Car driver attitudes, perceptions of social norms and aggressive driving behaviour towards cyclists.

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Abstract

The interaction of car drivers and cyclists is one of the main causes of cycle incidents. The role of attitudes and social norms in shaping car drivers' aggressive behaviour towards cyclists, is not well understood and merits investigation. A sample of 276 drivers completed an online questionnaire concerning their attitudes towards cyclists, attitudes towards risky driving, perception of social norms concerning aggressive driving towards cyclists, and the frequency with which they engage in such aggressive driving behaviours. The results showed that attitudes towards cyclists, as well as social norm perceptions concerning aggressive driving towards cyclists, were associated with aggressive driving towards cyclists. Negative attitudes towards cyclists were more pronounced in non-cyclists than cyclists and their association with aggressive driving behaviour was stronger in cyclists than non-cyclists. The perception of social norms concerning aggressive driving towards cyclists had a stronger association with aggressive driving in non-cyclists than cyclists. Attitudes towards risk taking did not affect aggressive driving towards cyclists. These findings can inform campaigns that aim to improve cyclist and car driver interaction on the roads, making them safer to use for cyclists.

Keywords: cyclists, car drivers, aggressive driving, attitudes, social norms

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> *"Definitely knocked a cyclist off his bike earlier – I have right of way he doesn't even pay road tax! #bloodycyclists'*."
> (@emmaway20, tweet from the 19th of May 2013 extensively reported in the UK press)

Cycling is sustainable, cost effective, reduces congestion in cities and is healthy (British Medical Association, 1992; Heinen, van Wee and Maat, 2010; Ogilvie, Egan, Hamilton, Petticrew, 2004). Despite these positive benefits of cycling, 50% of Europeans (EU 28) report never using bicycles as a mode of transport (European Commission, 2013). Statistics for England illustrate that small distances, ideal for cycling, are often travelled by car. For example, in England around 15% of trips under 1 mile long (i.e. 1.6 km) and ca. 70% of trips between 1 (ca. 1.6 km) and 5 miles (ca. 8km) long are travelled by car (Department of Transport, 2014). Many factors play a role in transport mode choices for such trips, including the cycling history and culture in different countries. Research has found that reasons for not cycling include lack of personal fitness, weather, hilly terrains (e.g. Gatersleben and Appleton, 2007), as well as fear that it is unsafe, particularly in a car-centred society (Chataway, Kaplan, Nielsen and Prato, 2014; Garrard, Greaves, and Ellison, 2010; Gatersleben and Appleton, 2007; Horton, 2007; Joshi, Senior and Smith, 2001). Indeed, cyclists perceive higher levels of risk and hostility than other road users (Joshi et al., 2001) and inconsiderate (Gatersleben and Appleton, 2007) and dangerous drivers (Gatersleben and Uzzel, 2007) are recurrent factors in traffic mode choices.

CAR DRIVERS AND CYCLISTS

One of the most effective ways to reduce the risks associated with the interaction of cars and cyclists on the roads is through a good cycling infrastructure (e.g. Scheepers,Hagenzieker, Methorst and van Wee, 2014; Wegman, Zhang and Dijkstra (2012). In fact, good cycling infrastructure increases bicycle usage (Gårder, Leden and Pulkkinen, 1998). However, it is not always available. For instance in the UK, where this study was conducted, drivers and cyclists are often required to share the roads, and 84% of all serious or fatal cycle crashes involve collision with another vehicle, mostly motor vehicles (The Royal Society for the Prevention of Accidents, 2012). A recent study by Dozza and Werneke (2014) collected naturalistic cycling data using sensors, GPS and cameras installed on bicycles in Sweden. They found that 33% of the conflicts and critical events (such as crashes, or a car crossing the bicycle lane) that cyclists experienced involved a motorised vehicle. Their findings illustrate that issues associated with road sharing are not restricted to the UK.

Sharing the roads can result in dangers for cyclists. For car drivers it can be associated with annoyance and frustration. Basford, Reid, Lester, Thomson and Tolmie (2002, studying drivers from five towns in the UK) found that car drivers perceive cyclists as an out-group, blame cyclists for difficulties they experience when interacting with them on the roads, and hold negative to hostile views of 'the cyclists'. Johnson, Oxley, Newstead and Charlton (2014) reported that car drivers experienced frustration with repeatedly having to overtake cyclists on the roads in Australia. Similarly, Basford et al (2002) describe car drivers as being annoyed by cyclists' presence on the roads, particularly because they are perceived as weaving in and out of traffic, not using proper signalling, and because they 'get in the way'. They also identified cyclists filtering through traffic in front of traffic lights, slowing down traffic and behaving in an unpredictable manner as sources of annoyance in car drivers. This frustration with cyclists has been proposed to influence driver behaviour towards cyclists (Johnson et al, 2014).

We propose that drivers' annoyance and hostility towards cyclists, are likely to be vented through aggressive behaviour. We derive the link between frustration with cyclists and aggressive behaviour from Näätänen and Summala's (1974) reflection on the role of motives in driver behaviours. Their zero risk theory suggests that the need to progress smoothly in traffic and the irritation resulting from slower traffic participants, are motives that lead drivers to adopt more aggressive behaviour towards slower traffic participants, which can pose risks to cyclists. The tweet quoted above illustrates the friction that can result from car drivers and cyclists interacting on the roads, leading to aggressive behaviour and in this case a police investigation.

This study focuses on the link of attitudes and the perception of social norms with the tendency of car drivers to show aggressive driving behaviour towards cyclists. Researchers have investigated a number of issues with a focus on car drivers' and cyclists' interactions on the roads. Walker (2007) found that wearing a helmet while cycling led to closer overtaking by drivers, whereas appearing female (i.e. by wearing a wig) resulted in wider overtaking margins. Another study by Walker (2005) investigated the effectiveness of the ways in which cyclists can communicate with car drivers at junctions using hand signals. In a Norwegian study, Thørrisen (2013) found car drivers' extraversion and neuroticism to be positively associated with aggressive driving behaviour towards cyclists. He further found the association of neuroticism with such behaviours was mediated by attitudes towards cyclists. His thesis appears to be the only research that considers attitudes towards road sharing with cyclists in relation to aggressive driving behaviour. A study by Wood, Lacherez, Marszalek and King (2009) found that visibility is the main factor to which cyclists and car drivers attribute crashes involving cyclists. In line with this finding, Räsänen and Summala (1998) report that search strategies and misplaced expectations are the main causes of crashes involving cars and cyclists when visibility is not the issue. Herslund and Jørgensen, (2003) discuss that traffic experience

(i.e. automated search patterns in experienced drivers are tuned to looking for motorised vehicles) and the perception of cyclist as posing a danger affect drivers' visual search strategies. Such strategies can create inattentional blindness (Mack & Rock, 1998), ultimately contributing to 'looked but failed to see errors" in relation to cyclists. Other factors identified as increasing the likelihood of fatal injury of cyclists in collisions with other vehicles are greater vehicle speed, truck involvement, intoxicated driver or cyclist, cyclist age, weather, darkness without streetlights and head-on collision (Kim, Kim, Ulfarsson and Porrello, 2007). Rissel, Campbell, Ashley and Jackson (2002) considered car driver attitudes towards cyclists as an outcome of driver knowledge about road rules. They found that more negative attitudes towards cyclists were associated with less road rule knowledge. Johnsons et al (2014) report that more positive attitudes towards cyclists were associated with safer driving behaviour in the case of doing a left turn while crossing the path of a cyclist.

These studies identify crucial issues in relation to cyclists' safety, and Basford et al (2002), Johnson et al (2014), as well as Thørrisen (2013) illustrate the nature of attitudes of car drivers towards cyclists and how they are associated with various driving behaviours. While these studies recognise aggressive behaviour or hostility towards cyclists as an issue that is driven by attitudes and the perception of social norms, they do not directly address this issue by concurrently studying the link of aggressive driving with attitudes and social norms (note that Thørrisen (2013) does not consider social norms). Thus our study builds on this previous work by investigating the association of attitudes towards cyclists and the perception of social norms with aggressive behaviour towards cyclists. These factors are particularly suited for understanding aggressive driver behaviour towards cyclists. Attitudes and perception of norms have both been found to predict other types of driving behaviour (e.g. Ulleberg and Rundmo, 2003, Parker, Manstead, and Stradling, 1995) and are applicable to car driver interaction with cyclists (e.g. Basford et al., 2002). Thus, it is important to concurrently study perception of

social norms, as well as attitudes towards cyclists, to better understand car driver behaviour towards cyclists.

Attitudes describe a "relatively enduring tendency to respond to someone or something in a way that reflects a positive or negative evaluation of that person or thing" (p.3, Manstead, 1996, p. 3). Attitudes have been theorised to influence behaviour (Ajzen, 1991). This link has been supported in a meta-analysis of 119 studies by Kraus (1995; see also Cooke and Sheeran, 2004) where the correlation between attitudes and future behaviours had a median strength of .33 and was highly significant. The impact of attitudes on behaviour is likely to also apply to driver attitudes and their aggressive behaviour towards cyclists. In this study, we propose that negative attitudes towards cyclists will contribute to more aggressive driving towards cyclists. A driver who is more inclined to evaluate cyclists as a nuisance on the roads is more likely to show more aggressive driving towards this group. Accordingly, we hypothesize:

H_1: Negative attitudes towards cyclists are related to more aggressive driving towards cyclists.

We further consider drivers' attitude towards risk taking when driving as a factor that is linked to aggressive driving towards cyclists. Previous studies have investigated driver attitudes towards risky driving in relation to more general driver behaviour on the roads. For example, Iversen (2004) has found attitudes towards rule violations and speeding to be a predictor of subsequent risky driving behaviour. A study by Parker, Manstead, Stradling, Reason and Baxter (1992) found attitudes towards traffic violations to be related to the intention to commit such driving violations in car drivers. It is likely, that drivers' general attitudes towards risky driving (rule violation and speeding) also impact the extent to which

143 they are inclined to show aggressive driving towards cyclists, as these driving behaviours can
144 often be risky. We hypothesize:
145
146 **H_2:** Negative attitudes towards risky driving when driving are related to less aggressive
147 driving towards cyclists
148
149 We also investigate the relation of perceived social norms with driver behaviour towards
150 cyclists. Norms have been paraphrased as 'standards', 'frames of references' or 'common
151 sense' that develop and change through relationships between individuals (Sherif, 1936).
152 Armitage and Conner (2001) define a subjective norm as an "individual's perceptions of
153 general social pressure to perform (or not to perform) the behavior" (p.474). Parker et al (1995)
154 identified norms to be particularly relevant for understanding socially undesirable behaviours,
155 such as driving violations. We focus on what has been classified as descriptive norms, i.e. the
156 perceptions of others' behaviours. In their meta-analysis, Rivis and Sheeran (2003) found that
157 such descriptive norms influence the extent to which people engage in health risk behaviours,
158 and their intention to engage in such behaviours. Basford et al (2002) report that drivers hold
159 social norms about driving behaviour towards cyclists. However, they did not investigate
160 whether these perceived norms impact driver behaviour. A driver's perception of others'
161 behaviours implies what is believed to be acceptable and as such is likely to influence their
162 behaviour towards cyclists.
163
164 **H_3:** A perception that aggressive driver behaviour towards cyclists is common (i.e. the
165 norm) is related to more aggressive driving towards cyclists.
166

Finally, we explore whether the attitudes and perceived social norms, as well as their association with aggressive behaviour, differ between drivers who cycle and those who do not cycle. The extent to which cycling is established as a mode of transport, has been found to be inversely related to the frequency of collision between motorists and cyclists (Jacobsen, 2003). Jacobsen attributes this effect to changes that occur in motorists' behaviours because drivers are more likely to be cyclists themselves. Jacobsen's suggestion has been somewhat supported by Johnson et al (2014), who identified significant differences in the extent to which cyclists and non-cyclists report to give cyclists sufficient space on the roads when overtaking, but not for any of the other behaviours that they studied. Basford et al (2002) found drivers who cycle to be more considerate towards cyclists but indicate that the difference is not large.

It is plausible that drivers change their behaviours because they become more experienced when interacting with cyclists on the roads, if more cyclists are present. Such an effect can reduce misplaced expectations, which had been identified as a main factor in car drivers and cyclists' interaction by Räsänen and Summala (1998). However other factors have been suggested as contributing to the safety in numbers effect. Wegman et al (2012) identify that higher numbers of cyclists often coincide with better cycling facilities. They suggest that Jacobsen's proposition of changes in behaviours due to more drivers also being cyclists may not hold if the safety quality in the infrastructure for cyclists is considered as an additional factor.

It is also possible that differences in attitudes towards cyclists and the perception of social norms concerning the acceptability of cycling in cyclists and non-cyclists underlie the safety in numbers effect. Differing attitudes towards cyclists between cyclists and non-cyclists who drive have been reported, (Johnson et al, 2014), however Basford et al's report (2002) concludes that attitudes between these two groups did not differ systematically. Basford et al (2002) also did not identify systematic differences in the perception of norms concerning

behaviour towards cyclists between the two groups. Thus we compare cyclists and non-cyclists' attitudes, perception of social norms and behaviours towards cyclists, to explore whether these attitudes and norm perceptions differ in these two groups. We further explore the extent to which attitudes and the perception of norms concerning aggressive driving behaviour differ in their link with aggressive behaviour towards cyclists in drivers who cycle regularly and those who do not cycle. A better understanding of the extent to which these variables differ in their contribution to aggressive driving in drivers who are also cyclists and those who do not cycle provides insights into the possible underlying role of these variables in the safety in numbers effect, given that drivers' status as cyclists and non-cyclists has been proposed by Jacobsen (2003) as contributing to this effect.

In summary, we propose that attitudes concerning cyclists and risky driving, as well as perceived social norms concerning aggressive driving around cyclists, are likely to play a critical role in car drivers' behaviour towards cyclists. We also explore the extent to which these operate differently in drivers who cycle and those who do not cycle. Focussing on the psychological variables related to aggressive driver behaviour towards cyclists is of high practical relevance as this kind of evidence can be used to specifically target the most relevant attributes in campaigns aimed at reducing the frustrations of car drivers and cyclists sharing the roads and, most importantly making the roads safer for both cyclists and car drivers.

2. Method

2.1 Sample

The data were collected in 2013 via an online questionnaire hosted on the university's web server. The university is based in the UK (University of Aberdeen), so that it can be assumed that the majority of the participants live in the UK. However, as the survey was web based, this cannot be firmly concluded (we did not collect information on the participants' location). The survey link was distributed through the university website and an internal mailing list, via

students who forwarded the link to friends and relatives, and was posted on social media websites. Overall, 289 participants completed the survey, out of which 13 were excluded as they either did not have a driving licence or made no indication whether they hold a licence (resulting in a sample size of 276 participants). The level of experience as a driver (holding a driving licence) ranged from less than a year to more than 15 years (the majority had held their licence for more than 15 years (45.2%)). Participants' age ranged from 18 years to over 65 years (modal age was 18-25 years (at 27.5%)) and half the sample (n = 137) were female. Fifty participants had never ridden a bicycle on the roads since the age of five. Responses of 226 participants who had ridden a bike since the age of twelve, ranged from riding a bicycle every day to never in the past twelve months (30.5% of participants indicated they had not ridden a bicycle in the last year). Accordingly, the sample contained a cross-section of individuals with different levels of personal experience as drivers and cyclists. It should however be noted that the number of people who reported not to use a bicycle regularly (responding 'never' and 'not in the last year') is slightly lower in our sample (43.3%) than patterns reported across the EU (50% never cycle) and the UK (69% never cycle; European Commission, 2013). This suggests that our survey has attracted a higher number of participants with an interest in cycling than represented in the general population. However this stronger representation of cyclists might be a side-effect of the higher rate of younger respondents (age 18- 24) in our sample as only 39% of this group is reported to never use a bicycle (compared to 44% of the 25-39 year olds, 47% of the 40-52 year olds, and 62% of the 55 years and older respondents) in the European mobility survey (European Commission, 2013).

2.2 Measures

Attitudes towards cyclists were assessed using the attitudes towards cyclists scale developed by Rissel et al (2002), which contains nine items (example item: *It is very frustrating sharing the road with cyclists*). The Likert scale ranged from 1 = strongly disagree to 5 =

strongly agree, so that a higher score represented a more negative attitude towards cyclists. Cronbach's alpha for this scale was $\alpha = .83$ and a sum score across all items was computed (as described by Rissel et al., 2002).

Attitudes towards risky driving were measured with eleven items from Iversen's risk-taking attitudes questionnaire (2004), using items concerned with rule violations and speeding (example item: *Many traffic rules must be ignored to ensure traffic flow*). We identified these items as most relevant to the present study compared to the other items developed by Iversen. The other subscales are more specific in their applicability as they concern attitudes towards others' careless driving and drink driving. Thus, although the selected items might not represent the entire range of attitudes towards risky driving, we put forward that they represent the most central aspects associated with risky driving attitudes in the context of our study. The Likert scale ranged from 1 = fully agree to 5 = fully disagree, so that a higher score represents more negative attitudes towards risky driving. Cronbach's alpha was $\alpha = .80$ and a mean score across all items was computed (as described by Iversen, 2004).

Aggressive driving towards cyclists and perceived social norms of aggressive driving towards cyclists were assessed using a modified version of the DAIS (Driver Anger Indicators Scale; Özkan and Lajunen, 2005, see Table 1 for the items). This scale had originally been designed for general aggressive driving behaviour and the perception of related norms. In this study, the scale was modified to assess driver behaviour and the perception of behavioural norms towards cyclists (note that we did not change the items, just the instruction to refer explicitly to behaviour towards cyclists). The original scale contains 13 items, however we excluded one of these items as it was evaluated as not applicable to driver behaviour towards cyclist (drove slowly to annoy the driver behind). The scale included 12 items to assess driver behaviour by asking drivers to indicate on a scale of 1 (never) to 5 (nearly all the time) how often they committed each of the driving behaviours towards cyclists. The perception of the

social norms was assessed with the same 12 items, in this case asking participants how frequently they perceive other drivers to engage in such behaviours (ranging from 1 = never to 5 = nearly all the time).

As we had modified the scale to use it in the context of driving towards cyclists, we tested the structure of this altered scale using exploratory factor analysis, extracting two factors (based on the theoretical model by Özkan and Lajunen, 2005). The initial factor analysis, which included all items, did not return clear factor loadings as a large number of items had only weak loadings on both factors or loaded on both factors (see Appendix). However we found that a clearer factor structure emerged when we excluded the item concerned with preventing or obstructing cyclists' from manoeuvring the bicycle. Subsequently, the item loadings were similar to the two factors reported by Özkan and Lajunen (2005) as representing hostile aggression and aggressive warnings. Only the item "threatened verbally" loaded on aggressive warnings in our analysis and had been included as hostile aggression in the original scale. It may however represent a verbal form of aggression that fits to aggressive warnings. Moreover, all but one item's loadings on the two factors were consistent across the self-reported behaviour and the perception of other drivers' behaviours towards cyclists. Only one item (hugged the rear) was found to not load strongly on any of the factors and was excluded from all subsequent analysis.

Table 1

Factor analysis of aggressive driving towards cyclists items

	Aggressive behaviour self			Aggressive behaviour others		
Variable	Communalities	Aggressive warnings	Hostile aggression	Communalities	Aggressive warnings	Hostile aggression
cut up	.31	**.53**	.01	.37	**.57**	.02
swore/verbally abused	.46	**.71**	-.09	.57	**.86**	-.07
sounded horn	.44	**.56**	-.02	.42	**.68**	-.06
made a hand gesture	.42	**.70**	-.07	.62	**.86**	-.07
threatened verbally	.43	**.61**	.10	.59	**.63**	.21
flashed	.36	**.48**	-.01	.52	**.66**	.10
physically attacked	.55	-.21	**.98**	.76	-.12	**1.01**
chased	.58	.06	**.69**	.57	-.02	**.78**
rammed a cyclist	.28	.12	**.44**	.68	.11	**.76**
threatened physically	.33	.33	.33	.58	.16	**.66**

hugged the rear	.31	.33	.15	.29	.31	.19

Note: Extraction method Maximum Likelihood, rotation method: Oblimin with Kaiser Normalization; Items taken from Özkan and Lajunen, 2005; Principal Axis Factoring generated identical factor solutions with only slight variation in factor loadings

The reliability of the items reflecting self-reported aggressive warnings towards cyclists was α = .76 and the self-reported hostile aggression scale was indicated to be unreliable at α = .56. The reliability of the perceived norms concerning aggressive warnings was α = .80 and perceived norms concerning hostile aggression had a reliability score of α = .88. We computed mean scores for each of the scales. When inspecting theses scores we found that the distribution of values for self-reported hostile aggression was very limited (s^2 = .01). The scores only ranged from values 1 to 2 and 94% of the participants scored with an average of 1 on the scale, indicating they never engage in any of these behaviours. This may be due to the fact that the scale assesses behaviour that may be perceived by some as socially undesirable, leading participants to not openly report on hostile behaviours towards cyclists. However the limited distribution can also indicate that hostile aggression is not readily applicable to aggressive driver behaviour towards cyclists. We decided to only focus on self-reported aggressive warnings as an outcome, as it had a good distribution across the participants (ranging from 1 – 3.83, s^2 = .27) and we evaluated these items as highly applicable to aggressive driver behaviour towards cyclists.

Notably the perception of norms concerning hostile aggression towards cyclists was not that limited (range from 1 to 4, s^2 = .39). This finding is at odds with the responses of the participants' own behaviour concerning hostile aggression, which suggests that people generally do not engage in such behaviours or do not report to do so. From our data, we cannot conclude whether the lack of distribution in hostile aggression as a behaviour was due to the self-reported nature of the data or the lack of applicability of the items to actual driver behaviour towards cyclists. It is therefore also unclear to what extent such potentially inapplicable behaviour can be justified as a valid source of norm perceptions. Accordingly, we

did not include behaviours and the perception of social norms related to hostile aggression in the analysis.

Demographic information. Participants were asked to provide information about their age (ranging from 1 (18-25 years) to 7 (more than 65 years of age)), gender, driving experience (ranging from 1 (less than a year) to 6 (more than 15 years)) and frequency of cycle use (ranging from 1 (every day) to 6 (never)). These items were taken from Rissel et al. (2002).

2.3 Analysis

We first explored whether our data were normally distributed. The Kolmogorov-Smirnov test indicated that all scales were not normally distributed (D (264) ranging between 0.06 and 0.35; all $p < .05$). Accordingly, the data were analysed using non-parametric tests. We employed Spearman's rank correlation. The hypotheses were tested using hierarchical regression. We entered the participants' age and their gender in the first step as controls. It was decided to include these two variables as both have previously been found to influence aggressive driver behaviour (e.g. Efrat, and Shoham, 2013; González-Iglesias, Gómez-Fraguela, and Luengo-Martín, 2012). In the second step of the regression, we added attitudes towards risky driving, attitudes towards cyclists and perceived social norms concerning driver behaviour towards cyclists to the controls. Aggressive warnings towards cyclists was the outcome measure in the regression analysis. It should be noted that the P-P plots and the histograms of the distribution of the outcome variables' residuals indicated that there was a slight deviation from normality. Thus we employed bootstrapped samples to test the hypotheses via regression analysis (5000 bootstrapped samples; Efron and Tibshirani, 1993). Finally, to explore the extent to which attitudes and behaviours towards cyclists differed between drivers who cycle and do not cycle, we classified participants who had indicated that they had never cycled or had not cycled within the past year as non-cyclists. This split returned 125 of our participants as non-cyclists and 164 as cyclists. The Levene test indicated that the distributions

of the variables were equal in cyclists and non-cyclists[1]. We used the Mann-Whitney U test to compare the means. To identify whether the relationships of the attitudes and norms with aggressive driving behaviour towards cyclists were significantly different for non-cyclists and cyclists, we conducted a Chow test (Chow, 1960; Lee, 2008). The Chow test indicates whether the coefficients in two linear regressions on different data sets are equal (Lee, 2008). We used listwise exclusion for missing cases in the analysis.

3. Results

Descriptive statistics and the correlations between the included variables are shown in Table 2. Age was associated with aggressive warnings towards cyclists (r = -.15, p <. 05), so that younger participants tended to score higher on these behaviours. Gender was associated with aggressive warnings in a way that males were more likely to engage in this type of behaviour (r = .20, p < .01). The data further indicate that negative attitudes towards cyclists (r = .31; p < .01), negative attitudes towards risk taking (r = -.25; p < .01), and the perception of perceived social norms concerning aggressive warnings towards cyclists (r = .41; p <. 01) were linked to aggressive warnings towards cyclists.

Table 2

Descriptive statistics and correlations

Variable	M (SD)	1	2	3	4	5
1. Gender	1.47 (0.50)					
2. Age	2.96 (1.73)	.02				
3. Negative attitudes towards risky driving	3.74 (0.61)	-.16**	.20**			
4. Negative attitudes towards cyclists	33.60 (7.91)	-.03	-.20**	-.26**		
5. Perceived social norms of aggressive warnings towards cyclists	2.33 (0.71)	.09	-.07	-.05	.03	
6. Aggressive warnings towards cyclists	1.48 (0.52)	.20**	-.15*	-.25**	.31**	.41**

Note: * p<. 05; ** p<. 01, Gender coded so that 1 = female, 2 = male.

[1] $F_{\text{negative attitudes towards risk taking}}(1, 270) = 2.48$, $p > .10$; $F_{\text{negative attitudes towards cyclists}}(1, 270) = 2.32$, $p > .10$; $F_{\text{perceived social norms concerning aggressive warning towards cyclists}}(1, 270) = 2.21$, $p > .10$; $F_{\text{aggressive warning towards cyclists}}(1, 270) = 0.34$, p > .10

Table 3 shows the results of the regression analysis run with aggressive warnings towards cyclists as the dependent variables. The control variables entered in the first step were both significant in their association with aggressive warnings towards cyclists and explained 7% of the variance in this outcome. All variables entered together in the second step (controls and independent variables) explained 32% of the variance in aggressive warnings towards cyclists.

Table 3

Bootstrapped regression analysis of aggressive warnings towards cyclists on attitudes and norm perceptions

Variable	*B*	*SE B*	*β*	R^2	$CI_{LL\ 95\%}$	$CI_{UL\ 95\%}$
Step 1						
Gender	.19	.06	.21**		.10	.33
Age	-.04	.02	-.16**	.07	-.08	-.01
Step 2						
Gender	.14	.05	.15**		.05	.25
Age	-.01	.02	-.06		-.5	.01
Negative attitudes towards risk taking	-.09	.04	-.12*		-.19	.00
Negative attitudes towards cyclists	.02	.00	.27***		.01	.03
Perceived social norms of aggressive warnings towards cyclists	.29	.04	.38***	.32	.20	.34

Note: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$, gender is coded so that 1 = female, 2 = male, F (5, 263) = 24.13, p < .001 (F is reported for Step 2 only), number of bootstrapped samples is 5000

After controlling for age and gender, negative attitudes towards cyclists were associated with higher levels of aggressive warnings towards cyclists (β = .27, p <. 001). Accordingly, hypothesis 1 was confirmed. Furthermore, a more negative attitude towards risky driving was associated with less aggressive warnings towards cyclists (β = -.12, p < .05), however the confidence interval included zero, indicating the link to be non-significant. Thus hypothesis 2 was not supported. Perception of social norms concerning aggressive warnings towards cyclists was significantly associated with higher levels of self-reported aggressive warnings, (β = .38, p < .001). Accordingly, hypothesis 3 was supported.

When comparing the scores for cyclists and non-cyclists in our sample, we found that aggressive warnings towards cyclists did not differ between cyclists and non-cyclists (tested using the Mann-Whitney U test, $U_{aggressive\ warnings}$ = 9,126, p = .68). The attitudes towards risky

driving and the perception of social norms also did not differ between the two groups ($U_{risk\ taking\ attitudes}$ = 8,780, p = .39; $U_{perception\ of\ norms}$ = 8,524, p = .32). However a significant difference between the two groups was indicated for their attitudes towards cyclists (U = 13,135, p = .000; $M_{non\ cyclists}$ = 36.65, $M_{cyclists}$ = 31.24), so that negative attitudes towards cyclists were more pronounced in non-cyclists than cyclists.

To explore whether the association of the attitudes and the perception of norms with aggressive driving towards cyclist were different for cyclists and non-cyclists, we ran separate regression analyses for non-cyclists and cyclists (see Table 4). As previously, we entered the control variables in the first step and added the independent variables in the second step. The second step of the regression for non-cyclists explained 15% of the variance, in aggressive warnings towards cyclists. In the regression for cyclists, the second step explained 24% of the variance in aggressive warnings.

The results showed that in non-cyclists, only the perceived social norms concerning aggressive warnings towards cyclists (β = .35, p < .001) were associated with higher levels of aggressive warnings towards cyclists. For cyclists more negative attitudes towards cyclists (β = *.32*, p < .001) and the perception of norms concerning aggressive warnings (β = *.29*, p < .001) were associated with higher levels of aggressive warnings towards cyclists.

Table 4

Bootstrapped regression analysis of aggressive driving behaviour towards cyclists on attitudes and norm perceptions in non-cyclists and cyclists

Variable	*B*	*SE B*	*β*	R^2	$CI_{LL\ 95\%}$	$CI_{UL\ 95\%}$
Non-cyclists						
Step 1						
Gender	.00	.03	-.01		-.06	.05
Age	-.01	.01	-.16	.03	-.03	-.01
Step 2						
Gender	-.03	.03	-.09		-.09	.03
Age	-.01	.01	-.14		-.03	.00
Negative attitudes towards risk taking	.00	.03	-.01		-.06	.06
Negative attitudes towards cyclists	.00	.00	.02		.00	.00
Perceived social norms of aggressive warnings towards cyclists	.08	.02	.35***	.15	.02	.14
Cyclists						

Step 1						
Gender	.21	.08	.13		-.04	.24
Age	-.03	.02	-.10	.02	-.08	.03
Step 2						
Gender	.09	.07	.10		-.04	.24
Age	.00	.02	.00		-.04	.04
Negative attitudes towards risk taking	-.06	.05	-.09		-.18	.06
Negative attitudes towards cyclists	.02	.01	.32***		.01	.03
Perceived social norms of aggressive warnings towards cyclists	.20	.01	.29***	.24	.11	.30

Note: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$, gender is coded so that 1 = female, 2 = male; $F_{\text{non-cyclists}}(5, 115) = 3.79$; $p < .005$; $F_{\text{cyclists}}(5, 150) = 8.88$; $p < .001$; (F is reported for Step 2 only), number of bootstrapped samples is 5000

The Chow test, conducted to compare the beta scores obtained in the regressions for cyclists and non-cyclists, showed that the relationships of attitudes towards cyclists and perception of social norms differed significantly in their association with aggressive warnings towards cyclists between the two groups ($F_{\text{attitudes cyclists}}(2, 264) = 11.49$, $p < .001$; stronger link in cyclists; $F_{\text{perceived social norms aggressive warnings}}(2, 264) = 27.75$, $p < .001$; stronger link in non-cyclists). It should be noted, that although the results of the Chow test were significant for the link between aggressive warnings towards cyclists and the perception of norms this difference in the beta scores as shown in Table 4 was small. The strength of relationship of attitudes towards risky driving with aggressive driving towards cyclists did not differ between the two groups ($F(2, 264) = 2.56$, $p > .05$).

4. Discussion

This study investigates the extent to which attitudes and perceptions of social norms explain car drivers' inclinations to show aggressive driving behaviour towards cyclists on the roads. In line with our first hypothesis, the results indicated that more negative attitudes towards cyclists are linked to a higher frequency of aggressive driving towards cyclists. This finding illustrates that attitudes specific to cyclists should be considered as critically impacting how car drivers act towards cyclists on the roads. It confirms Basford et al.'s (2002) evaluation of attitudes as relevant to explaining general car driver behaviours towards cyclists as

specifically applicable to their aggressive behaviour towards cyclists. Our study extends Johnsons et al's (2014) findings, who had examined the role of attitudes towards cyclists in relation to car driver behaviour at turns, as it identifies that such attitudes are also linked to aggressive behaviour towards cyclists. The finding is in line with results concerning the impact of attitudes towards cyclists on car driver aggressive behaviour reported by Thørrisen (2013) in Norway. Our hypothesis 2, concerning the link of attitudes towards risky driving with aggressive driving towards cyclists was not supported. The indicated effect, while not significant, followed the proposed direction. It is possible that attitudes towards risky driving were not linked with aggressive driving towards cyclists as they lacked specificity to cyclists. The extent to which attitudes are directly concerned with the targeted issue has been identified as determining the extent to which they predict specific behaviours (Ajzen and Fishbein, 1980). This suggestion found support by Kraus's meta-analysis (1995), which reported that attitudes are better predictors of behaviour the more specific they are to the behaviour. A link between the perception of social norms concerning aggressive driving and driver behaviour towards cyclists was supported in our study (Hypothesis 3). This finding extends earlier results by Basford et al (2002), who found that drivers consider social norms in relation to their driving towards cyclists.

When comparing the scores and associations of the specified variables in cyclists and non-cyclists, the link of negative attitudes towards cyclists with aggressive behaviour was found to be more pronounced in drivers identified as cyclists than in non-cyclists. To our knowledge, the difference in strength of the relationship between attitudes towards cyclists and driver behaviour towards cyclists had not been investigated for cyclists and non-cyclists in the driving population. Our finding suggests that car drivers who are cyclists derive their tendency to show aggressive driving behaviour towards other cyclists more specifically, or immediately from their attitude concerned with cyclists, than non-cyclists. It should also be noted that non-

cyclists scored more highly on the negative attitudes scales than the cyclists involved in the study. This finding is in line with the results reported by Johnson et al (2014) and is likely to be driven by an in-group favouritism occurring in cyclists (e.g. Mullen, Brown and Smith, 1996). However, cyclists and non-cyclists did not differ in the extent to which they reported aggressive behaviour towards cyclists. This finding is in line with the results reported by Johnson et al (2014), who found that the majority of behaviours occurring during interactions of car drivers and cyclists at junctions, did not differ significantly between the two groups. Our finding however contradicts findings by Basford et al (2002), who found small differences in behaviours towards cyclists. Moreover it suggests that Jacobsen's (2003) proposition that drivers who are also cyclists will be more considerate in their behaviour towards other cyclists is not applicable to aggressive driving towards cyclists. It supports Wegman et al's (2012) proposal that factors other than own cycle use, such as better cycling infrastructure, may be critical in generating the safety in numbers effect,.

Further, the difference in the association of norm perceptions with aggressive behaviours towards cyclists in the two groups was small, yet significant in our study. Notably the perception of norms concerning aggressive behaviour towards cyclists was the only variable that was significantly associated with higher levels of aggressive behaviour in non-cyclists in our study. This finding suggests that the perception of others' behaviour critically informs aggressive driving behaviour towards cyclists in those who do not cycle themselves. It should also be noted that we found no differences in the extent to which attitudes towards risky driving were linked with aggressive warnings towards cyclists in non-cyclists and cyclists. Thus the lack of specificity of this attitude towards risky driving in relation to aggressive driving behaviour towards cyclists was common in both groups.

Finally, we measured aggressive behaviour towards cyclists using an adapted version of a scale by Özkan and Lajunen (2005), which had originally been developed to assess general

aggressive behaviour in drivers. Almost all of the participants (94%) indicated that they never engaged in behaviours that reflect hostile aggression, such as chasing cyclists or ramming them. This response pattern indicates that such behaviours are either not applicable to aggressive driving towards cyclists, or that they are unsuitable for assessment via self-report. Behaviours that were grouped under aggressive warnings were reported as occurring more frequently by our participants and also with wider degrees of variation between individuals. Thus, less severe forms of aggressive driving behaviour (i.e. flashing, hand gesture) are likely to be more applicable to driver behaviours towards cyclists, and are potentially more suited to be assessed using self-reports. It needs to be considered whether our participants did not openly admit to engage in more severe forms of aggressive behaviour towards cyclists due to social desirability. Self-reports of driving behaviour have been described by Lajunen and Summala (2003) as not being notably affected by bias caused by social desirability. Other studies however find that drivers' self-reported behaviours (for example related to crashes, mileage and violations) are unreliable and potentially suffer from different types of self-reporting biases (Af Wåhlberg and Dorn, 2015). Af Wåhlberg and Dorn (2015) propose cautious use of self-reported information concerning such behaviours, as they evaluate them as suffering from low validity. Our findings suggest that this proposition is particularly applicable to more severe forms of aggressive behaviour on the roads.

4.1 Future studies

To extend our study's findings and to address some of its shortcomings, future research can focus on the following issues. First, this study relied on self-reported outcome measures. As described in the previous section, self-reports, particularly of the more severe forms of aggressive behaviour towards cyclists can limit the results' validity regarding the extent to which these represent actual behavioural tendencies in drivers and how openly they may be reported. Future research should explore the extent to which hostile aggression is applicable to

499 driver behaviour directed at cyclists. This can for example be achieved through observation
500 and simulation studies in which aggressive behaviour can be classified into hostile aggression
501 and aggressive warnings. Such a study design can help to identify whether underreporting
502 caused the low frequency that was indicated for hostile aggression in our study, or whether
503 these behaviours actually almost never occur on the roads. Similarly, studying the link between
504 attitudes and perceived norms with driving behaviour towards cyclists observed in a simulator
505 can expand our findings using a more valid outcome measure. Next, this study relied on
506 explicitly reported attitudes. Research in social psychology distinguishes such explicit attitudes
507 from implicit attitudes, which are introspectively unidentified feelings, thoughts or actions
508 towards an object (Greenwald and Banaji, 1993). It is likely that, in addition to the explicit
509 attitudes investigated here, implicitly held attitudes are also relevant to aggressive behaviour
510 towards cyclists and this can be investigated in the future.

511 Moreover, our study focussed on attitudes and the perception of social norms.
512 Traditionally in social psychology, attitudes and norms are studied together with intention and
513 perceived control concerning behaviours (Ajzen, 1991; Fishbein, and Ajzen, 1975). We
514 decided to focus on attitudes and perception of norms in this study, as they have been identified
515 as most applicable to behaviours on the roads (Parker et al, 1992). It is particularly conceivable
516 that car drivers do not plan, or intend to act aggressively towards cyclists. However, perceived
517 behavioural control might explain additional variance in car drivers' aggressive behaviour
518 towards cyclists. Other factors that have not been included here, might predict aggressive
519 behaviour towards cyclists, for example general aggressiveness, which has been reported to be
520 a factor in general driver hostility (Lajunen and Parker, 2001). Also, an additional control
521 variable could have been the drivers' attitudes towards other road users more generally. We
522 found that attitudes towards cyclists were central to explaining aggressive driving behaviour
523 towards cyclists, however car drivers have been described as experiencing irritation from

slower traffic participants in general (Näätänen and Summala, 1974). Therefore, considering attitudes that are not specific to cyclists and rather more widely related to issues associated with sharing the roads with slower road users more generally may provide an additional explanation of what drives aggressive behaviours towards cyclists. Finally, sharing the road is a two way street. Future research should also consider the role of attitudes and norms in the behaviours of cyclists towards car drivers on the roads.

4.2 Conclusion

Cycling has benefits for health and the environment and can contribute to reduced congestion and pollution in more and more densely populated cities. Thus governments have an interest in promoting cycling, particularly in countries with low incidence of cycling. Our study indicates that attitudes towards cyclists and the perception of social norms are particularly relevant to aggressive driving towards cyclists. Therefore, these psychological attributes can be targeted in campaigns designed to improve cycling safety, as well as its image as a desirable mode of transport. Particularly campaigns targeted at non-cyclists can focus on the perception of social norms concerning such behaviours. Such campaigns can complement knowledge initiatives and training targeted at both cyclists and drivers. Campaigns can focus on reducing negative views about cyclists in drivers, by de-emphasising them as an out-group (i.e. they are also just people trying to get from a to b). Moreover, increasing positive perceptions concerning cyclists can further reframe road users' views. This can for example be achieved by illustrating the amount of congestion and pollution that is reduced by cycling rather than driving in cities, which ultimately benefits all road users.

Appendix

Factor analysis of aggressive driving towards cyclists – 12 item solution

	Aggressive behaviour self			Aggressive behaviour others		
Variable	Communalities	Factor 1	Factor 2	Communalities	Factor 1	Factor 2
cut up	.32	**.55**	.01	.40	**.61**	-.01
swore/verbally abused	.47	**.73**	-.11	.57	**.83**	-.08

sounded horn	.44	**.55**	-.03	.42	**.69**	-.08
made a hand gesture	.43	**.70**	-.09	.62	**.86**	-.08
threatened verbally	.43	**.61**	.10	.60	**.64**	.20
flashed	.36	**.48**	-.02	.52	**.66**	.08
physically attacked	.55	-.20	**.96**	.76	-.11	**1.01**
chased	.58	.05	**.70**	.58	-.01	**.77**
rammed a cyclist	.28	.12	**.44**	.68	.11	**.75**
threatened physically	.34	.32	.33	.58	.17	**.65**
hugged the rear	.33	.33	.16	.37	.34	.16
Prevented or obstructed from manoeuvring the bicycle	.13	.23	.14	.43	.18	**.46**

Note: Extraction method Maximum Likelihood, rotation method: Oblimin with Kaiser Normalization; Items taken from Özkan and Lajunen, 2005; Principal Axis Factoring generated identical factor solutions with only slight variation in factor loadings

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