing distances of vehicles overtaking cyclists

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1 Introduction

I consider data on the distances at which vehicles pass pedal cyclists when overtaking them, and possible influences on these distances such as vehicle type and time of day. [1]

The file `Overtaking.txt` contains 2317 passing distances (measured in metres using an ultrasonic distance sensor) for a male cyclist, along with the corresponding times of day (hours), distances from the kerb, the types and colours of the overtaking vehicles, and an indication of whether he was bare-headed or wearing a cycle helmet. The distances from the kerb were fixed at 0.25, 0.50, 0.75, 1.00 or 1.25 metres.

2 Statistical analysis

Tables 1 and 2 show mean passing distances for combinations of helmet use with hour of the day and distance from the kerb respectively. These distances tend to be smaller between 7 and 9 am than at other times, and passing distance is clearly reduced as distance from the kerb increases. The mean passing distance is greater for bare-headed riders for most of the hours and all but one of the distances from the kerb.

Hour	7–	8–	9–	10–	11–	12–	13–	14–	15–	16–	17–
Bare	—	1.169	1.310	1.317	1.377	1.442	1.380	1.325	1.338	1.436	1.339
Helmet	1.210	1.161	1.283	1.196	1.260	1.281	1.219	1.281	1.390	1.360	—

Table 1: Mean passing distances (metres) by hour of the day and head covering

Distance from kerb	0.25	0.50	0.75	1.00	1.25	Overall
Bare	1.483	1.376	1.297	1.230	1.188	1.354
Helmet	1.395	1.305	1.223	1.243	1.139	1.272

Table 2: Mean passing distances (metres) by distance from kerb and head covering

[1] The study from which the data are taken is described at
`http://www.bath.ac.uk/news/articles/archive/overtaking110906.html`.

Tables 3 and 4 show mean passing distances classified by helmet use, along with the type and colour of the vehicle. The mean distances are least for buses and heavy goods vehicles, and also for white vehicles. Any apparent effect of vehicle colour may occur because the distribution of colours differs substantially between vehicle types (Table 5).

	Car	Bus	Heavy goods	Light goods/minibus	SUV/pickup	Taxi
Bare	1.377	1.089	1.225	1.308	1.376	1.196
Helmet	1.295	1.068	1.073	1.226	1.290	1.214

Table 3: Mean passing distances (metres) by vehicle type and head covering

	Black	Blue	Green	Red	Silver/grey	White	Other
Bare	1.345	1.367	1.325	1.398	1.370	1.290	1.273
Helmet	1.332	1.280	1.228	1.243	1.289	1.219	1.308

Table 4: Mean passing distances (metres) by vehicle colour and head covering

	Black	Blue	Green	Red	Silver/grey	White	Other	Total
Car	209	531	112	286	452	84	33	1707
Bus	0	3	6	22	0	14	1	46
Heavy goods	0	12	8	13	3	37	6	79
Light goods/minibus	6	32	3	30	33	183	6	293
SUV/pickup	32	41	16	19	27	7	1	143
Taxi	12	9	2	4	15	7	0	49

Table 5: Cross-classification of passing vehicles by type and colour

Figure 1 shows boxplots of passing distances (for bare head and helmet) against time of day and distance from the kerb. As well as the remarks made above about Tables 1 and 2, these plots suggest that the distribution of passing distance is positively skewed.

If a linear model is fitted for passing distance with terms for hour (considered as a factor), distance from kerb, head covering, vehicle type and vehicle colour, then the estimated coefficients for the distance from the kerb and wearing a helmet are -0.26 and -0.06. However, a Normal probability plot of the residuals from this model shows substantial positive skewness.

I therefore consider transforming the passing distances to square roots and logarithms: taking square roots improves the appearance of the residual plots for a model containing the same variables, but transforming to logarithms produces negative skewness.

Table 6 shows the analysis-of-variance table from fitting a linear model with the above variables, but no interactions between them, to the square roots of the passing distances. All the variables except vehicle colour appear to influence passing distance, particularly time of day and distance from kerb. Figure 2 shows residual plots for this model, which appear satisfactory apart from a few outliers.

Attempting to remove variables from the model by using Akaike's Information Criterion (AIC) removes vehicle colour and also hour. If AIC is applied after including all two-factor interactions in the model then hour, distance from the kerb, head covering and vehicle type remain in the model along with the interaction between hour and distance from the kerb.

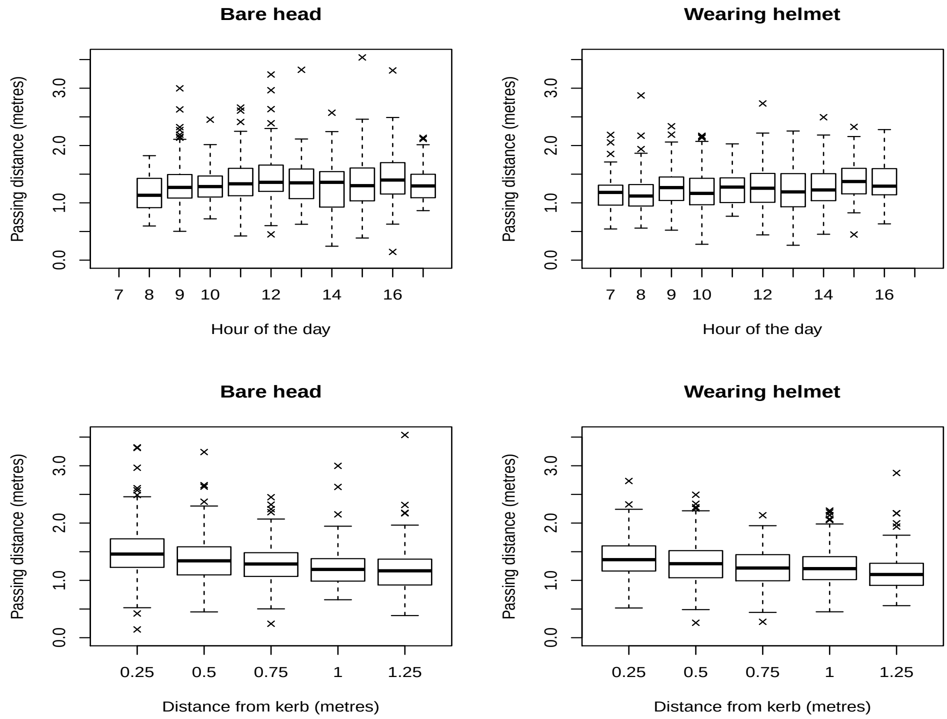

Figure 1: Boxplots of passing distance against hour of the day and distance from kerb

3 Conclusions

The passing distances of cars when overtaking the cyclist tended to be reduced when the distance of the rider from the kerb was increased: increasing this distance from 0.25 to 1.25 m reduced the passing distance by about 27 cm. The hour of the day was also influential, with passing distances tending to be lower before 9 am. Mean passing distances were lower for larger vehicles, i.e. buses and heavy goods vehicles, but taxis also tended to allow less distance. Vehicle colour appeared to have no effect on passing distance. The cyclist was given slightly but significantly more room (about 8 cm on average) when bare-headed than when wearing a helmet.

The last point provides an interesting contribution to the debate on whether helmet wearing makes cycling safer: possibly drivers perceive helmeted cyclists as more experienced and less likely to change course unexpectedly, and therefore tend to allow smaller distances.

	Df	Sum sq	Mean sq	F value	Significance probability
Hour of day	10	1.956	0.196	7.73	2.8×10^{-12}
Distance from kerb	1	2.684	2.684	106.09	$< 2 \times 10^{-16}$
Head covering	1	0.234	0.234	9.26	2.4×10^{-3}
Vehicle type	5	1.142	0.228	9.03	1.6×10^{-8}
Vehicle colour	6	0.090	0.015	0.59	0.74
Residuals	2293	58.009	0.025		

Table 6: Analysis of variance table for the dependence of the square root of passing distance on the hour of the day, the distance from the kerb, head covering, vehicle type and vehicle colour

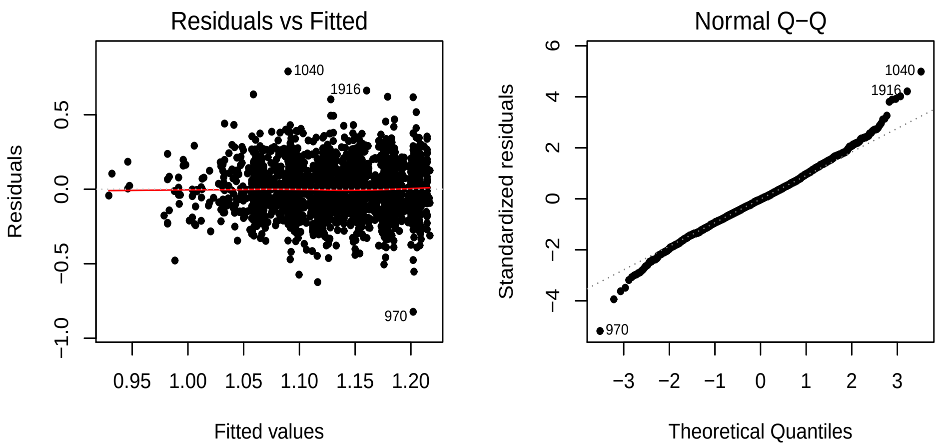

Figure 2: Plots of residuals from the linear model of Table 6