Cross-modal Intervention to Improve Cyclist Awareness Levels (CRITICAL): A Report to the Road Safety Trust

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Executive summary

Cyclists are one of the most over-represented types of road user in road traffic casualty and fatality statistics. These casualties and fatalities occur, in the overwhelming majority of cases, as a result of an interaction with a motorised vehicle. In the popular media it is common to read of the conflict between drivers and cyclists; however, 'drivers' and 'cyclists' are not defined by their mode choice. They are simply individuals using a given mode of transport to achieve a mobility goal. That said, a person experiences differing constraints on behaviour when using a particular transport mode. There are different requirements placed upon them, the rules that govern them are different, and the strategies by which they safely interact with the road system and other road users are different. This project sought to explore and understand some of those differences in terms of the understanding one group has of the 'other' and to improve inter-group understanding and empathy through cross-modal training. In short, the project asked if it is beneficial to train those who drive and do not usually cycle what it is like to be a 'cyclist', and, conversely, whether there is benefit in teaching those who cycle and do not usually drive what it is like to be a 'driver'.

The project addressed this topic in two stages. The first, a focus group and questionnaire study, aimed to shed light on just what each group knows about the rules that govern the 'other', as well as their perceptions of the 'other'. The second, an online training study, was informed by results of the first. Two online training programmes, one for cyclists, the other for drivers, were designed and delivered, and a series of questionnaires used to investigate their impact on participants' knowledge of, skills in, and attitudes towards the 'other' mode (and its users).

The focus group and questionnaire study revealed some significant shortcomings in people's knowledge of the rule that govern on-road cycling behaviours. In responses to a quiz about road rules (based on the Highway Code), there were differences between those that usually only drive ('drivers'), those that usually only cycle ('cyclists'), and those that commonly do both ('driver-cyclists'), with 'driver-cyclists' performing the best. To give an example of where differences were most acute, far fewer 'drivers' than respondents in the other two groups were aware that cycling two abreast on quiet roads is advised by the Highway Code, instead indicating it to be an illegal act, or 'advised against'. There was also a significantly higher proportion of 'drivers' that had incorrect knowledge of the Highway Code's stance on cycling on a roadway when there is a cycle lane present. Again, many indicated this to be an illegal or 'advised against' behaviour; in fact, the Highway Code states that a person's level of cycling skill and ability should guide whether cycle lanes are used, not a lane's presence or absence.

To explore perceptions, people were asked what words or phrases come to mind when thinking of 'drivers' and 'cyclists' in urban and rural scenarios, and what risky behaviours they associate with the two road user types. When asked about 'drivers', respondents in all three groups provided similar responses, insofar as perceptions were typically negative, with themes such as 'impatient', 'dangerous', and 'speeding' identified. When asked to provide words and phrases that come to mind when thinking of 'cyclists' in

urban and rural scenarios, there were marked difference between groups, with 'cyclists' and 'driver-cyclists' providing comments representing a positive view (e.g., 'efficient', 'environment', 'forward thinking') and drivers giving responses that almost exclusively reflected negative views (e.g., 'dangerous', 'selfish', 'rule breaking').

The training study invited two groups to participate, those that only drive and those that only cycle (i.e., 'driver-cyclists' were not included in this study), providing each with a seven-module, online training programme that aimed to teach them what it is like to be the 'other'. The training programme was designed based on the academic literature, on the knowledge, skills, and attitudes conceptualisation of competency, on the results of the focus group and questionnaire study, and in collaboration with colleagues in Cycling UK. To assess the training programme's impact, participants completed questionnaires before, immediately after, and six weeks after course completion.

Results showed a beneficial impact of the training in both groups, with improvements in knowledge of the rules that govern the other and in the understanding of why road users perform certain behaviours. In many cases, improvements were sustained into the six-week follow up period. This was true for cyclists trained to understand drivers and for drivers trained to understand cyclists. There were also improvements in the understanding of the skills required by users of the other mode in both groups; however, attitudes towards the 'other', although initially impacted by the training, were not significantly affected in the longer term.

Results from both studies taken together give the impression of a lack of understanding between groups, a lack of knowledge of the rules that govern the modes not usually used by an individual, and the potential for cross-modal training to improve that knowledge and understanding. Taken together with existing evidence of the benefits to driving safety of having experience riding a bicycle on the roads, we would therefore recommend that such training should be included as an element of the standard mandatory driver training process. To improve the understanding and knowledge that non-driving cyclists have of car users, expansion of the optional Bikeability (cycling proficiency) cycle training scheme as well as broader public education and awareness campaigns are likely to be a more suitable. That said, the latter would need very careful design to avoid victim blaming and the placement of excessive onus on the vulnerable road user for road safety outcomes.

Table of contents

1. Introduction

Cyclists are disproportionately represented in road traffic collision statistics; there were around 17000 cyclists injured in road traffic collisions across the UK in 2020, 4356 of whom were killed or seriously injured (DfT, 2021a). Often, cycling collisions include a motorist emerging into, or turning across, the path of a cyclist, or a cyclist riding off the pavement into the path of a vehicle or making right turns into the path of a vehicle. These interactions can be understood (in part) as different road users interpreting the same road situation differently.

Drivers are required to interact and deal with a variation of cyclist skill and behaviour just as cyclists must learn how to deal with varying driver skill and behaviour. Ultimately, a large contributor to collisions is a lack of awareness and understanding of the opposite road user (RoSPA, 2017). The most common solution to addressing these issues is to separate the two road user groups through cycling infrastructure (Laker, 2016), thus eliminating the interaction; however, we often see cyclists avoiding cycle lanes. Whilst this can cause confusion and frustration from a driver's perspective, there is usually a valid reason (e.g., bike-lane debris, poor design, poor state of repair, etc.; Pucher, 2018; Robertshaw, 2018; Walker, 2012). Moreover, if we reduce the levels of interactions that drivers and cyclists have, we will reduce the chance for behavioural adaptations (Thompson et al., 2017) and limit opportunities for safe, shared spaces (Iwińska et al., 2018).

Currently in the UK there is no mandatory training for cyclists. Children, in their final years of primary school (up to 11 years of age), are offered a 'Cycling Proficiency' course. Course content focusses primarily on basic manoeuvres (e.g., signalling and turning); however, as evidenced by Teyhan (2016), many people never revisit this training again as an adult. Recently there has been a new form of voluntary training called 'Bikeability'. This comes in three levels, from basic to advanced. The curriculum focuses on general cycling safety and builds on cycling proficiency. Level 1 deals with journey preparation and pulling away and stopping, Level 2 with identifying hazards on the road and navigating around them (including road positioning), and Level 3 with integrating into traffic and sharing the road (Bikeability, 2021).

In the UK, drivers are required to pass theory and practical driving tests. These focus on teaching drivers the rules of the road and the practical skills of how to drive. New learner drivers receive some instruction on the skills required to interact with a cyclist; however, it is limited. In the driving theory test, there are around 1120 possible questions, 50 of which are asked in each test. Of these 1120, 40 (3.6%) are related to cyclists. In practice, therefore, only one cyclist-related question will typically be asked per test (DSA, 2011). Hazael (2015) highlighted that one question on, for example, overtaking a cyclist, isn't enough. There needs to be more scenarios presented to leaner drivers. In 2018 there were calls from Cycling UK for cycling awareness to be integrated into general driver training (CyclingUK, 2018). This was also voiced by a large UK driving school; in a survey of 'RED' instructors, 75% believed that a cycling awareness module should be introduced into the UK driving test (RED, nd). If new drivers aren't learning the skills required to safely interact with cyclists, then a large proportion of drivers on the road are interacting with other mode users without the appropriate training to do so (Johnson et al. 2010). There are optional, additional driver training courses (e.g., Pass Plus, IAM Road Smart, RoSPA, and AA in the UK); however, there is little or no focus on vulnerable road users (Sullivan, 2021). Drivers and cyclists typically receive training focussed on their current domain (and the needs and requirements therein) with very little training available to teach drivers and cyclists about each other's needs.

Given this lack of support for better understanding between the two road user groups of interest and the lack of formal training provided to learn about the 'other', this research took two main aims, addressed sequentially:

- First, to understand people's perceptions of 'other' road users, and their knowledge of the rules that govern the behaviour of those 'other' road users
- Second, to explore the potential for cross-modal training to enhance empathy and understanding between groups and improve road safety

To address the former, we used focus groups and questionnaires. To address the latter, we had initially planned for the design of two practical training courses: one on-road bicycle training course (for drivers learning what it is like to be a cyclist), one Southampton University Driving Simulator based training course (for cyclists learning what it is like to be a driver). Unfortunately, due to the pandemic that was not possible. Instead, two online training courses were designed with the same objectives. The methods and results of these studies will be discussed in turn (Sections 2 and 3), with a joint discussion then presented (Section 4). Note that throughout this report we use the terms 'cyclist', 'driver', and 'driver-cyclist' (for those that typically do both) for practical reasons, to separate our participants into groups. We want to stress that all study participants self-identified as members of these groups and that they are simply people who use a particular form(s) of transport (see Delbosc, 2019, for a discussion on dehumanisation when defining individuals by their mode choice).

2. Focus groups and questionnaire

2.1 Introduction and design

The focus groups and questionnaire addressed the first of our two aims. In other words, what do people who primarily cycle think of and know about drivers and the rules that govern them, and vice versa. The research was also interested in the views and knowledge of a third group; those that both cycle and drive. Based on these groups, i.e., drivers, cyclists, and driver-cyclists, the following questions were addressed:

- Are there any differences between drivers, cyclists, and driver-cyclists in terms of their knowledge of the rules of the road?
- What are the main thoughts and perceptions that drivers, cyclists, and driver-cyclists have about themselves and each other, and the differences therein?

The focus groups, of which three were held (one for each road user group), each comprised a general discussion section and a quiz, and each lasted approximately 90 minutes. The objective was to inform the design of the questionnaire. The discussion section was largely unconstrained, with participants invited to give their opinions on other road users, while the quiz section comprised questions about the rules governing other road users. These questions were designed based on discussions with Cycling UK and with recourse to the Highway Code. Participants performed this part individually (without group discussion). Recruitment to the focus groups was achieved through advertising the study via Twitter, Facebook, email, the local press, and word of mouth. To distinguish between groups, study adverts asked for drivers who do not cycle, cyclists who do not have a driver's license, and people who use both modes of transport at least once a week. Ethical approval was requested from and approved by the University of Southampton's Ethics and Research

Governance committee, reference number 53175. Only those of 18 years and over and resident in the UK were asked to participate.

Of the twenty-six people that responded to study adverts, five identified as cyclists (four male, one female, 19%, Cycling UK report that, in England, 14% of people report cycling more than once a week), nine identified as drivers (four male, five female), and twelve identified as driver-cyclists (ten male, two female, 46%, in 2017 the Department for Transport estimated that 31% of people who held driving licences also cycled and 85% of people over 18 who cycled also held a driving licence). Demographics are summarised in Table 1. All drivers and driver-cyclists held valid UK driving licences, and three of the five cyclists held licences. Given recruitment difficulties, it was decided to retain the cyclists that held licences as all indicated that they did not drive, despite having learnt to do so in the past. The number of years participants had held a license varied from less than one to 53 years (M=28.13, SD=15.35); the number of years cycling varied from less than one to 56 years (M=24.67, SD=18.85).

Table 1. Age and Gender of the twenty-six focus group participants (D=Driver, C=Cyclist, DC=Driver-cyclist)

		Age Group					
		18 - 35	26 - 35	36 - 45	46 – 55	56 - 65	Over 65
Gender	Male	1 *(C)*	4 *(1C, 2D, 1DC)*	4 *(1D, 3DC)*		7 *(2C, 1D, 4DC)*	2 *(DC)*
	Female	1 *(D)*	3 *(1C, 1D, 1DC)*		2 *(1D, 1DC)*	2 *(D)*	

The questionnaire had three sections: (1) demographics, (2) perceptions of other road users, and (3) quiz. In the demographics section, in addition to items concerning age, gender, and experience, the questionnaire included a road user self-identification question. Following recruitment difficulties for the focus groups (in part due to the low number of adults who never cycle or do not have a driver's license), the following criteria were used to distinguish respondents to the questionnaire:

- Cyclist: You must primarily cycle and rarely drive (maximum of once a month)
- Driver: You must primarily drive and rarely cycle (maximum of once a month)

- Driver-cyclist: You must regularly use both modes of transport (minimum of once per week each)

This categorisation method is consistent with previous research (e.g., Beanland & Hansen, 2017; Chaurand & Delhomme, 2013). Each respondent self-assigned themselves to a group in the first section of the questionnaire and then all participants received the same set of questions.

During the focus group discussions, it became apparent that drivers' and cyclists' opinions regarding the opposite road user group depended on the context of interaction. As such, to assess people's perceptions of other road users in different environments, the questionnaire asked respondents to list phrases or words that came to mind when they thought of cyclists and drivers in urban and rural areas. To gather more general views, the questionnaire also asked respondents to list up to five risky behaviours that they associate with each road user type in each of those areas. Given comments made (in all three focus groups) concerning cyclists' use of equipment, an item was added to the questionnaire that asked respondents to list up to five things they thought cyclists should wear to enhance safety (the question did not ask about legal requirements). Finally, the questionnaire asked respondents to give up to five ways in which they thought safety between drivers and cyclists could be improved. In all cases, free text responses were invited, with no minimum or maximum length (though response box size implied no more than a short sentence was expected for each response).

For the quiz section, questions were split into two sub-sections: scenarios and equipment. The scenarios questions were designed with reference to The Highway Code (DfT, 2021b), rules 59 – 82 and 159 – 203. A range of on-road scenarios were presented, and respondents asked about the legality of the described manoeuvre. To help participants to visualise the scenarios, they were presented with images for each of the 16 questions included (see Figure 1 for an example). Based on focus group discussions, five response options were offered: 'Legal' (a legal requirement), 'Illegal' (an illegal act), 'Advised' (a behaviour advised in the Highway Code, but not a legal requirement), 'Advised against' (advised not to do in the Highway Code, but not an illegal act) and 'Permitted' (a legal behaviour without recommendation for or against in the Highway Code). Questions regarding passing distances, used in the focus groups, were removed because despite campaigns within the UK promoting a 1.5m rule (Gallagher, 2020) the highway code currently states: “give at least as much room as you would when overtaking a car” (DfT, 2021b). This was highlighted by several focus group participants as ambiguous.

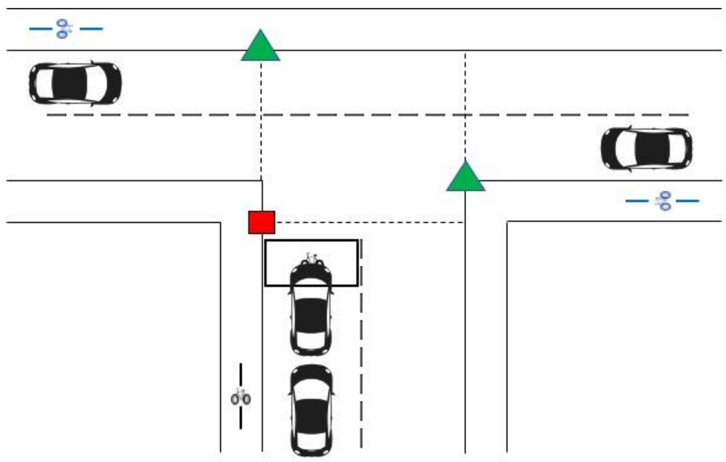


Figure 1. “What does the highway code say about… a car coming to a stop in an advanced stop line (bike box) if no cyclists are present?” (Q10)

Following the scenario section, an equipment section asked participants to indicate what equipment they thought to be a legal requirement for cyclists, chosen from 18 options including brakes, high-visibility clothing, ankle bands, reflectors, etc. (three of which were correct). A second question asked participants to indicate what lights are legally required (no light, front light, rear light, or both front and rear light) for three lighting scenarios (daylight, sunset/sunrise, and night). These questions were unchanged from the focus groups.

A link to the questionnaire was disseminated through social media platforms (including Twitter and Facebook), email, local and national press, and word of mouth. Ethical approval was requested from and provided by the University of Southampton's Ethics and Research Governance committee, reference number 53175.A1. Only those aged 18 years and over and based in the UK were asked to participate. It was also stipulated that only drivers with a licence issued in the UK were eligible for inclusion (i.e., those that would, in theory, be familiar with the UK’s Highway Code).

Of the 409 individuals that completed the questionnaire, 47 self-identified as cyclists (28 males, 19 females), 101 as drivers (39 Males, 60 Females, and one other), and 260 as driver-cyclists (185 Males, 74 Females, and two others). Demographic characteristics of the 409 respondents are summarised Table 2. In addition to all drivers and driver-cyclists, 16 (34%) of the cyclists held valid UK driving licences. The number of years participants held a license varied from less than one year to 59 years (M=27.68, SD=11.9). All drivers and driver-cyclists had regular access to a car, and all cyclists and driver-cyclists had regular access to a bicycle. Respondents' driving and cycling frequency are presented in Figures 2 and 3. Regarding crash history, 84% of drivers, 72% of cyclists, and 52% of driver-cyclists reported having been involved in a collision in the past.

Table 2. Age and Gender of the four hundred and nine participants

		Age Group						
		18 - 25	26 - 35	36 - 45	46 – 55	56 - 65	Over 65	*Total*
Cyclist	Male	1	8	5	9	5		*28*
	Female	1	6	4	5	3		*19*
Driver	Male	4	4	4	9	15	3	*39*
	Female	2	5	15	22	15	1	*60*
	Other			1			1	*1*
Driver-Cyclist	Male	5	15	44	68	41	12	*185*
	Female		13	24	22	14	1	*74*
	Other		1			1		*2*
	Total	*13*	*52*	*97*	*135*	*94*	*18*	*409*

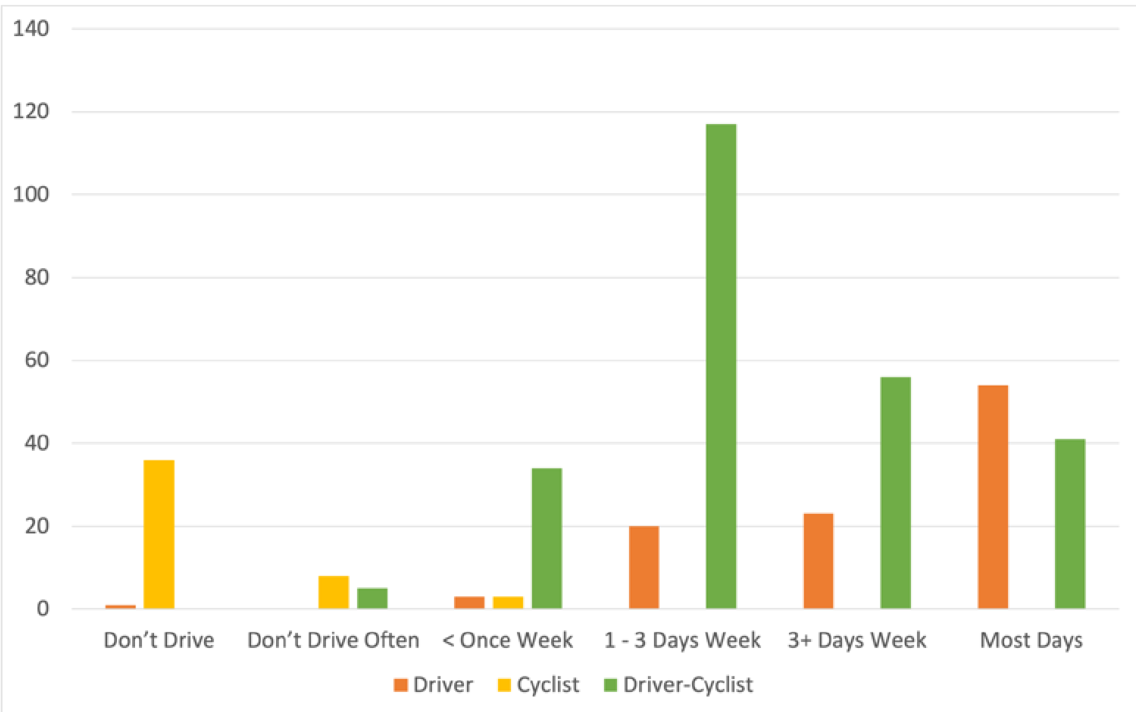


Figure 2. Driving frequency

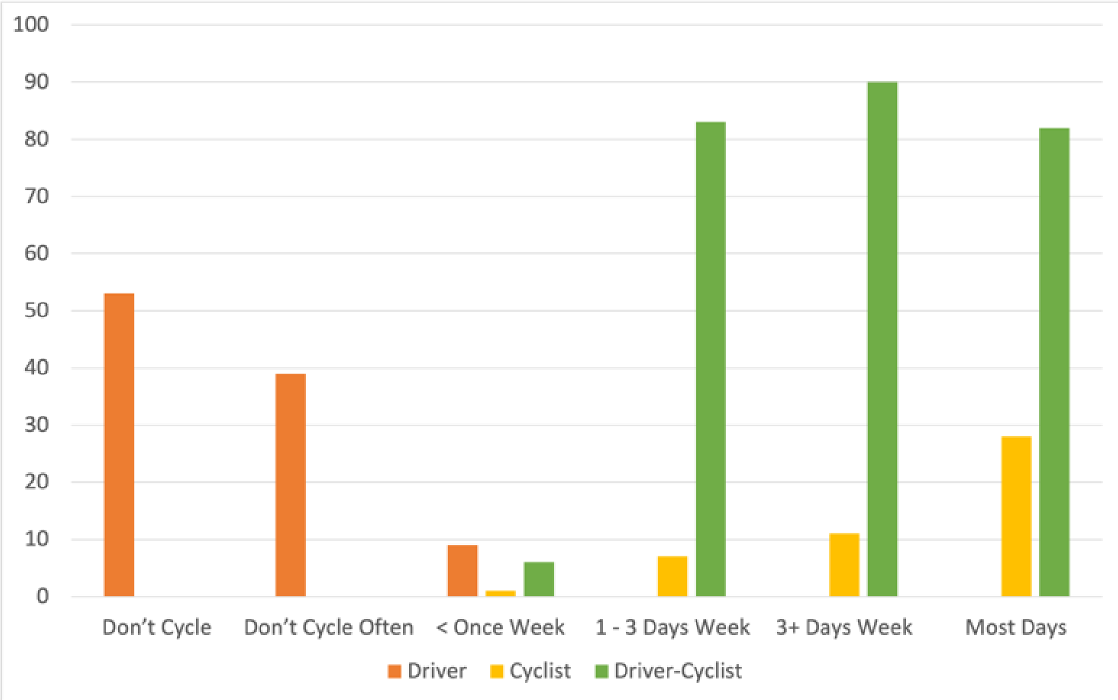


Figure 3. Cycling frequency

2.2 Results

2.2.1 Perceptions of road users

As aforementioned, the aim of this section was to elicit respondents’ thoughts and perceptions of road users in different situations. Of the 47 cyclists that responded to the questionnaire, 45 provided responses for this section. Given the large amount of free-text data, and the uneven group sizes, the decision was made to only analyse data from 45 respondents from each of the driver and driver-cyclist groups. These were selected at random, resulting in a sample of 135 for this analysis. The demographic characteristics of that sample are summarised in Table 3.

Table 3. Demographics of the sample used for the analysis of Section 1 questions

		Age Group						
		18 - 35	26 - 35	36 - 45	46 - 55	56 - 65	Over 65	**Total**
Driver	Male	3	1	1	3	9	2	**19**
	Female	1	3	6	9	6	1	**26**
Cyclist	Male	1	8	5	8	5		**27**
	Female	1	6	3	5	3		**18**
Driver-Cyclist	Male		3	10	11	6	6	**36**
	Female	1		4	2	2		**9**
	Total	**7**	**21**	**29**	**38**	**31**	**9**	

The free text responses to ten statements were subjected to inductive thematic analysis, with a unique coding scheme developed for each question. One analyst performed all analyses. Each question invited up to a maximum of five responses with no minimum (i.e., respondents were not obliged to answer the question). Across the ten questions, a total of 3132 responses were provided. The average number of responses given per question was 2.32 (SD 1.53); for drivers it was 3.18 (SD 1.63), for cyclists the mean was 2.92 (SD 1.56), and for driver-cyclists it was 2.84 (SD 1.38). The consistency and implementation of each of the ten coding schemes was assessed by having a second individual analyse 10% of the responses, using the coding schemes developed by the main analyst. Cronbach's alpha and percentage agreement were then calculated (results of which are presented below). Themes scoring less than a total of five across the three groups were excluded from the analyses. In addition to the inductive analysis, responses to four statements (see below) were also coded according to whether they were negatively worded (i.e., indicating a negative perception of the road user in question), positively worded (i.e., indicating a positive perception), or neutrally worded (e.g., neutral descriptions or statements). The positive/negative/neutral coding was also subjected to inter rater reliability testing in the same way.

2.2.2 Thematic coding

Table 4 summarises the total and average numbers of responses, the number of themes (appearing at least five times) extracted from those responses, and the inter-rater reliability test results for the coding process, for each of the ten statements included in the analysis. Following Cohen (1960), agreement was perfect or almost perfect in all cases. Of note was that the two items asking respondents to list risky behaviours associated with drivers and cyclists were those that attracted the most responses.

Table 4. Summary of responses and thematic analysis inter rater reliability tests.

Statement	Total number of responses across respondents	Average (SD) number of responses per respondent			Number of themes extracted *	Inter-rater reliability	
		Drivers	Cyclists	Driver-cyclists		Kappa	% Agreement
List some of the words or phrases that come to mind when you think of 'urban cyclists'	268	2.0 (1.20)	1.8 (0.97)	2.0 (1.29)	15	.87	87.9%
List some of the words or phrases that come to mind when you think of 'rural cyclists'	244	1.9 (1.91)	1.7 (0.92)	1.9 (1.08)	6	.95	95.8%
List some of the words or phrases that come to mind when you think of 'urban drivers'	233	1.6 (1.91)	1.3 (0.92)	1.5 (1.08)	11	.89	91.0%
List some of the words or phrases that come to mind when you think of 'rural drivers'	203	2.0 (1.70)	2.1 (1.07)	2.0 (1.03)	10	.96	96.7%
Please list some risky behaviours you would commonly associate with cyclists	441	4.0 (1.14)	3.2 (1.90)	2.5 (1.30)	14	.90	91.5%
Please list some risky behaviours you would commonly associate with drivers	536	4.0 (1.10)	4.0 (1.27)	3.9 (1.73)	16	.92	91.3%
If you drive, please list some words or phrases that go through your mind when you approach a cyclist	290	2.7 (1.40)	1.4 (1.21)	2.4 (1.22)	10	.82	87.1%
If you cycle, please list some words or phrases that go through your mind when you are on your bicycle and a car approaches you from behind	256	0.8 (1.20)	2.7 (1.74)	2.2 (1.95)	10	.90	86.1%
Please list up to 5 things you think cyclists should wear in order to enhance their safety	378	3.7 (1.34)	2.5 (1.57)	2.2 (1.64)	13	1.00	100%
How do you think safety between drivers and cyclists can be improved?	283	2.1 (1.57)	2.0 (1.27)	2.1 (1.10)	12	.92	93.3%

* Number of themes *appearing at least five times* among the response to that statement

Statement 1: List some of the words or phrases that come to mind when you think of 'urban cyclists'

Figure 4 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. Across groups, the most present themes were *Commuter*, *Dangerous*, and *Efficient*. When broken down by mode, the most common answers from the cyclists were *Commuter*, *Efficient*, and *Progressive*. From the driver-cyclists, the most common answers were *Commuter*, *Dangerous*, and *Concern for the environment*. Notably, the most common codes applied to the words and phrases drivers connected with 'urban cyclists' were *Dangerous*, *Breaking Rules*, and *Thoughtless*.

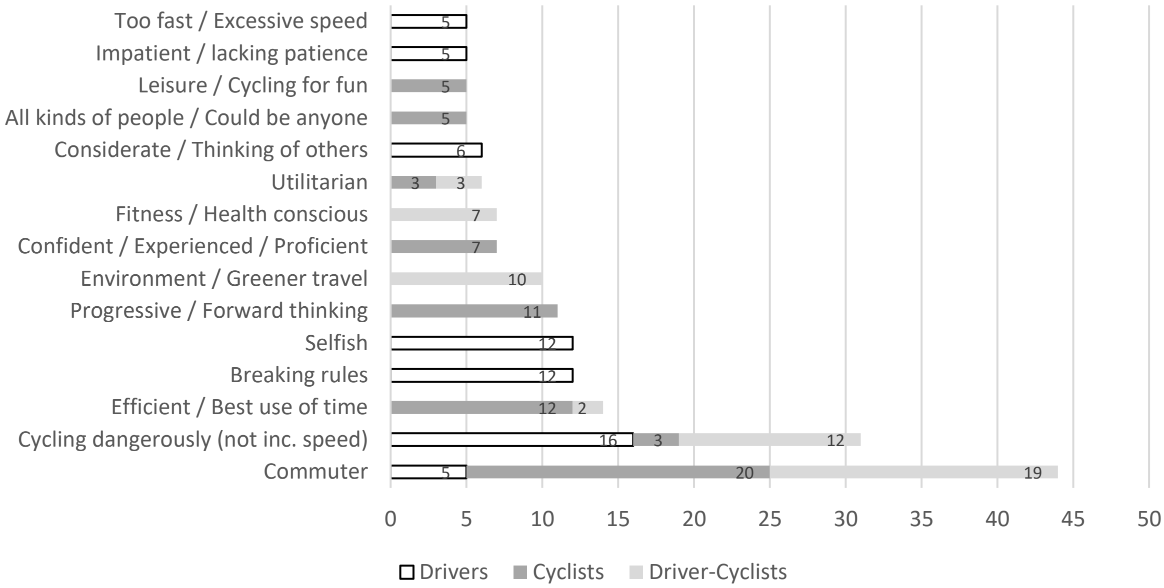


Figure 4. Frequency with which each identified theme was present in the responses to statement one, "List some of the words or phrases that come to mind when you think of 'urban cyclists'", separated by road user group.

Statement 2: List some of the words or phrases that come to mind when you think of 'rural cyclists'

Figure 5 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. As can be seen *Club Riders* and *Leisure* were the most commonly present themes overall, and in the responses of each separate group. The third most common theme in drivers' responses was *Dangerous* (which was absent from cyclist and driver-cyclist responses), and they did not provide any responses coded as *Brave* or *Families*.

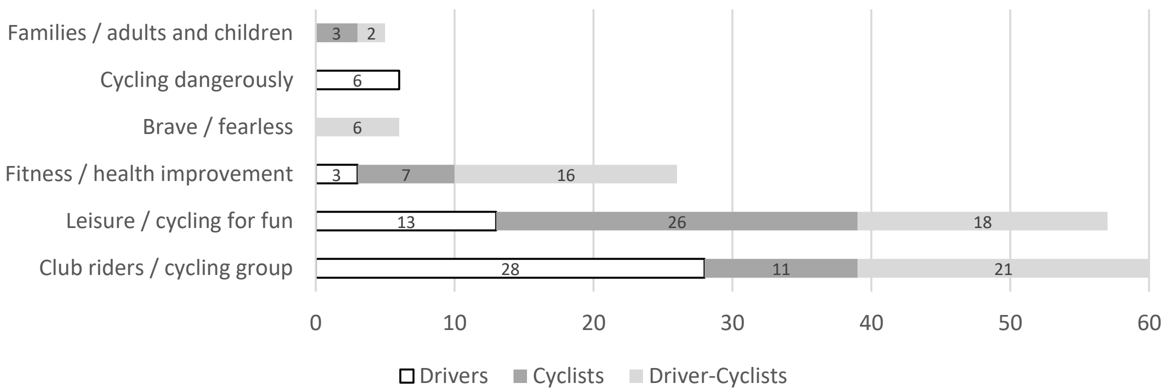


Figure 5. Frequency with which each identified theme was present in the responses to statement two, "List some of the words or phrases that come to mind when you think of 'rural cyclists'", separated by road user group.

Statement 3: List some of the words or phrases that come to mind when you think of 'urban drivers'

Figure 6 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. The *Impatient*, *Dangerous driving*, and *Distracted* codes were most present across groups. These top three were reflected in the cyclists' comments, while driver-cyclists made more comments related to *Congestion* than to being *Distracted*. Drivers' responses showed a similar pattern, though members of that group also referred to *Speeding*, a theme not seen in the cyclist or driver-cyclist responses.

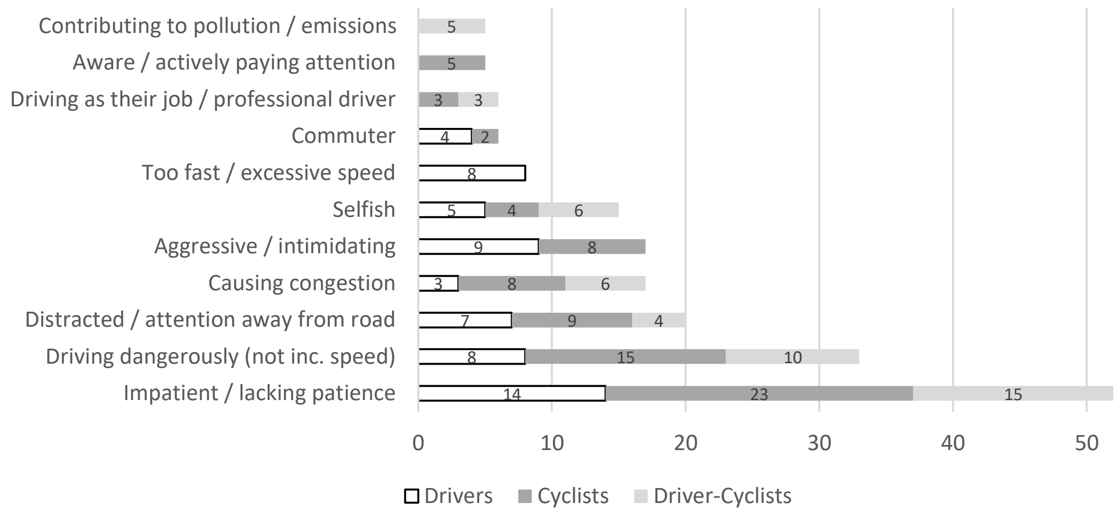


Figure 6. Frequency with which each identified theme was present in the responses to statement three, "List some of the words or phrases that come to mind when you think of 'urban drivers'", separated by road user group.

Statement 4: List some of the words or phrases that come to mind when you think of 'rural drivers'

Figure 7 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. The most present themes across groups were *Dangerous driving*, *Selfish*, and *Leisure*, but there were some clear group differences. Drivers and driver-cyclists provided a significant number of responses coded as *Selfish* whereas cyclists made no such comments; their responses were dominated by those coded as *Impatient*, followed by *Dangerous.*

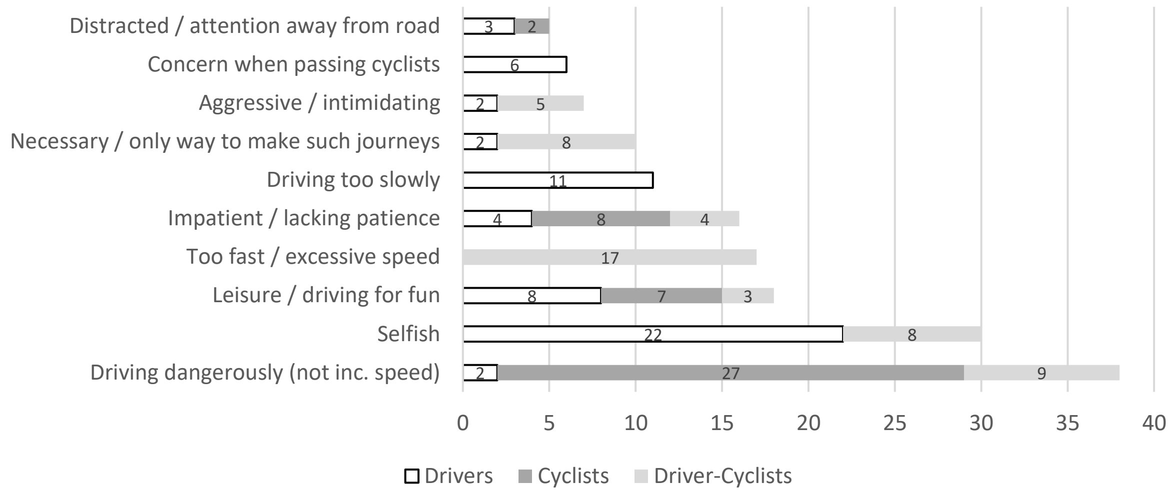


Figure 7. Frequency with which each identified theme was present in the responses to statement four, “List some of the words or phrases that come to mind when you think of ‘rural drivers’”, separated by road user group.

Statement 5: Please list up to five risky behaviours you would commonly associate with cyclists

Figure 8 displays the frequency with which each theme was present in the respondents’ answers, separated by road user group. As can be seen, the most common themes across groups were *Breaking Rules*, *Dangerous Cycling*, and *No PPE*. Patterns were relatively similar across groups, with some notable differences. Drivers more commonly referred to *Filtering* and to *Three abreast / groups* than either cyclists or driver-cyclists whereas drivers made no comments referring to *Cycling on busy roads*, something referred to by both cyclists and driver-cyclists as risky behaviours associated with cyclists.

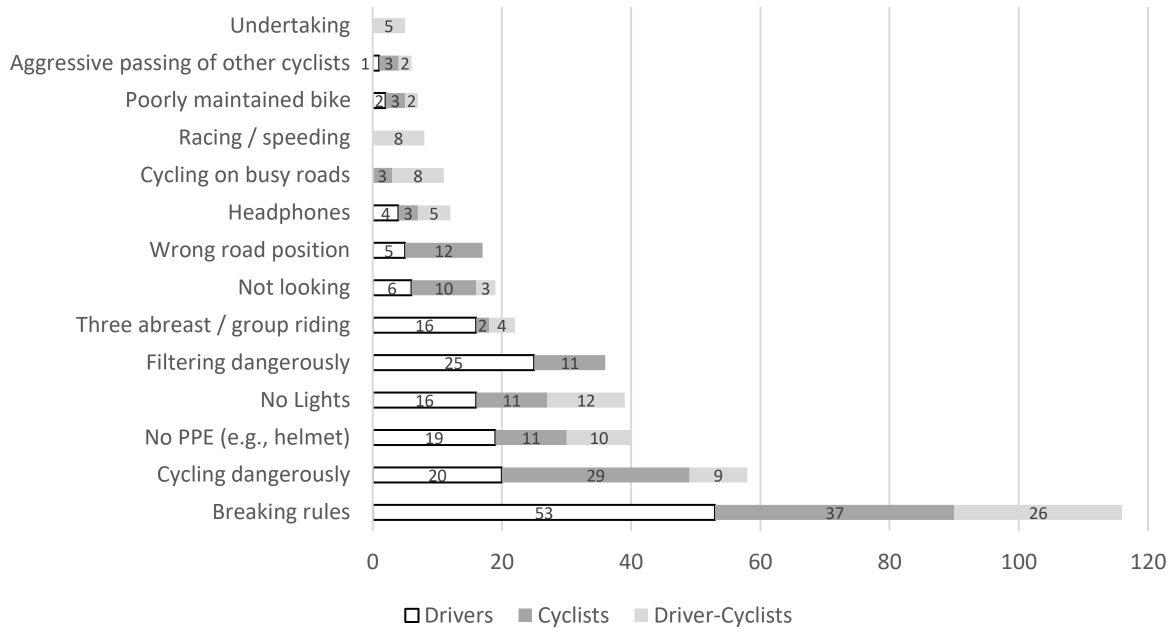


Figure 8. Frequency with which each identified theme was present in the responses to statement five, “Please list up to five risky behaviours you would commonly associate with cyclists”, separated by road user group.

Statement 6: Please list up to five risky behaviours you would commonly associate with drivers

Figure 9 displays the frequency with which each theme was present in the respondents’ answers, separated by road user group. The most referenced risky driver behaviours were *Speeding*, *Breaking Rules*, and *Driving too close to cyclists*. Notably, this latter category was prominent in the cyclist and driver-cyclist responses but much less so in the drivers’ responses. The two cycling groups also made a significant number of responses coded under the *Dangerous driving* and *Not looking* themes, whereas the drivers did not. Among the drivers’ responses, comments related to being *Distracted* were more common, a theme not found in the two cycling groups’ responses.

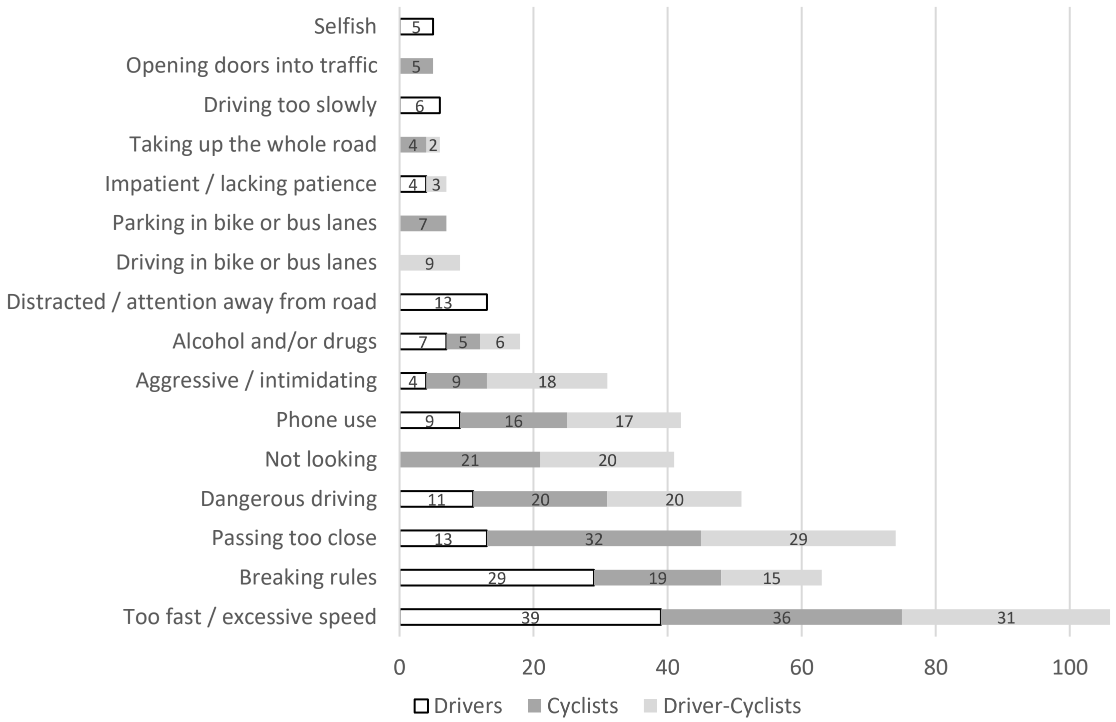


Figure 9. Frequency with which each identified theme was present in the responses to statement six, “Please list up to five risky behaviours you would commonly associate with drivers”, separated by road user group.

Statement 7: If you drive, please list some words or phrases that go through your mind when you approach a cyclist

Figure 10 displays the frequency with which each theme was present in the respondents’ answers, separated by road user group. As can be seen, the most common phrases associated with approaching a cyclist when driving a car were *Give Room*, *Overtake when safe*, and *What is cyclist doing?* The *Give room* theme was dominant in all three groups’ responses whereas the *What is cyclist doing?* theme was more common among the drivers’ responses, with the *Overtake when safe* theme being less common. Drivers also made more responses related to generally being alert (*Caution*) and under the *Check road/traffic ahead* theme, whereas several of the driver-cyclists’ comments were coded under the *How competent* and *Humanise* themes (themes not present in the other two groups’ responses).

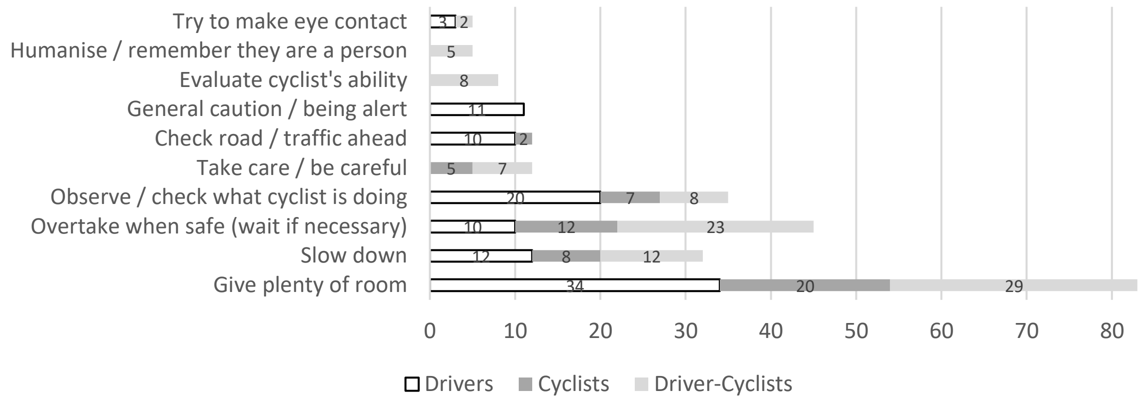


Figure 10. Frequency with which each identified theme was present in the responses to statement seven, “If you drive, please list some words or phrases that go through your mind when you approach a cyclist”, separated by road user group.

Statement 8: If you cycle, please list some words or phrases that go through your mind when you are on your bicycle and a car approaches you from behind

Figure 11 displays the frequency with which each theme was present in the respondents’ answers, separated by road user group. As can be seen, the most common themes were *Too Close*, *Feeling scared*, and *Hope visible*. Interestingly, only the driver-cyclists referred to *Checking traffic* or to vehicle driver being *Aggressive* when thinking about being approached from behind, while only the cyclists made comments about drivers being *Impatient*. Of the few driver responses, the majority were under the *Feeling scared* theme

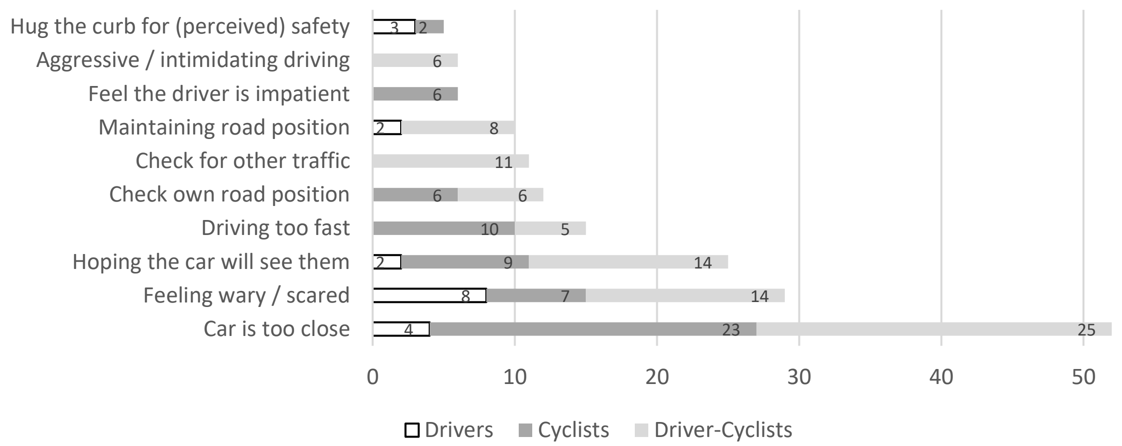


Figure 11. Frequency with which each identified theme was present in the responses to statement eight, “If you cycle, please list some words or phrases that go through your mind when you are on your bicycle and a car approaches you from behind”, separated by road user group.

Statement 9: Please list up to five things you think cyclists should wear in order to enhance their safety

Figure 12 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. As can be seen, the most common themes were *Hi-Viz*, *Helmet*, and *Lights on the bike*, a pattern that was identical across groups. All groups prioritise some form of PPE; however, there was also strong feeling amongst some cyclists and driver-cyclists that no special equipment should be required (*Nothing special)*, pointing to a feeling that the onus should be on the driver not to endanger a cyclist, not the cyclist to protect themselves from harm.

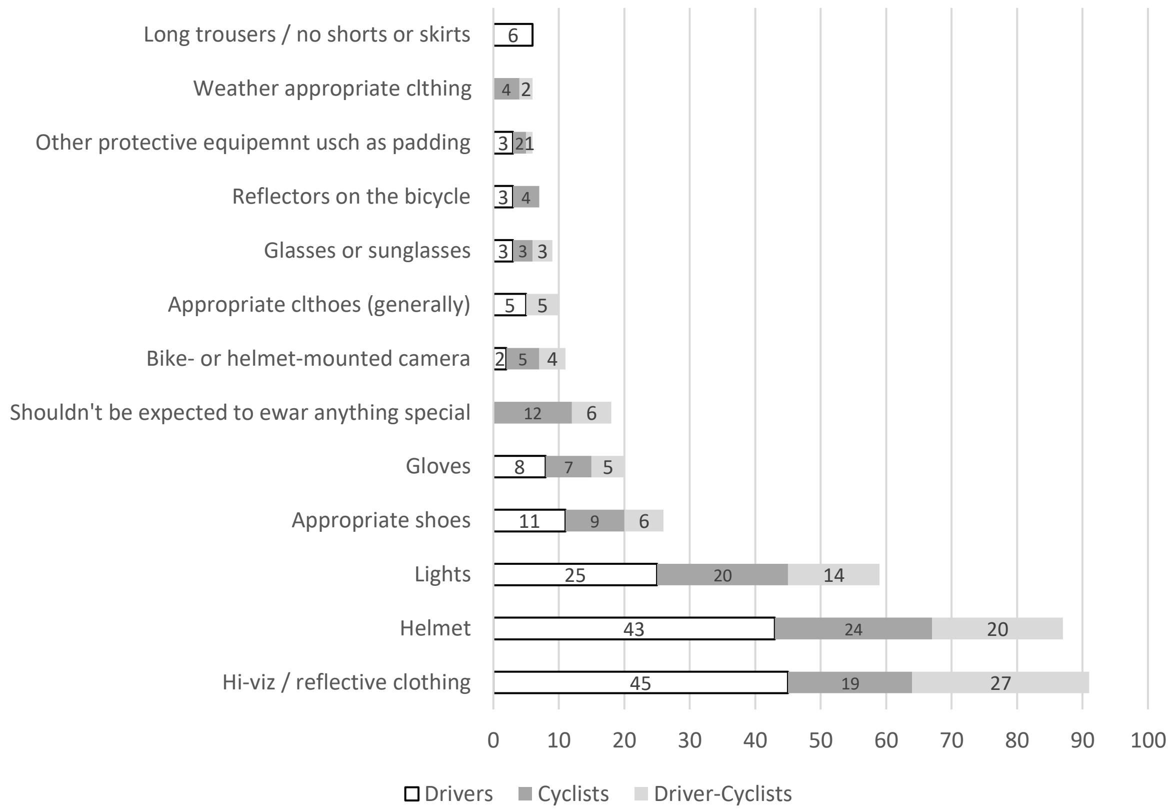


Figure 12. Frequency with which each identified theme was present in the responses to statement nine, "Please list up to five things you think cyclists should wear in order to enhance their safety", separated by road user group.

Statement 10: How do you think safety between drivers and cyclists can be improved?

Figure 13 displays the frequency with which each theme was present in the respondents' answers, separated by road user group. There were several noteworthy group differences in responses to this question. First, the two cycling groups made relatively more comments coming under the *Segregated infrastructure* theme than drivers. Second, where drivers and cyclists both commonly made suggestions to generally *Improve infrastructure*, such comments were absent from driver-cyclist responses. Third, the *Enforcement (cars)* theme was common among the responses of the two cycling groups, yet almost absent from the drivers' responses. Conversely, the *Enforcement (bicycles)* theme was similarly present across the three groups' responses. Fourth, only cyclists provided responses coded under the *Cars passing bikes safely* theme, while only driver provided responses suggesting *Compulsory use of cycle lanes.* Finally, *Presumed liability* was mentioned by both cyclists that do and do not often drive, but was not suggested by any drivers. Although not included in these analyses due to having fewer than five instances, more unusual suggestions included not allowing cyclists on busy roads or not allowing cyclists at rush hour, both of which were suggested only by drivers.

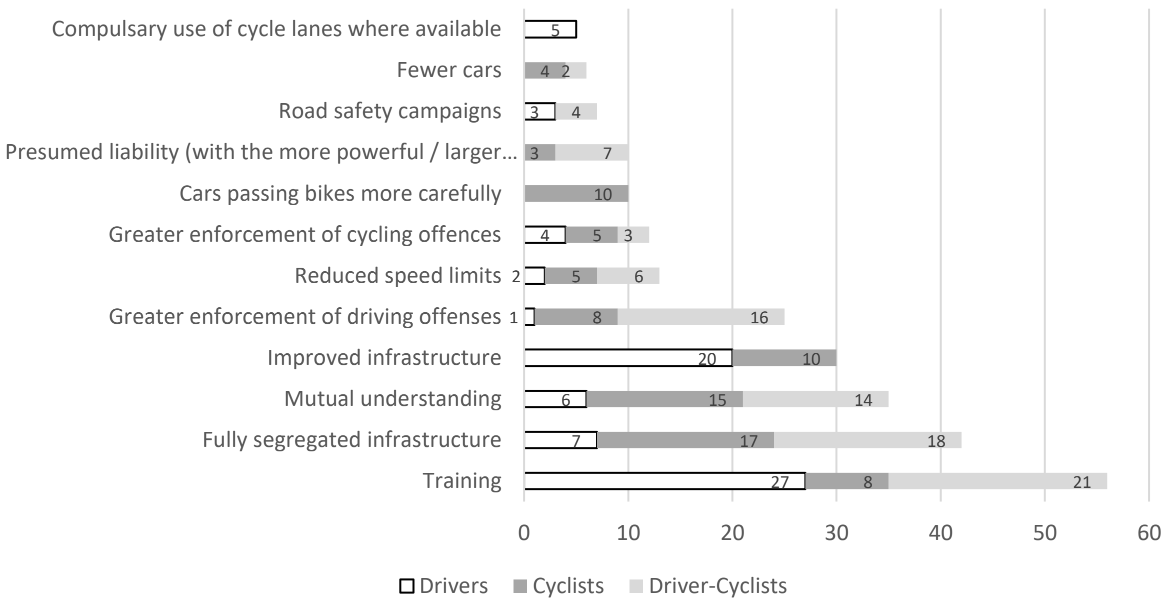
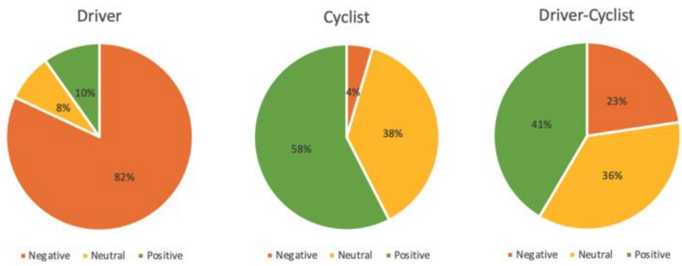


Figure 13. Frequency with which each identified theme was present in the responses to statement ten, "How do you think safety between drivers and cyclists can be improved?", separated by road user group.

2.2.3 Valence coding

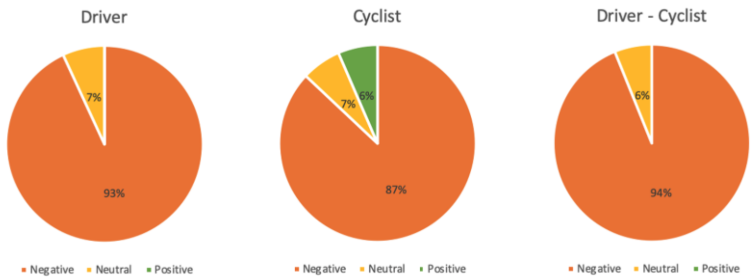
As described above, in addition to thematic coding, responses to the first four statements discussed above were also subjected to valence coding, i.e., they were coded as being either positively worded, negatively worded, or neutral. Of the 948 responses provided across all four statements, 120 were subjected to inter rater reliability calculations. Agreement was at 90.8% and Cohen's kappa was .86, indicating very good agreement between raters.

Some marked differences were seen in the way the three groups responded to the statements about other road users, as can be seen in Figure 14. In responding to the statement "List some of the words or phrases that come to mind when you think of 'urban cyclists'", drivers' responses were mostly negative, driver-cyclists' responses were mixed, and cyclists' responses were mostly positive (Figure 14, part a). Responses to the second statement, concerning 'rural cyclists', differed somewhat insofar as most responses, across groups, were either positive or neutral (Figure 14, part b). That said, a similar pattern can be observed; drivers typically made fewer positive and more negative comments. Responses to the statement concerning 'urban drivers' were very similar across groups (Figure 14, part c), with the only positive comments coming from (perhaps surprisingly) cyclists. Drivers' and driver-cyclists' comments had an almost identical pattern; a small number of neutral comments were made, with the very large majority of comments negatively describing 'urban drivers'. Finally, responses to the statement asking for words or phrases that come to mind when thinking about 'rural drivers' were largely negative across groups, with only a slight pattern discernible; drivers made the most positively coded comments, followed by driver-cyclists, with the fewest number of cyclists' comments being coded as such (Figure 14, part d).

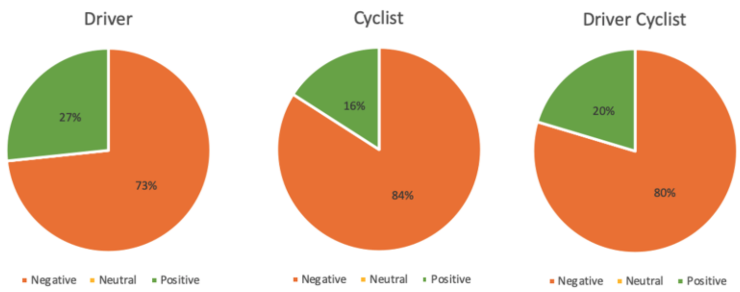


a) Valence coding to responses to the statement *List some of the words or phrases that come to mind when you think of 'urban cyclists'*

b) Valence coding to responses to the statement *List some of the words or phrases that come to mind when you think of 'rural cyclists'*



c) Valence coding to responses to the statement *List some of the words or phrases that come to mind when you think of 'urban drivers'*



d) Valence coding to responses to the statement *List some of the words or phrases that come to mind when you think of 'rural drivers'*

Figure 14. Summary of valence coding of responses to four statements

2.2.4 Quiz

2.2.4.1 Scenarios

Respondents were asked twelve questions in this section, the results of which are summarised in Figure 15. Notably, fewer than 30% of drivers correctly answered the question regarding cycling two abreast on wide quiet roads (which is a permitted behaviour). Drivers also performed poorly on the question asking about cycling on the main road when a cycle lane is present, with fewer than 20% correctly indicating that it is not a legal requirement. Half of the drivers thought that it was a behaviour that is advised against (which it is not), whilst the remaining drivers thought you were legally required to use the provided cycle lane. Fewer than 50% of the respondents in each of the of the three groups correctly indicated that cycling in either direction on a shared path is legally permissible. Over 90% of participants correctly answered that cycling through a red light, even when there are no pedestrians around, is an illegal act.

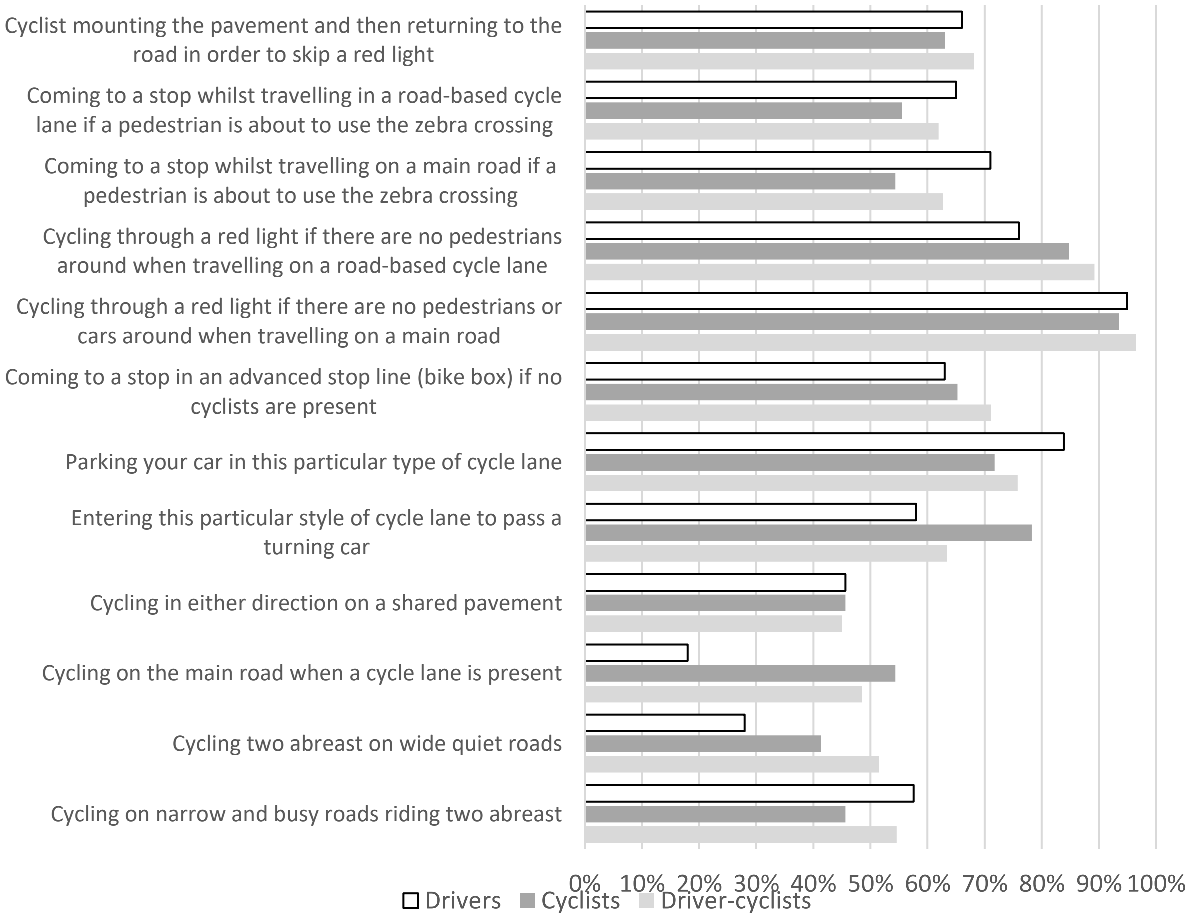


Figure 15. Percentage of respondents in each road user group that answered each of the 12 scenario questions correctly

Overall scores (out of 12) were similar across road user groups; these are summarised in Figure 16. On average, driver-cyclists performed the best, with an average score of 7.9 (SD = 2.0), followed by cyclists, with an average score of 7.6 (SD = 2.0). Drivers performed the worst, with an average score of 7.0 (SD = 2.1). Only two cyclists (4.3%) and 11 driver-cyclists (4.2 %) got all twelve questions right. Two people (one driver, one driver-cyclist) got zero correct. To assess whether there were any group differences in these scores, an ANOVA test was used. The ANOVA revealed a significant difference between groups ($F_{(2,406)} = 24.5$, $p = .002$). Subsequent pairwise comparisons, with the Bonferroni correction applied, revealed that drivers scored significantly lower than driver-cyclists ($p < .001$). There were no significant differences between cyclists and drivers (p = .520) nor between cyclists and driver-cyclists (p = .809).

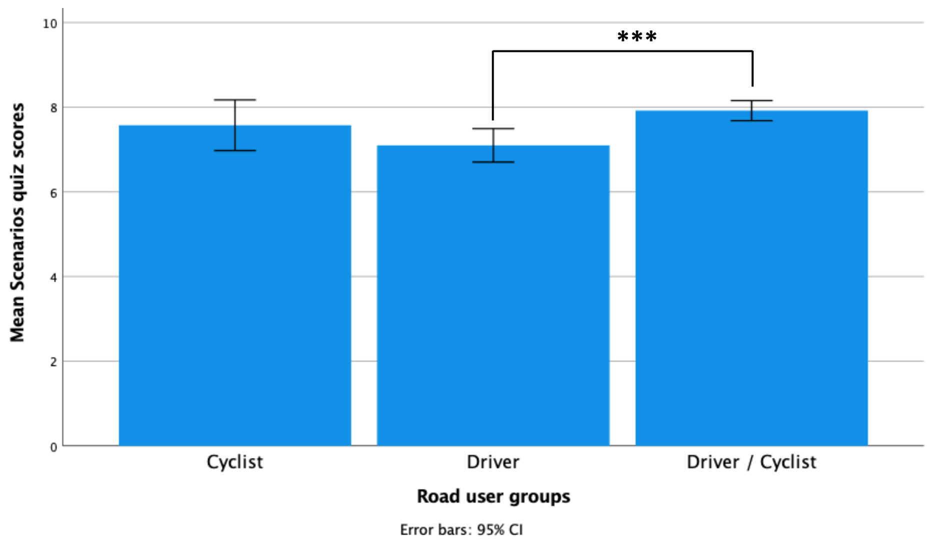


Figure 16. Average road user group scenario quiz results (out of 12), with 95% confidence intervals and significant group differences displayed (****p* < .001).

2.2.4.1 Equipment

Three scores were calculated for each participant in this section: two for equipment, one for lighting. For the equipment part, one score indicated the number of legally required equipment options correctly selected (out of three), the other indicating the number of incorrect selections of equipment that are not legally required (out of 15). As such, higher first scores indicate better performance whereas lower second scores indicate better performance. Lighting scores were displayed as one score indicating the number of questions answered correctly (out of three).

For the equipment sub-section, there were 21 cyclists (45%), 52 drivers (52%), and 82 driver-cyclists (31%) who correctly selected all three legally required equipment options. Of those respondents, 11 cyclists (23%), 21 drivers (21%) and 13 driver-cyclists (11%) also made no incorrect equipment selections. Regarding incorrect selections, 22 cyclists (47%), 54 drivers (54%), and 120 driver-cyclists (46%) made one or more incorrect selections. The average number of incorrect selections across all three road user groups were below one; cyclists and driver-cyclists performed the best, both with an average score of 0.6 (cyclist SD = 0.8, driver SD = 1), whilst drivers average score was 0.9 (SD = 1.3). Results again were very similar for all three road user groups for the lighting sub-section, with cyclists scoring an average of 2.5 out of three (SD = 0.6), drivers 2.4 (SD = 0.6), and driver-cyclists 2.5 (SD = 0.6). 25 cyclists (53%), drivers 47 (47%), and 132 driver-cyclists (51%) correctly answered all three lighting questions and only one participant (a driver-cyclist) who got all three questions wrong.

To assess whether there were any differences between road user groups in their equipment and lighting scores, a MANOVA test was performed. Three outcome variables were included: correct equipment selections (out of three), incorrect equipment selections (out of fifteen), and correct lighting selections (out of three). Due to uneven sample sizes, Pillai's Trace statistic was selected. The MANOVA revealed a statistically significant difference between road user groups (Pillai's Trace = .047, $F_{(3, 806)} = 3.529$, $p < .004$). Subsequent univariate tests revealed significant differences between road user groups for correct equipment scores ($F_{(2, 404)} = 5.462$, $p < .005$) and incorrect equipment scores ($F_{(2, 404)} = 5.331$, $p < .005$). There were no statistically significant group differences in lighting scores ($F_{(2, 404)} = .393$, $p = .675$).

Regarding correct identification of legally required equipment, subsequent pairwise comparisons with Bonferroni correction applied revealed that drivers scored significantly higher than driver-cyclists' ($p = .006$). There were no significant differences between drivers and cyclists ($p = 1.000$) nor cyclists and driver-cyclists ($p = .277$). Figure 18 summarises results. Regarding the incorrect selection of equipment that is not legally required, subsequent pairwise comparisons with Bonferroni correction applied revealed that drivers scored significantly higher (i.e., performed worse) than driver-cyclists' ($p = 0.006$), There was no significant differences between drivers and cyclists ($p = .052$) nor cyclists and driver-cyclists ($p = 1.000$), figure 11 summarises.

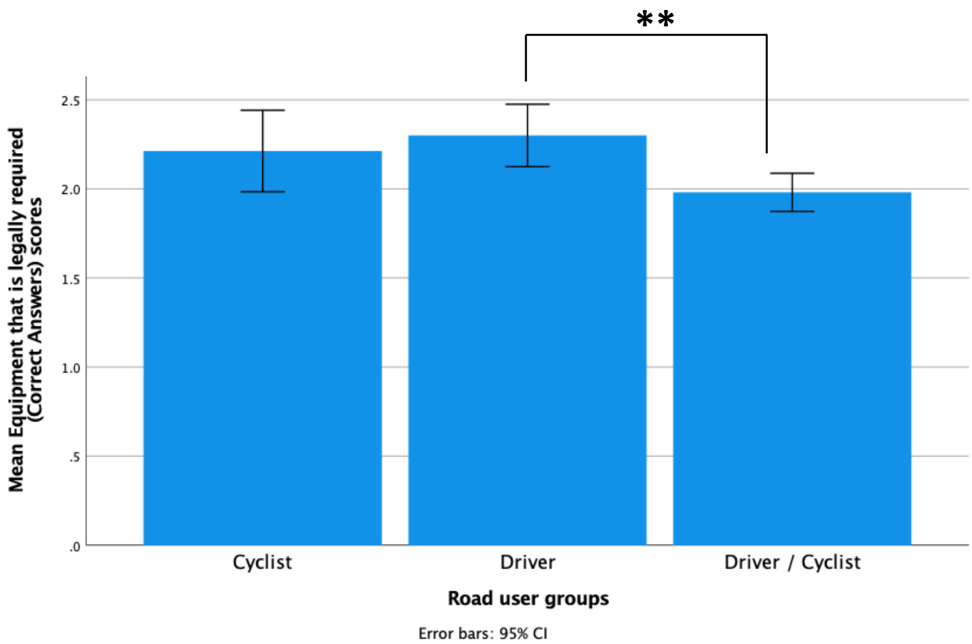


Figure 17. Average road user group correct equipment scores (out of 3), with 95% confidence intervals and significant group differences displayed (**p < .01). Higher scores indicate better performance.

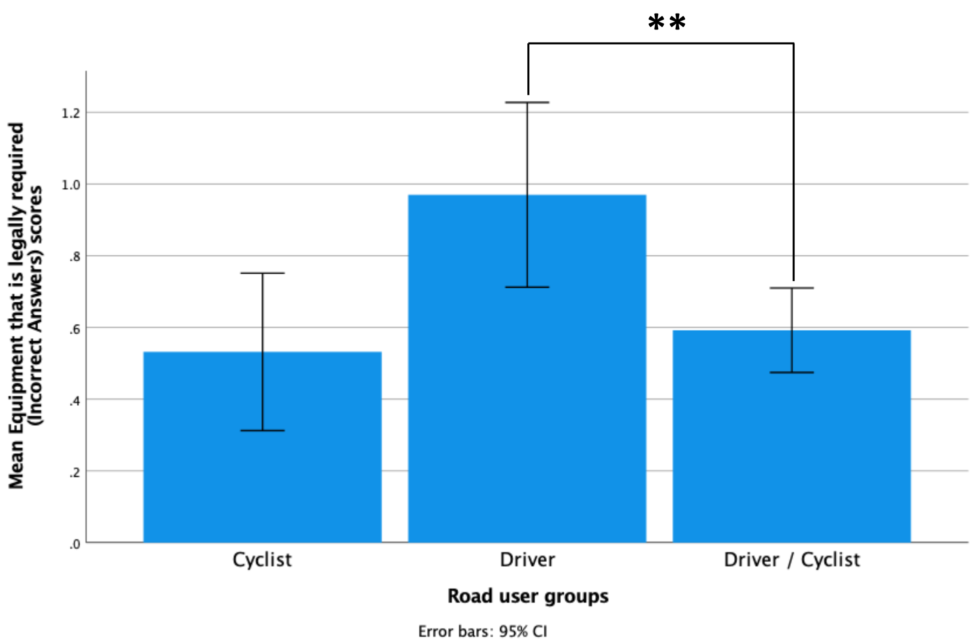


Figure 18. Average road user group incorrect equipment scores (out of 15), with 95% confidence intervals and significant group differences displayed (**p < .01). Lower scores indicate better performance.

3. Training course

3.1 Introduction and design

This aspect of the project addressed the second of our research aims, i.e., to explore the potential for cross-modal training to enhance empathy and understanding between groups. To do so we focussed on competency as comprising three aspects; knowledge, skills, attitudes (KSA; Etling, 1993). In an on-road context, drivers' and cyclists' competencies (and resulting behaviours) are a product of their combined knowledge (e.g., of road rules), their skills (in controlling the vehicle), and their attitudes (e.g., towards rules, or a road user) (e.g., Morharrer, 2011).

To understand if a person's competency has improved, the effect of training on each of the three factors needs to be understood. Typically, knowledge would be measured in the form of a quiz or test, where improvement is demonstrated by higher scores after vs. before training (Matoskova, 2016). Skills are usually measured in the form of a physical assessment, for example being able to complete a lap of a circuit more quickly than was previously possible (Jørgensen, 1993). Finally, attitudes are typically measured through Likert scales whereby an individual is asked the extent to which they agree or disagree with a range of statements, with differences before and after training giving an indication of attitudinal change.

As described above, the global pandemic rendered impossible our initial plan to hold in-person training (on the road and in our driving simulator). As such, we designed online training courses. Although the online assessment of knowledge and attitudes is relatively straightforward, the assessment of skills in an online setting is less straightforward. That said, there have been studies that have addressed all three aspects using self-report scales (e.g., Buchanan et al. 2015; George et al. 2014; Ghaiour and Eslamipour, 2016; Johnston et al. 2020; Néri et al. 2017), although applications in the driver and cycling domains are limited (Sersli et al., 2019; Useche et al. 2019). Therefore, questionnaires disseminated before and after training were used to assess the training's impact on each of the knowledge, skills, and attitudes dimensions.

3.1.1 Training Course design

Two separate (but related) training courses, one for drivers and one for cyclists, were designed. The cyclist course aimed to teach cyclists what it is like to be a driver, whilst the driver course aimed to teach drivers what it is like to be a cyclist. In total, seven modules were produced: Introduction, Attitudes, Skills (parts one and two), Knowledge (parts one and two), and a summary. To create the training courses, Adobe Captivate was used, with Captivate Prime used to host the courses. Each course took around two hours to complete. Data from several sources informed the design of the training courses. A think aloud study (reported elsewhere; see McIlroy et al. 2021) was conducted that had 15 drivers and 14 cyclists negotiate a ~11km route around Southampton city whilst verbalising their thought processes (i.e., thinking out loud). Of those participants, three were expert drivers (they were advanced driving course instructors) and one was an expert cyclist (they were a cycling proficiency trainer). Verbal data informed training design through supporting a deeper understanding of the way in which drivers and cyclists execute certain manoeuvres. Results of the focus groups and online survey described above also informed the design of the courses. A first version of each course was designed based on these data and drawing from online sources of information concerning cycling and driving safety, including the UK's Highway Code. The two courses were then reviewed by three Cycling UK training experts. In addition to providing feedback, confirming, and editing (where necessary) the two courses, Cycling UK contributed additional content.

The content of the final courses was as follows. The *introduction* explained the course structure and what to expect. The *attitudes* module highlighted what an attitude was and the link between a person's attitude and their behaviour. It highlighted common perceptions held by different drivers and cyclists, it discussed how attitudes can manifest into behaviours, why people drive or cycle, and common attitudes that each road user group has towards the opposite road user group. Finally, it highlighted how unconscious bias affects the prejudgment of certain drivers and cyclists. The *knowledge part one* module focussed on how a cyclist or driver takes information from the world, the actions they perform, and the schema (or mental model) that guides action and information searching (i.e., based on the Perceptual Cycle Model; see Neisser, 1976). The *knowledge part two* module focussed on the Highway Code. In it, participants were asked to select what they thought was the answer to a given question and then provided with a detailed description of why a particular answer was correct. The *skills part one* module had either a) a set of videos showing drivers how cyclists perform a variety of manoeuvres, or b) a set of videos showing how drivers perform a variety of manoeuvres. The *skills part two* module was where the IPSGA (information, position, speed, gear, and acceleration) technique was introduced and applied to certain scenarios to teach participants how to safely interact with the opposite road user group. This is an advanced driver training technique used by expert Police drivers as well as by the IAM Roadsmart advanced driver training organisation. Finally, the *summary* recapped what had been taught across the previous modules and gave further tips on what to look out for when interacting with the opposite road user group.

3.1.2 Questionnaire design

To assess the effectiveness of the training programmes, participants were asked to fill out a questionnaire relating to the three elements on which the training was based, i.e., knowledge, skills, and attitudes. Questionnaires were administered before participants undertook training, immediately after course completion, and then again six weeks later (follow-up). Questionnaires were hosted using iSurvey, the University of Southampton's online questionnaire tool. Both drivers and cyclists received very similar questions; drivers learning what it is like to be a cyclist were given questions about their views (related to knowledge, skills, and attitudes) towards cyclists, whilst cyclists learning to be a driver were given questions about their views towards drivers. The questions used were designed based on course content and informed by Useche et al.’s (2018) cycling behaviour questionnaire tool and the UK’s Highway Code. A pilot study ensured questions were not leading. There were four main sections to the survey: demographics, knowledge, skills, and attitudes.

The demographics section focussed on the frequency of using their main mode of transport (driving or cycling) and the number of years using that mode of transport. Respondents were also asked if they had been involved in a collision with a cyclist or driver and asked to identify who was at fault (cyclist, driver, equally at fault, or not sure). Finally, cyclists were asked how they feel being approached and overtaken by drivers and drivers were asked how confident they feel driving around or past cyclists.

The knowledge section was split into two parts. *Knowledge part one* comprised 14 items focussed on previous experiences, how the environment affected their ability to interact with the opposite road user, and the actions participants take when interacting with the opposite road user group (e.g., “I understand how cyclists might think about, and process, a situation”). Each item invited responses on a four-point Likert scale (Never to Regularly). *Knowledge part two* comprised six questions relating to rules of the road, behaviours, and reasons why people behave the way they do. Responses were invited on a five-point Likert scale (from strongly disagree to strongly agree). The skills section comprised 18 questions based around common behaviours and safety measures and asked about the respondents' overall ability to interact with the opposite road user safely. Responses were recorded using a five-point Likert scale (strongly disagree to strongly agree). Finally, the attitudes section, also using a five-point Likert scale from strongly disagree to strongly agree, comprised 19 questions and focussed perceptions of and attitudes towards the opposite road user group. Several questions were reverse scored, and all questions can be seen in full in the results section below.

3.1.3 Participants, Recruitment and Ethics

Given previous experience of the difficulty to recruit those that only drive (and never cycle) or only cycle (in the focus group and questionnaire study), the following criteria were developed to allow participants to self-identify as members of a group:

- Cyclist: You must primarily cycle and rarely drive (maximum of once a month)
- Driver: You must primarily drive and rarely cycle (maximum of once a month)

As previously described, this categorisation method is consistent with previous research (e.g., Beanland and Hansen, 2017; Chaurand & Delhomme, 2013). Recruitment was achieved through advertising the study via Twitter, Facebook, email, national and local press, and word of mouth. Ethical approval was requested from and provided by the University of Southampton's Ethics and Research Governance committee, reference number 57036. Only those of 18 years and over and resident in the UK were asked to participate.

3.1.4 Procedure

After providing informed consent, participants were asked to fill out the pre-course questionnaire. Once completed they were given login details which enabled them to login in and out of the training course as and when it suited them. The seven modules could only be completed in order. After completion, participants were immediately asked to fill out the post-course questionnaire. They were contacted again six weeks later and asked to complete the questionnaire a third time.

3.1.5 Data reduction and statistical analysis

Data from cyclists and drivers undertaking the separate courses were treated separately. The aim of this research was to assess the effect of training rather than to explore differences between road user groups. Reliability analysis using Cronbach's alpha was performed on each of the sections of the questionnaire, i.e., knowledge part one, knowledge part two, skills, and attitudes, with each scale treated as uni-factorial (all questions in each section were designed to assess the same underlying construct). Item counts and reliability results are summarised in Table 5.

Single scores for each section were calculated for each participant by averaging their responses (after treating reverse-scored items). To assess the effect of the training on section scores across the three time points (i.e., pre-course, post-course, and follow up), two repeated measures MANOVAs were performed (i.e., one for drivers, one for cyclists). All statistical analyses were performed using SPSS v.26.

Table 5. Number of questions in each section and reliability analysis results

Category	**Driver questionnaire** Number of items	Cronbach's alpha	**Cyclist questionnaire** Number of items	Cronbach's alpha
Knowledge Part One	14	.827	14	.883
Knowledge Part One	6	.854	6	.745
Skills	18	.770	18	.728
Attitudes	19	.752	19	.800

3.2 Results

3.2.1 Participants

In total, 57 participants took part in the study. Of those, 29 identified as drivers (20 females, eight males, and one other) and 28 identified as cyclists (17 females, 11 males). Age and gender splits are summarised Table 6.

Table 6. Age and gender of the fifty-seven participants

		Age Group 18 - 35	26 - 35	36 - 45	46 – 55	56 - 65	Over 65	Total
Cyclist	Male	1	3	2	3	2		11
	Female	4	5	4	3	1		17
	Other							0
Driver	Male	1	1	2	2	1	1	20
	Female		7	3	4	5	1	8
	Other				1			1
	Total	6	16	11	13	*9*	2	57

In addition to all drivers, 16 (57%) of the cyclists held valid UK driving licences. The number of years drivers held a license varied from three years to 45 years (M=24, SD=13.2), whilst the number of years cyclists held a license varied from four years to 30 years (M=19, SD=8.6). Regarding crash history, seven drivers (24%) reported having been involved in a collision with a cyclist at some point, of which four said the cyclist was at fault, two said they (the driver) were at fault, and one said that they were both equally at fault. Twenty-three cyclists (82%) reported having been involved in a collision with a driver at some point. Of those, twenty cyclists said the driver was at fault, one said they weren't sure, another said both were equally at fault, and one failed to indicate who they thought was at fault.

3.2.2 Results for drivers trained to understand cyclists

The repeated measures MANOVA revealed a statistically significant difference in section scores across the three time points (Pillai's' Trace = .803, $F_{(8, 108)} = 9.061$, $p < .001$). Subsequent univariate tests revealed significant differences between time points for *knowledge part one* responses $F(_{1.585, 44.379)} = 17.317$, $p < .001$), *knowledge part two* responses ($F_{(2\ 56)} = 22.181$, $p < .001$), *skills* responses ($F_{(1.618, 45.297)} = 39.392$, $p < .001$), and *attitudes* responses ($F_{(1.689\ ,\ 47.295)} = 2.042$, $p = .148$). Subsequent pairwise comparisons (with the Bonferroni correction applied) are discussed below.

3.2.2.1 Knowledge Part One

There were significant differences in drivers' *knowledge part one* scores between pre-course and post-course times ($p = .049$), pre course and follow up times ($p < .001$), and finally between post course and follow up times ($p < .001$). Scores were higher at later time points, indicating greater agreement with statements asking about drivers' experience, understanding, and knowledge. Figure 19 summarises results. Figure 20 breaks down results per statement.

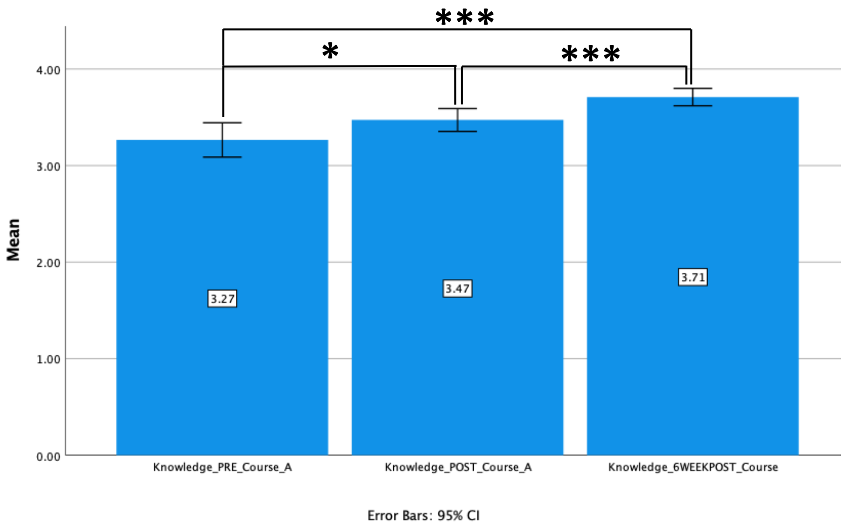


Figure 19. Average *knowledge part one* scores with 95% confidence intervals and significant group differences displayed (*p < .05, ***p < .001)

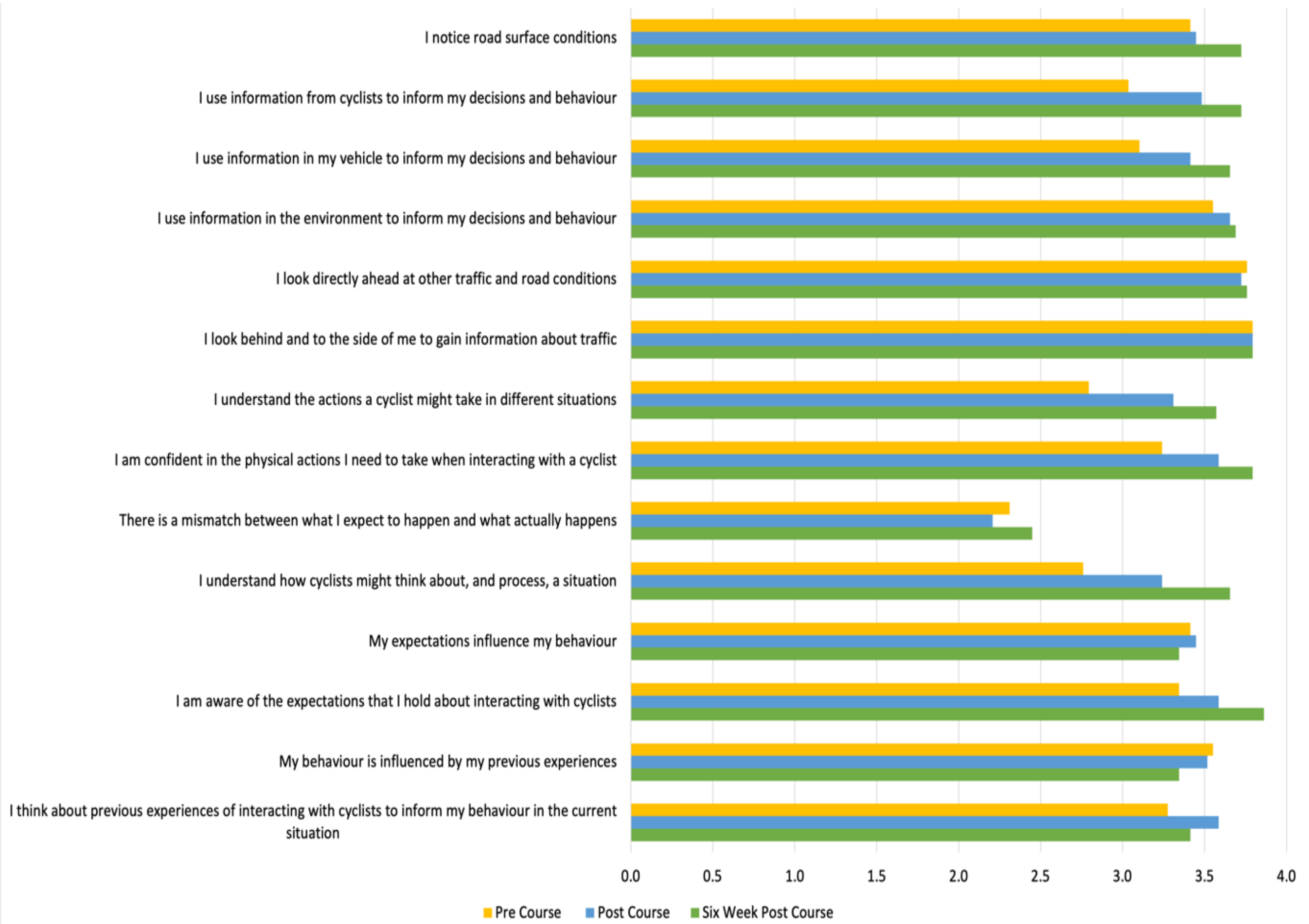


Figure 20. Average drivers' knowledge agreement scores per statement over the three time points

3.2.2.2 *Knowledge Part Two*

There were significant differences between drivers' pre-course and post-course ($p < .001$) and pre-course and six-week post-course ($p < .001$) *knowledge part two* scores. There were no significant differences in scores between post-course and six-week post-course ($p = 1.000$). Scores were higher at later time points, indicating greater agreement with statements asking about drivers' experience, understanding, and knowledge. Figure 21 summarises results.

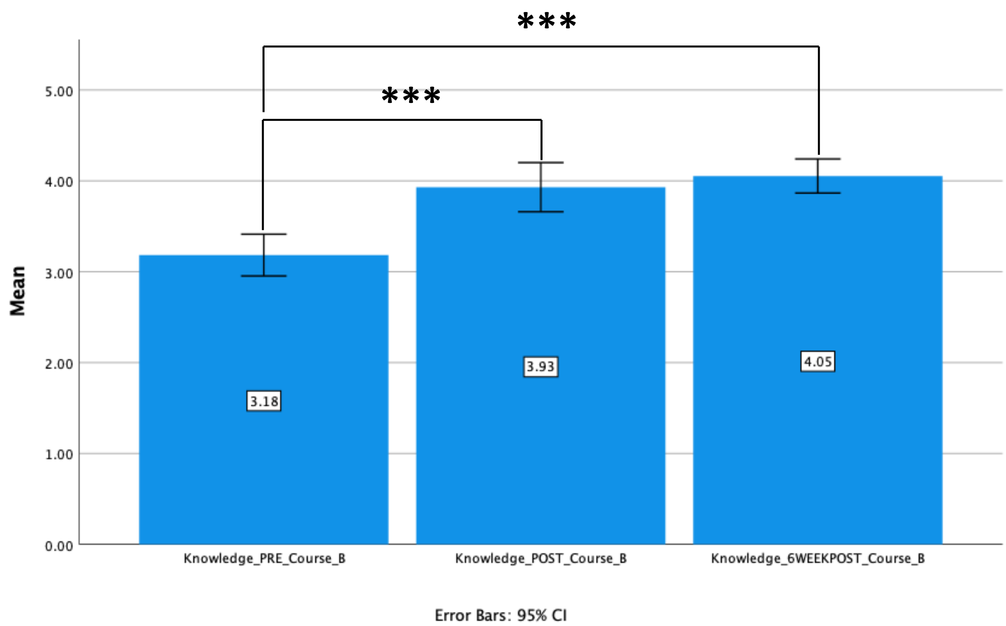


Figure 21. Average *knowledge part two* survey responses with 95% confidence intervals and significant group differences displayed
(***$p < .001$)

Figure 22 breaks down results per statement in this section. Drivers agreed to greater extent with all *knowledge part two* statements as time progressed, from pre-course to post course, then again from post-course to six-weeks post-course. The biggest change at was that drivers indicated to a greater extent that they understood why cyclists might not use the cycle lanes available to them, along with understanding why cyclists behave the way they do in different situations. Finally, they reported better knowledge of the different rules of the road in relation to cyclists.

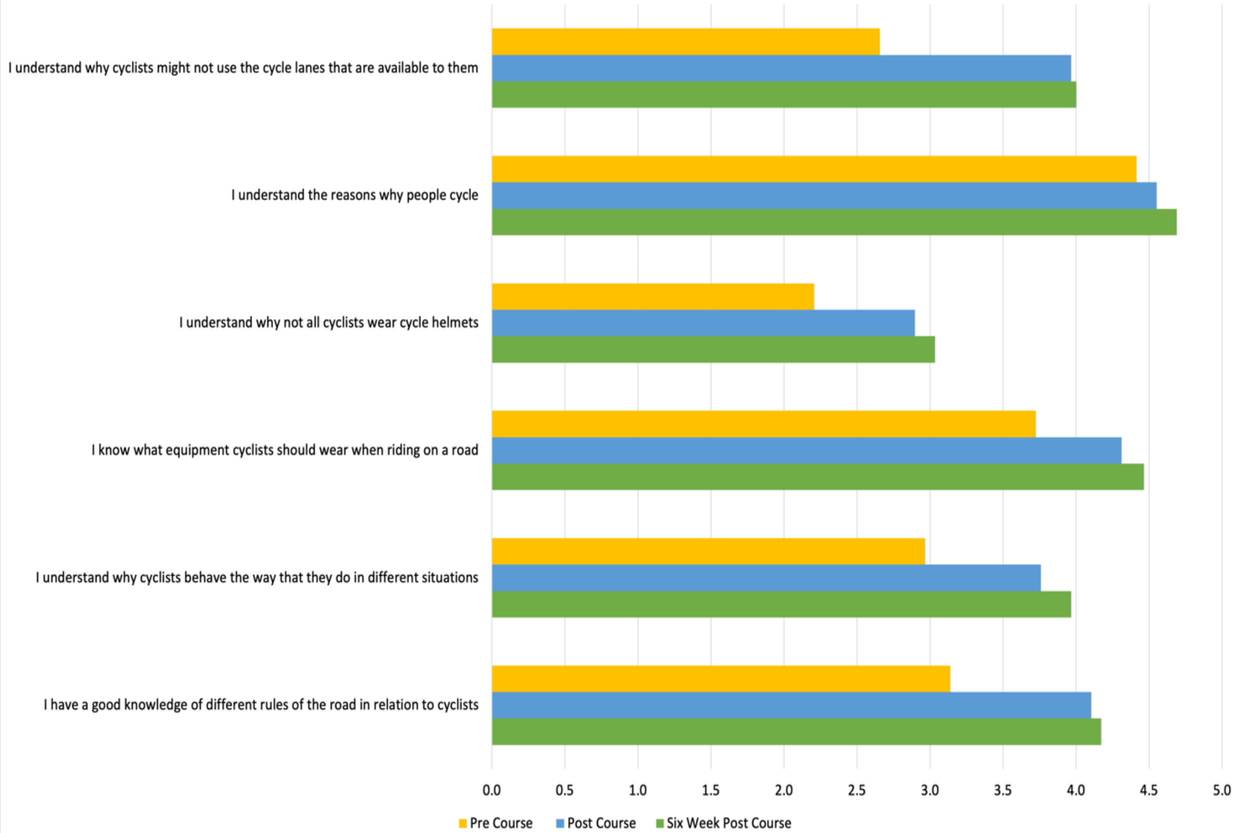


Figure 22. Average drivers' *knowledge part two* agreement scores per statement over three time points

3.2.2.3 Skills

There were significant differences in drivers' *skills* scores between the pre-course and post-course ($p < .001$) and pre-course to six-week post-course ($p < .001$) time periods. There were no significant differences in scores between post-course and six-week post-course ($p = 1.000$). Scores were higher at the post-course and follow up time points, indicating higher agreement with statements asking about drivers' experience, understanding, and knowledge. There was no difference in scores between the post-course and six-weeks post-course time points. Figure 23 summarises results.

Figure 24 breaks down results per statement in this section. Drivers expressed a greater agreement with twelve of the eighteen statements at six-week post-course compared to post-course. The biggest change in agreement pre- to post-course was that drivers indicated understanding to a greater extent what the IPSGA technique was and that they could apply the technique when interacting with cyclists out on the road. Furthermore, drivers also expressed a greater agreement at later time points in being confident when overtaking cyclists and in terms of knowing what information to use and what position to be in when overtaking. Agreement with the statement “Cyclists should position themselves to the far left of the road at all times” decreased after undertaking the course (indicating improvement in understanding); a further decrease was seen at six-weeks post-course.

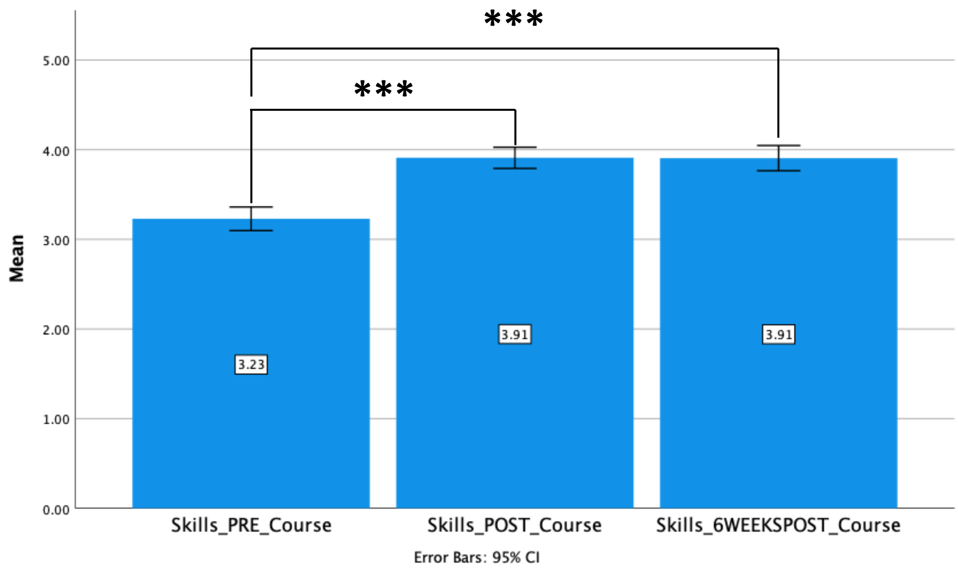


Figure 23. Average skills survey responses with 95% confidence intervals and significant group differences displayed (*** $p < .001$)

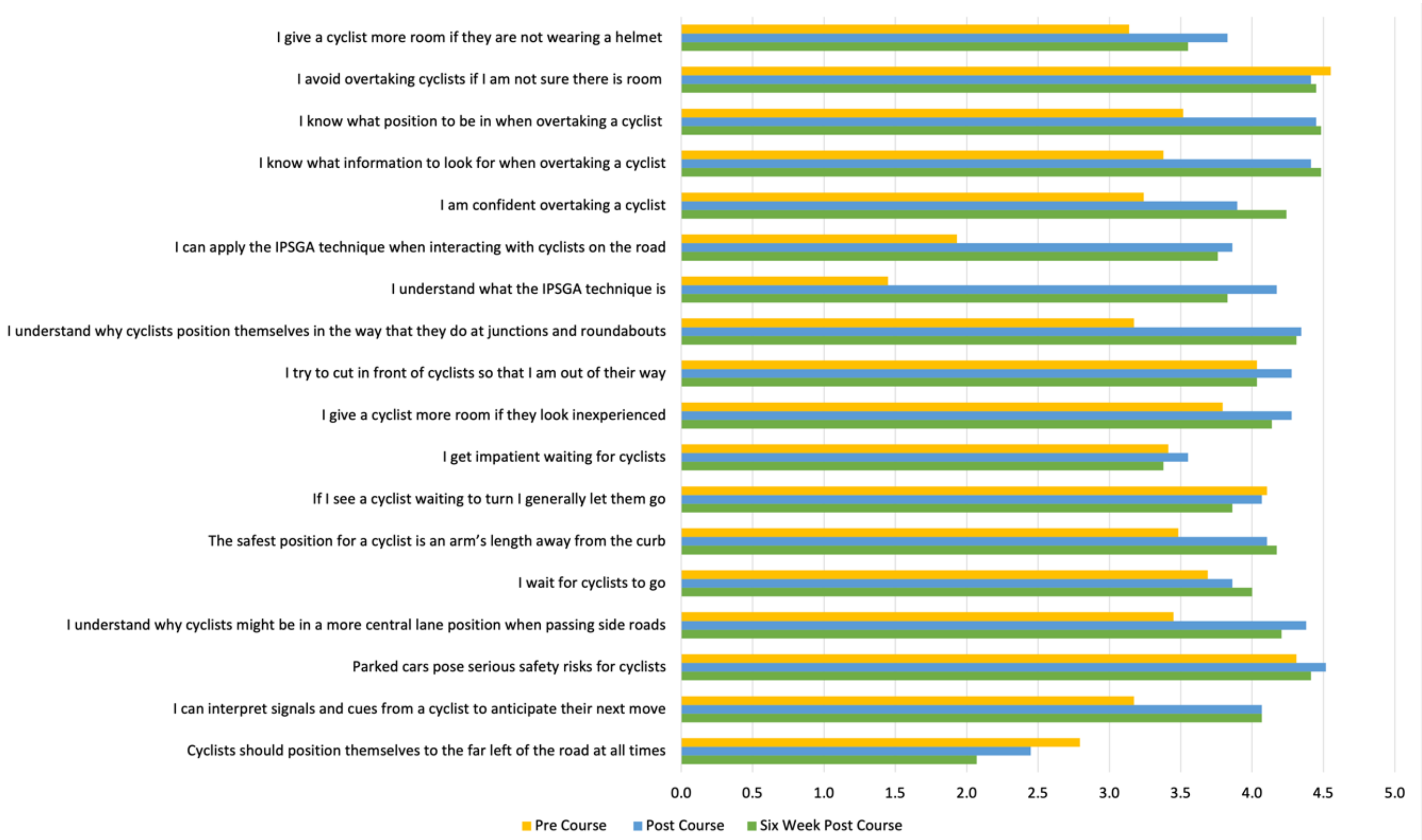


Figure 24. Average drivers’ skill agreements score per statement over three time points

3.2.2.4 *Attitudes*

There were no significant differences in *attitudes* scores between the pre-course and post-course times points (p = .132), between the pre-course and six-week post-course time points (p = .584), nor between post-course and six-weeks post-course timepoints (p = 1.000.) Figure 25 summarises results.

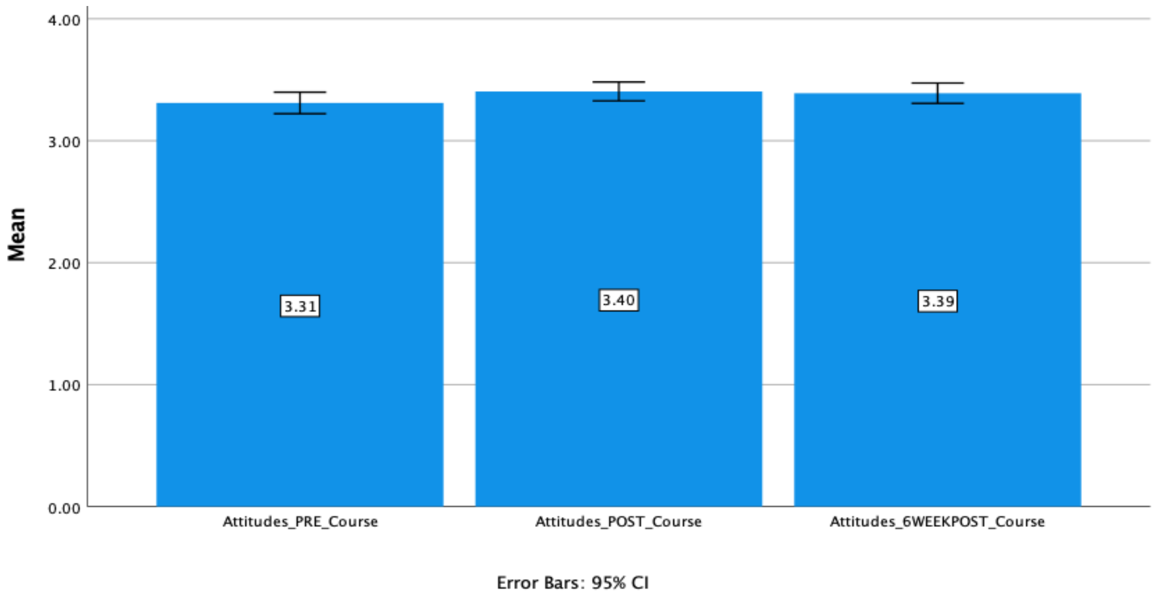


Figure 25. Average *attitude* survey responses with 95% confidence intervals

Figure 26 breaks down results per statement in this section. There were very few positive increases in participants agreeing with *attitude* statements. The most noticeable agreement changes were that drivers indicated a better understanding of why cyclists behave the way they do on the road, and that drivers should go smoothly into the opposite lane when overtaking rather than veering round them. There was a slight agreement improvement pre-course to post-course, showing slightly more positive attitudes towards cyclists; however, as aforementioned no differences were significant.

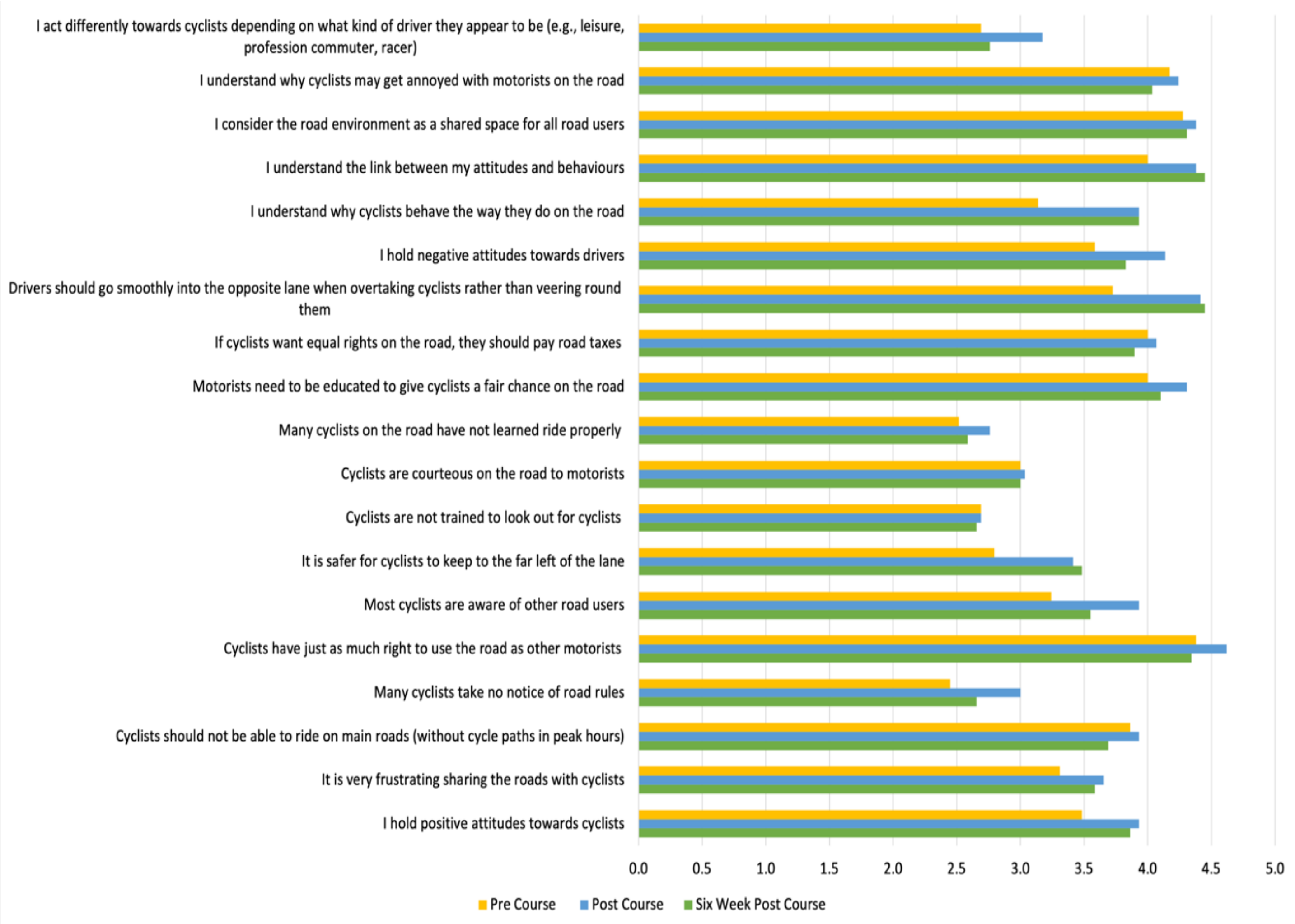


Figure 26. Average drivers' *attitude* agreement scores per statement over three time points

3.2.3 Results for cyclists trained to understand drivers

The repeated measures MANOVA revealed a statistically significant difference between cyclists' scores across the three time points (Pillai's' Trace = .614, $F_{(8, 104)}$ = 5.763, $p < .001$). Subsequent univariate tests revealed significant differences across three time points for *knowledge part one* responses $F_{(2, 54)} = 9.986$, $p < .001$), *knowledge part two* responses ($F_{(2, 54)} = 20.262$, $p < .001$), and *skills* responses ($F_{(1.627, 43.927)} = 18.586$, $p < .001$). No significant differences were found for attitudes responses ($F_{(1.404, 37.898)} = 2.351$, $p = .124$). Subsequent pairwise comparisons with Bonferroni correction are discussed below.

3.2.3.1 Knowledge Part One

There were significant differences in cyclists' *knowledge part one* scores between the pre-course and post-course time points ($p = .030$) and the pre-course and six-week post-course time points (*p* = .002). There were no significant differences in scores between post-course and six-week post-course (*p* = .182). Scores were higher at later time points, indicating a greater agreement with statements asking about cyclists' experience, understanding, and knowledge. Figure 27 summarises results.

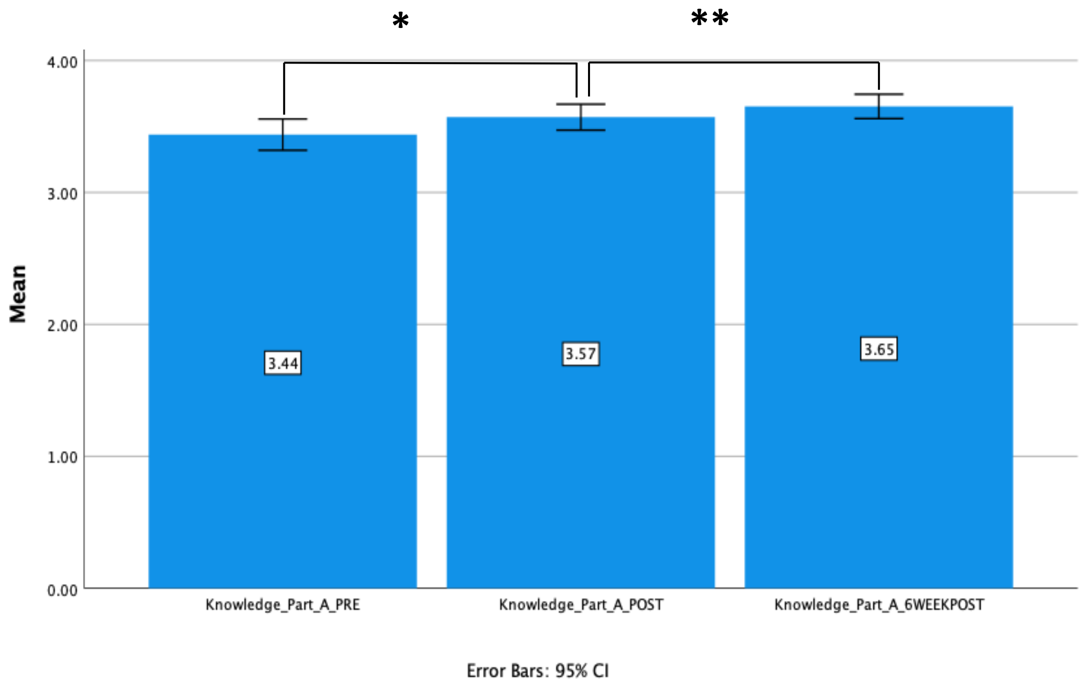


Figure 27. Average *knowledge part one* survey response with 95% confidence intervals and significant group differences displayed (**p* < .05, ** p < .005)

Figure 28 breaks down results per statement in this section There were some increases in cyclists' scores pre-course to post-course that continued into the six-week post-course time period. Notably, cyclists indicated that they used information from their bike (vehicle) to inform their decisions and behaviours, understood the actions a driver might take in different situations, and were more aware of the expectations they held about interacting with drivers to a greater extent at later time points. All increases in agreement scores showed noticeable changes pre-course to post-course, but little further improvement into the follow up stage

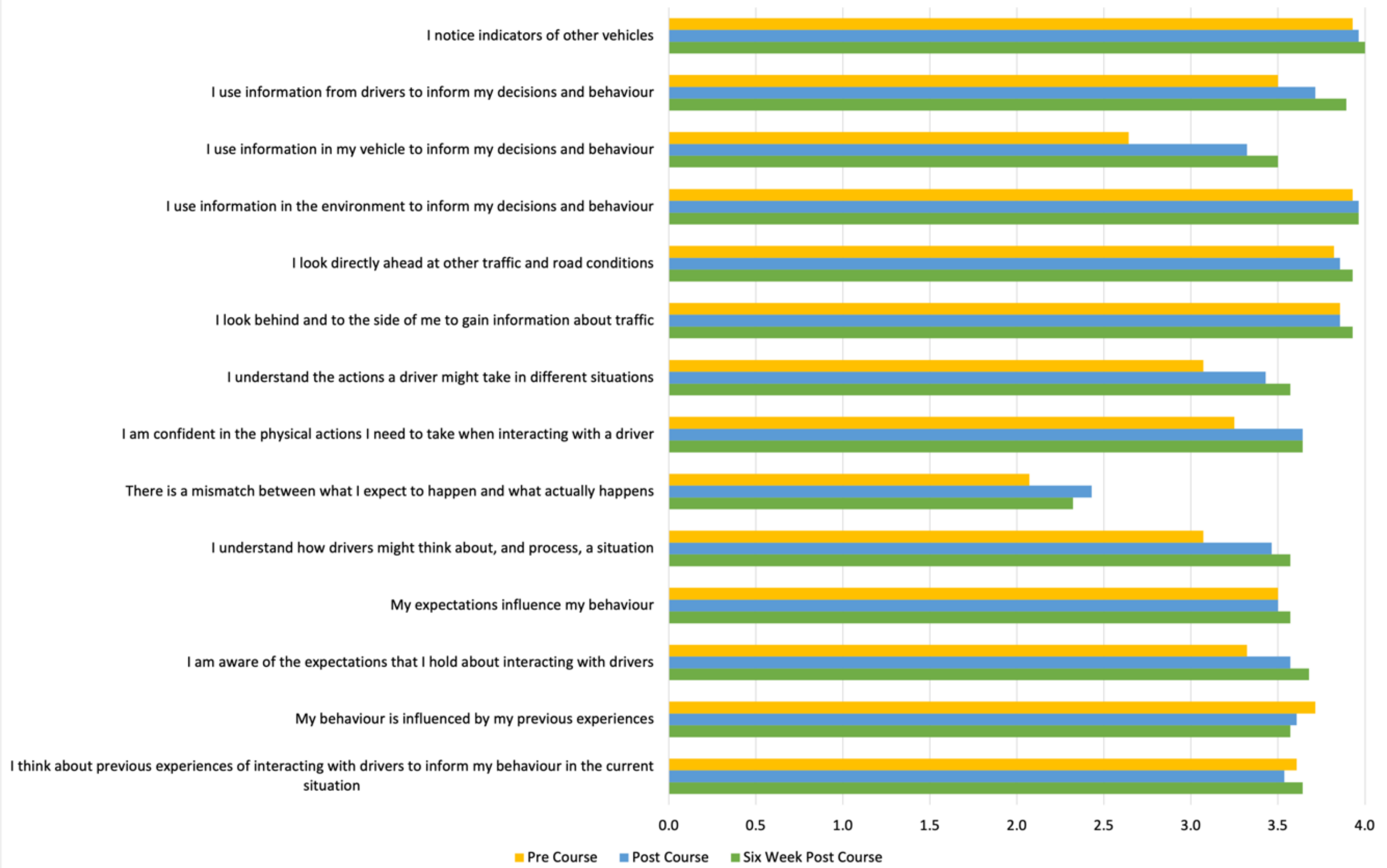


Figure 28. Average cyclists' knowledge agreement scores per statement over three time points

3.2.3.2 Knowledge Part Two

There were significant differences in *knowledge part two* scores between pre-course and post-course (p < .001), and pre-course and six-week post-course time points (p < .001). There were no significant differences in scores between post-course to six-week post-course time points (p = 1.000). Scores were higher later time points indicating greater agreement with statements asking about cyclists' experience, understanding, and knowledge. Figure 29 summarises results.

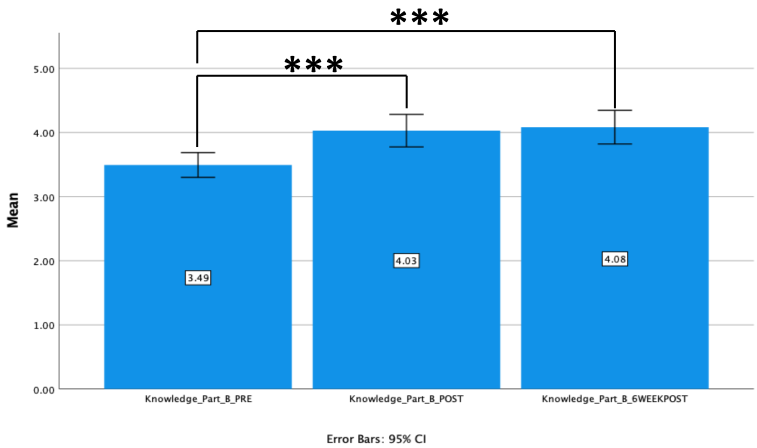


Figure 29. Average *knowledge part two* survey response with 95% confidence intervals and significant group differences displayed (***$p < 0.001$)

Figure 30 breaks down results per statement in this section. Cyclists agreed to a greater extent with the provided statements following the training course. There were few notable differences from post-course to six-week post-course. The biggest agreement change for cyclists was that they indicated knowing where drivers' blind spots were and understood why drivers behave the way they do in different situations. There was a slight increase in agreement concerning the understanding of why drivers may not overtake them straight away.

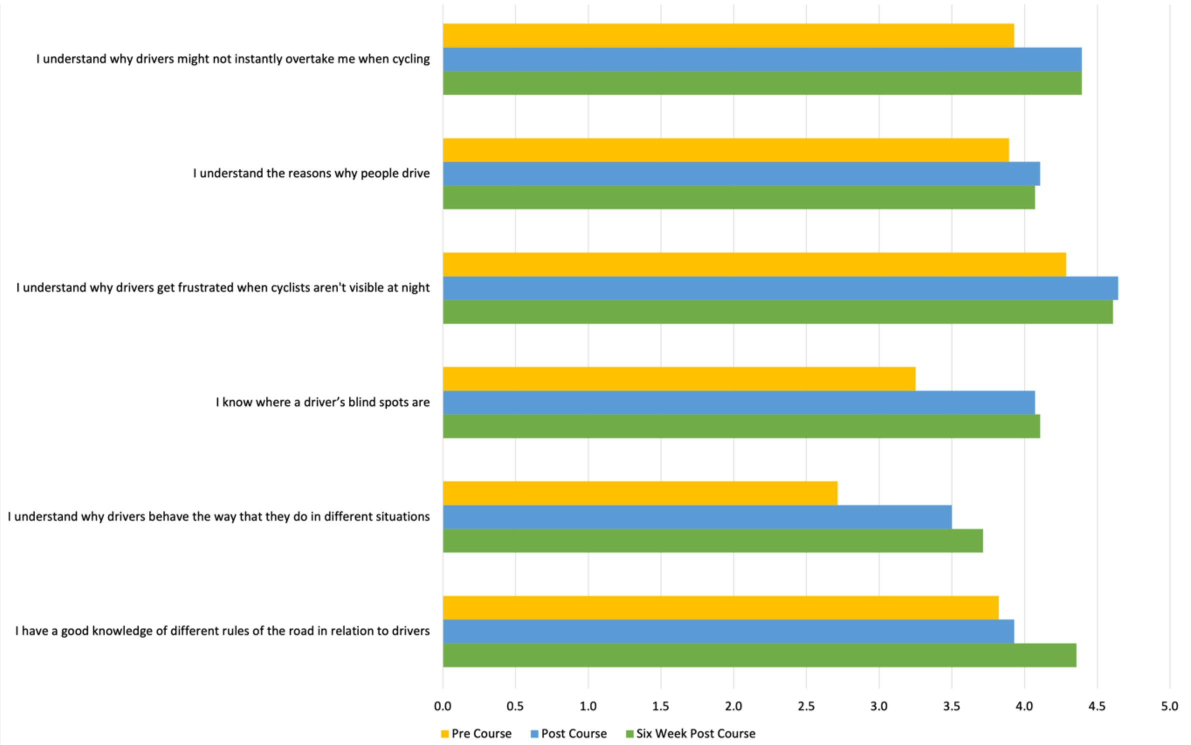


Figure 30. Average cyclists' *knowledge part two* agreement scores per statement over three time points

3.2.3.3 Skills

There were significant differences in skills scores between pre-course and post-course (p < .001) and pre-course and six-week post-course (p < .001) There were no significant differences between post course and six-week post course scores (p = 1.000). Figure 9 summarises results. Scores were higher at time points post course, indicating poorer agreement with statements asking about cyclists' experience, understanding, and knowledge. Whilst there was a small drop in agreement at follow up stage, Figure 31 summarises results.

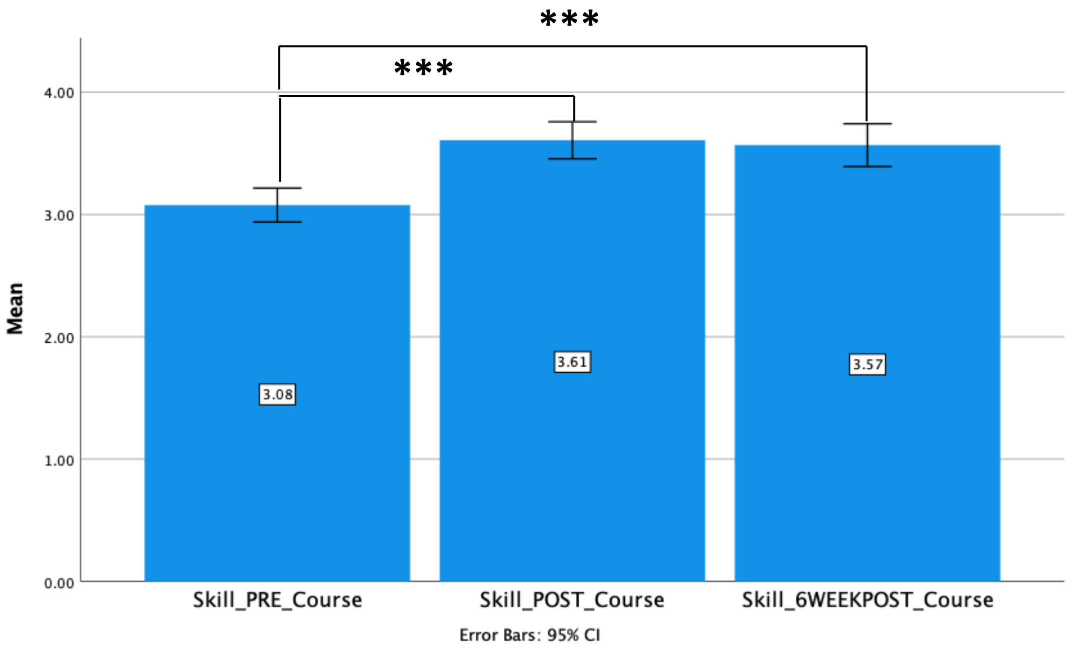


Figure 31. Average *skills* survey response with 95% confidence intervals and significant group differences displayed (***p < 0.00)

Figure 32 breaks down results per statement in this section. Like drivers, cyclists showed a greater agreement over time in understanding what the IPSGA technique was in their confidence in applying the technique when interacting with drivers on the road. They also indicated more confidence in filtering through traffic and showed an improved agreement post-training in understanding why drivers positions themselves the way they do at roundabouts and when passing side roads.

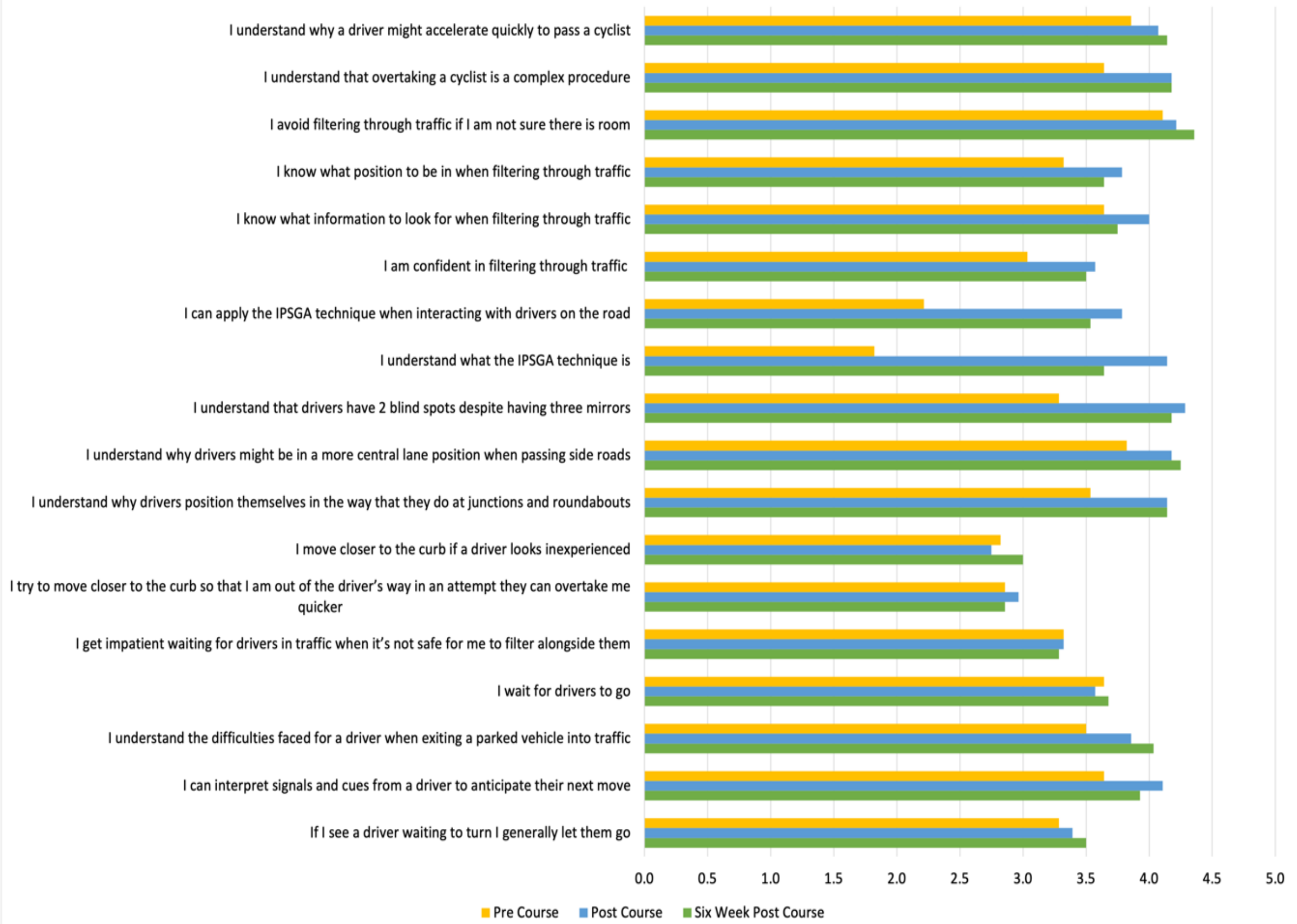


Figure 32. Average cyclists' *skills* scores per statement over three time points

3.2.3.4 Attitudes

Cyclists' *attitudes* scores were significantly different between the pre-course and post-course time points (p = .004). There were no significant differences between scores in the pre-course and six-week post-course time points (p = .762) nor post-course and six-week post-course time points (p = 1.000). Scores were higher post-course, indicating greater agreement with statements asking about cyclists' experience, understanding, and knowledge. There was a small, non-significant drop in scores at follow up. Figure 33 summarises results. Figure 34 breaks down results per statement. The most noticeable improvement in scores was that cyclists agreed they understood why drivers behave the way they do on the road, and a positive decrease in agreement to holding negative attitudes towards driver. There was a slight improvement in understanding why drivers may get annoyed with motorists on the road.

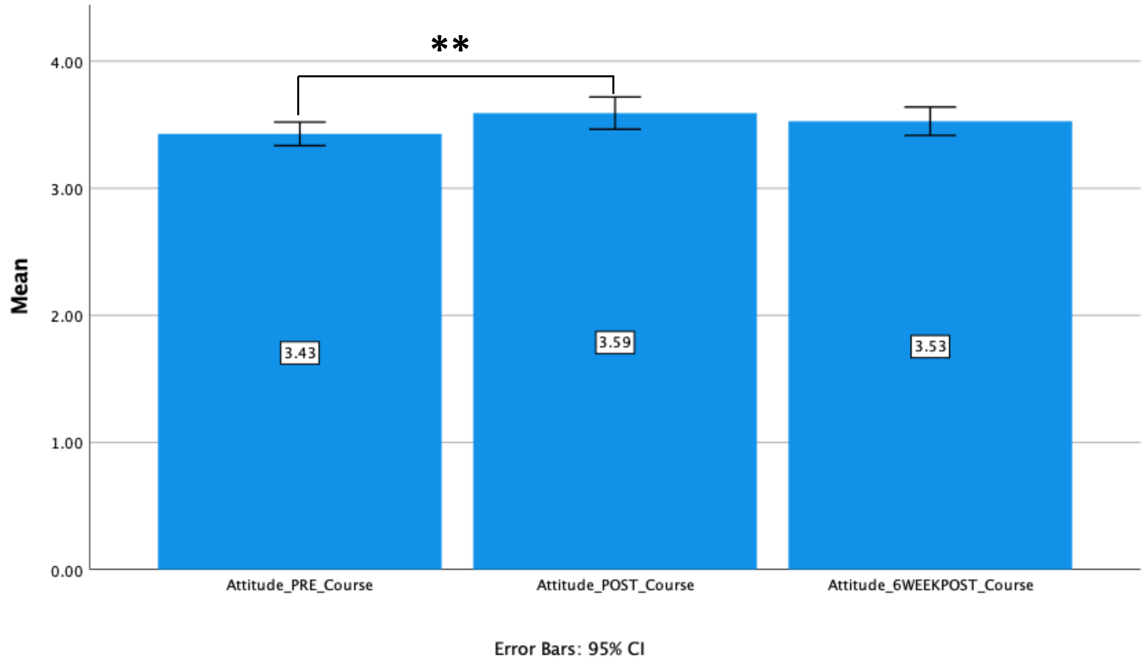


Figure 33. Average *attitudes* survey response with 95% confidence intervals and significant group differences displayed (* $p < 0.005$)

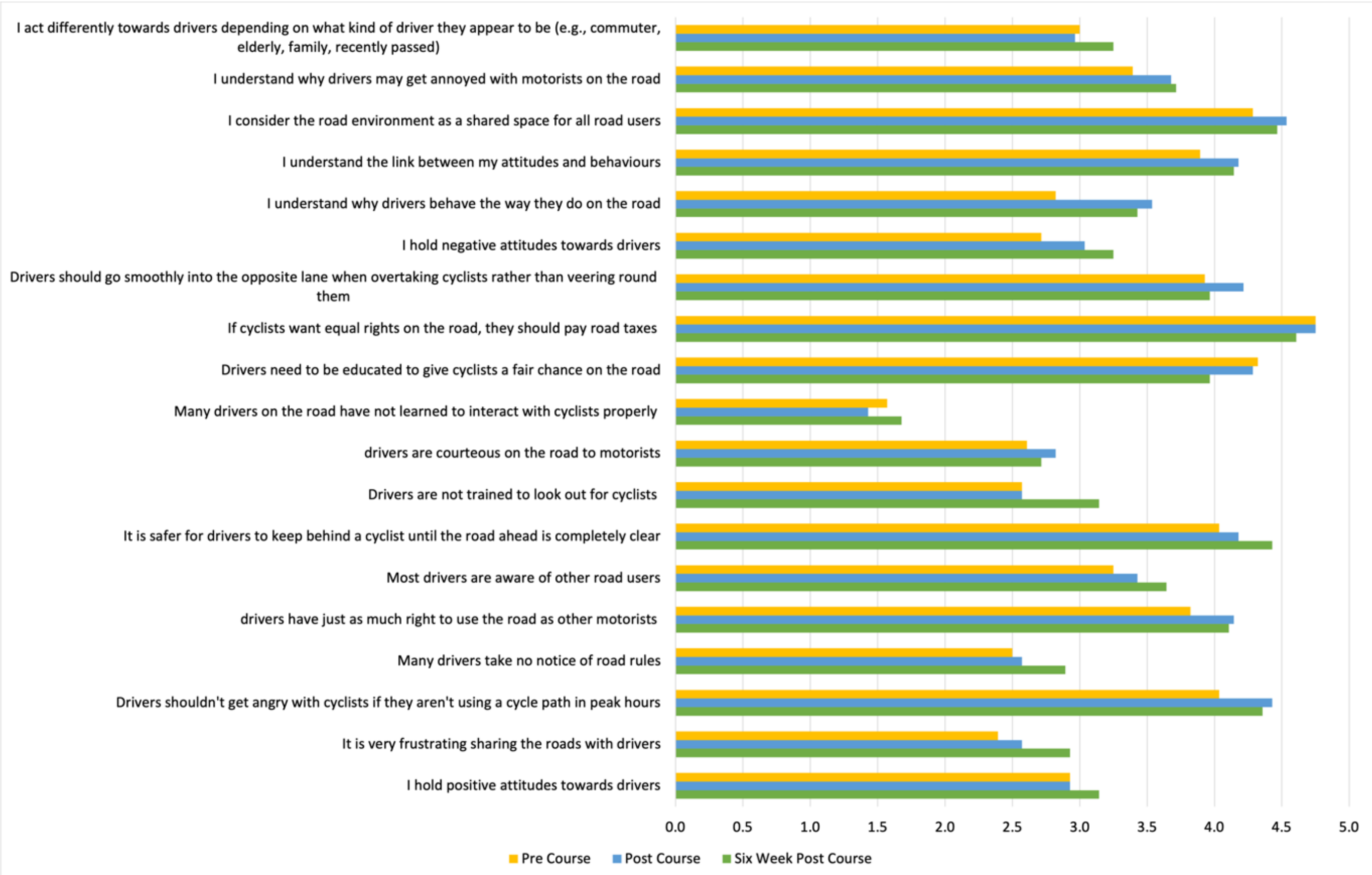


Figure 34. Average cyclists' *attitudes* scores per statement over three time points

4. General discussion

As described above this project had two broad aims. First, to understand people's perceptions of 'other' road users and their knowledge of the rules that govern the behaviour of those 'other' road users. Second, to explore the potential for cross-modal training to enhance empathy and understanding between groups. The former was addressed by the focus groups and questionnaire work, with the latter being addressed by the online training study.

4.1 Focus groups and questionnaire

Given that the primary aim of the focus group was to inform the design of the questionnaire, this discussion will focus on results of the latter. Regarding the quiz section of that questionnaire, results suggested that having experience in both domains increases your understanding towards other road user groups, with driver-cyclists performing the best. That said, differences between the three road user groups were not large. Some results are worth picking out. For example, one might expect all respondents to know that it is a legal requirement for a cyclist to come to a stop at a red light or at a pedestrian crossing when a pedestrian is present. This was not the case. Perhaps worryingly, less than 65% of all road users answered this correctly. This expectation, i.e., that a person can cycle straight through a pedestrian crossing rather than being prepared to stop (and to adjust scanning patterns accordingly) can have significant consequences, as was seen the Charlie Alliston case, a man on a bicycle who collided with a pedestrian, resulting in the death of that pedestrian (BBC, 2017). It is also worth noting that the Highway Code states "you must give way when a pedestrian has moved onto a crossing"; this can be ambiguous, as up until the point of a pedestrian stepping onto the crossing there is no obligation to stop. This can create a relatively complicated scenario for cyclists and pedestrians, especially as a cyclist is typically positioned near to the edge of the roadway from where the pedestrian steps out. Whilst the CRITICAL program specifically focused on driver and cyclist training, this example has relevance to red light and general 'rules of the road' compliance. It demonstrates that cyclists are not necessarily aware of the rules that apply to them (even more pertinent given the 2022 changes to the Highway Code and the introduction of the 'hierarchy of users') and this in turn can have an impact on the attitudes that other road users have of them, and subsequent behaviour.

Another questions that can trigger varying opinions is whether cyclists should ride two abreast when out on the road. Although typically seen negatively by drivers, riding two abreast discourages dangerous overtaking and encourages the social aspect of cycling (Gallagher, 2020). The Highway Code also encourages the behaviour when cycling on wide roads. It is perhaps no surprise that drivers performed worse in asked whether riding two abreast on wide roads is legal and encouraged. Over 70% of drivers answered this question incorrectly, suggesting driver training (and/or wider public education) on this specific aspect is lacking. This could be especially beneficial given that research suggests that overtaking groups of cyclists riding two-abreast is easier and quicker than overtaking the same group riding in single file (Clarke, 2015). There were also few in the cyclist group that knew that riding two abreast is encouraged. It's likely that those that were aware of this rule were regular cyclists, though this would need more exploration to confirm. What it does highlight is the variation in knowledge that people on bicycles have of the rules that govern them.

Interestingly, only 48% of the driver-cyclists, 54% of the cyclists, and a very low 18% of the drivers knew that it was not illegal or advised against to ride on the main road when a cycle lane is present. The Highway Code states that the use of a cycle lane is not compulsory, rather the level of skill and experience of the cyclist should determine whether they are used or not. The large number of drivers (82%) who did not know this highlights the issue with frustration that drivers have towards sharing the road with cyclists. Educating road users of the reasons why cyclists don't always use the cycle lanes available to them (e.g., because of debris, uneven surface, poor layout and design; Robertshaw, 2018) would be highly beneficial.

Results of the equipment section were not quite as one might expect; in the identification of legally required equipment, the drivers scored the highest, with driver-cyclists making the fewest correct selections. This may, however, be partly explained by the fact that drivers also made the most incorrect selections, i.e., they simply selected the most options. Only three of the pieces of equipment listed were legal requirements, i.e., brakes, lights (before sunrise and after sunset), and reflectors. In terms of lighting, only around 50% of all road user groups got all three scenario questions correct (day, sunrise/sunset, night). This lack of knowledge has been demonstrated to come through in use of bicycle lights. For example, in a night-time observational study of 392 cyclists, only 42% were seen to be using front and rear lights (McGuire & Smith, 2000). Similarly, another night-time study found that only 28% of 892 cyclists were seen to be using front and rear lights, and when 100 follow up interviews were conducted with those not using lights, one reason given was that the roads were already lit and bike lights are only needed to be visible (Setiawan, 2009), again showing a lack of knowledge of the rules of the road.

To assess respondents' subjective perceptions towards other road users they were asked to list some words and phrases that come to mind when thinking of drivers and cyclists in either urban or rural settings. This part of the study showed some marked differences between the respondent groups. For example, when asked about 'Urban Cyclists', the most common theme in responses from those that cycle (i.e., cyclist and driver-cyclists) was 'Commuter'. In the drivers' responses, the most common theme identified was 'Dangerous'. This is a telling difference and in line with other research on the perceptions of urban cycling and drivers' attitudes towards cyclists (e.g., Fruhen et al. 2019). For example, Stafford (2013) argued that drivers' jealousy towards cyclists arose from cyclists weaving in and out of traffic and skipping through the congestion. Equally interesting, perhaps, was that when asked the same question about 'Rural cyclists' responses were quite different, with similarly high responses under the 'Leisure' and 'Club riding' themes across all three road user groups, and no mention of 'danger' at all (though some cyclists did mention the idea of being 'brave'). One explanation is that in rural settings people are often in less of a hurry than in urban locations. It is in the urban setting that rush hour manifests most clearly, with traffic jams contributing to a heightened negative affective experience. Combining this with the perceived added disruption caused by an individual on a bicycle can result in drivers feeling frustrated. On the other hand, cyclists and driver-cyclists are likely to have a greater understanding of the person on the bicycle as someone also trying to get to work (thinking of the 'Commute' responses to the 'Urban cyclist' question), seeing cycling simply as a form of transport just as the car is (i.e., a means to get from A to B; Allan, 2019).

When asked about 'urban drivers', all three road user groups' most common answer was 'impatience'. Typically, cyclists describe drivers as impatient, especially when overtaking (Mullan, 2013). This is one of the main barriers to cycling (Manaugh et al. 2016). Similarly dangerous, 'aggressive' was another common term used to describe 'urban drivers'. This may arise from the driving situation typically imagined when thinking of urban driving, i.e., traffic, and the effect it has on a road user's mental state. When asked the same question but about 'rural drivers' similar themes around danger, selfishness, and impatience emerged. On rural roads there is typically less congestion, hence a greater potential for drivers to travel much faster. When presented with any slow-moving object, for example a cyclist, this could cause frustration (Wilson, 2017). This idea of impatience came through particularly in the cyclists' responses. Conversely, only two drivers mentioned impatience. Dangerous, impatient driving is something of which cyclists have a more immediate, visceral experience, for example in situations of blind corner overtaking and close passing (Chapman and Noyce, 2012).

Finally, in terms of questionnaire results, it is worth mentioning differences (and similarities) in the valence of responses to the questions, i.e., in the extent to which they were negatively worded, positively worded, or neutral. When thinking of urban and rural drivers, patterns were similar across our three road user groups. For 'urban drivers', the very large majority of responses were worded negatively (between 87% and 94%), while for 'rural drivers', the majority was large, though slightly less so (between 73% and 84%). The patterns were quite different, however, when asking the respondents to think about cyclists in urban and rural settings. For 'urban cyclist', 82% of drivers' responses reflected a negative view. In contrast, 23% of driver-cyclists' comments were worded negatively, with 36% neutrally worded (e.g., descriptive rather than judgemental), and 41% being positive. Even more positive were the cyclists' comments; 58% of their comments, when asked to think of what comes to mind when considering 'urban cyclists', were positive, and only 4% were negative. Although this pattern was less extreme in the comments offered in response to the question concerning 'rural cyclists', it was still evident, with 63% and 70% of driver-cyclist and cyclist comments being positive, and only 32% of drivers' comments being positive. This is interesting insofar as drivers thought negatively of other members of their own user group, but cyclists did not. In most cases, cyclists thought of other cyclists in a positive light. This may stem from the greater sense of a specific identity that cycling has over car use (e.g., Aldred, 2010).

4.2 Training study

The main purpose of this part of the project was to investigate whether a training programme that aimed to teach drivers what it is like to be a cyclist, and cyclists what it is like to be a driver, could impact upon a person's competencies in use of that 'other' mode, in terms of their knowledge, skills, and attitudes (KSA). To this end, the statistical analyses undertaken indicated that the training did indeed have a beneficial effect. There were significant differences between the time points explored (i.e., before training, immediately afterwards, and six-weeks later) for both drivers and cyclists in most categories. The largest improvement for drivers (trained what it is like to be a cyclist) was in their knowledge scores, indicating a better understanding of how cyclists might think about and process a situation. Taken in concert with the questionnaire results presented above, where drivers expressed their negative perception of 'urban cyclists', this has important implications for future training and education design.

The largest improvement for cyclists (trained what it is like to be a driver) was also in knowledge scores. One question that stood out was in the understanding of drivers' blind spots. This indicates a lack of knowledge that likely contributes to the potentially dangerous situation where a cyclist undertakes vehicles to filter through traffic. In Manchester alone, there were 68 incidents in a five-year period in which this manoeuvre was involved (Grant, 2017). Both drivers and cyclists also showed significant improvements in skills scores, particularly in learning the IPSGA technique (information, position, speed, gear, and acceleration), the road scanning and safety behaviour technique used by Police drivers in the UK and trained by IAM Roadsmart (formerly the Institute for Advanced Motorists) in their advanced training courses. This is perhaps unsurprising as it is not a technique with which people that have not taken advanced driver training are generally familiar. A slight drop in scores was observed between the post-course and six-week follow up timepoints; however, when being taught a new skill, this can be expected (Masters, 2019). Drivers' *knowledge part one* was the only section that had a positive increasing trend across all three time points, pointing to an increase in knowledge over time as lessons learned are put into practice on the road. This is important, as there have been concerns from drivers expressed in the literature that they often don't know how to interact with cyclists, for example when overtaking them (Aldred, 2012).

One aspect in which drivers did not show improvement over the three time points was in attitudes. There were some noticeable patterns in responses to some questions, for example to the statements "I understand why cyclists behave the way they do on the road" and "It is safer for cyclists to keep to the far left of the lane" (reverse scored). Here, drivers showed improvements that were maintained into the third time point; however, in general, driver attitudes towards cyclist did not get any more positive (or, to think of it in another way, they did not get less negative). The reasons for this are likely complex and varied, some of which may be related to feelings of envy or jealousy. As Stafford (2013) pointed out, cyclists can often perform manoeuvres that drivers cannot, for example filtering through standing and slow-moving traffic (see also Fruhen, 2019). It is difficult to change a person's attitude as it requires that person to disrupt the habit or belief that they have about something (Call, 2020). This was also evident in the cyclists' attitudes scores. Although straight after the course cyclists' agreement with statements increased (indicating more positive attitudes towards drivers), at the follow up stage this increase had disappeared. One suggestion would be that completing a one-off training course isn't enough to alter attitudes in a lasting way. It is also possible that although initially the training was sufficient to impact upon cyclists' attitudes, subsequent exposure to the road environment (and the experience of drivers' behaviours towards them) un-did that change (Swiers et al. 2017). Taken together, results suggest that changing road users' attitudes is a challenge that online training alone is unlikely to surmount (Kelly and Barker, 2016).

Although we did not test the difference statistically, an additional observed pattern worthy of note was that the drivers appeared to be more affected by the training than the cyclists. Research suggests that having experience in both cycling and driving significantly decreases your risk on the road (Beanland & Hansen, 2017), and 57% of our cyclists held driving licenses. As such, they may be expected to have had a higher level of base knowledge (or understanding) of the 'other'. This would require deeper exploration in future work to confirm.

Overall, the training course offered to participants had positive effects; however, some limitations should be considered. First, participants were offered just one training course. Online courses typically suffer from a 10%-20% failed retention rate (Herbert, 2006) and a 40%+ dropout rate (Smith, 2010). With the online course being self-paced and un-monitored we could not guarantee that every participant fully attended to every aspect. Second, with it being an online self-paced course, participants could complete it in their own time. This can be beneficial, as people absorb information at different rates (Bhagat, Vyas and Singh, 2015); however, there was no way to monitor if some participants completed the course in one session or whether some participants completed some of the modules in one session and the rest in another session. Exploring the impact of short, high intensity vs. longer, more spread-out training styles represents an interesting avenue for future study. Third, due to time and participant availability constraints we accepted as participants cyclists that do drive (rather than only those that do not have a driving license), whereas our driver sample only included those that did not cycle. Taking a sample of people who do not drive at all, and assessing the impact of training on that group, would be highly beneficial.

Practical, in-person training was initially planned as part of this project, whereby non-cycling drivers would undertake guided cycle training on the roads, and non-driving cyclists would undertake driver training in a simulator. The global pandemic rendered those plans unworkable within project timescales. This therefore represents a major avenue for further study. This approach has been explored in a heavy goods vehicle (HGV) setting, with HGV drivers undertaking a full-day training session on vulnerable users, part of which involved going out on a bicycle with a trained instructor (see CyclingUK, 2017). Although anecdotal evidence points to the training's effectiveness, a formal exploration of its impact is lacking in the literature, as is the exploration of wider cycle training on driver behaviour beyond the HGV domain.

5. Conclusions and recommendations

Results from the questionnaire study taken together with results from the training study give an impression of a lack of inter-group understanding and empathy, and the potential benefit of training programmes aimed at addressing these challenges. Not only do people lack knowledge of the rules governing the behaviours of cyclists on the road, but the attitudes that members of each road user group have towards the other are often negative. This points to a need for interventions that focus on the 'other', especially if we are to increase cycling rates in the UK (and achieve the raft of benefits associated with such a mode shift). One such approach could be the inclusion of a period of dedicated cycle training as part of the mandatory driver training programme. There is some evidence to suggest that training lorry drivers to focus on how they interact with cyclists at right turns can lead to improved monitoring behaviours (Kircher et al. 2020), and there is anecdotal evidence pointing to the benefit of getting lorry drivers to go out on the road on bicycles (Cycling UK, 2017). The project described above goes some way to provide evidence for the benefit of expanding that to all drivers; however, that evidence base should be strengthened with a more extensive test of practical, on-road training. Future research should also seek to strengthen the evidence around what areas are most suspectable to positive change. The analysis presented in this study looked at average change across all questions, but some questions had a bigger change than others, so detailed analysis of individual components of competency will help establish the direction future training programs should take (and whether there should be different focus for different road users, e.g. skills for drivers, but knowledge for cyclists).

The results indicated that it might be easier for training like this to have an impact on knowledge and skills, over attitudes. The enduring nature of attitudes can make this competency harder or longer to change, which would indicate a need for attitudes to be considered as a part of the initial driver training program when learning to drive. The 2022 changes to the Highway Code (inclusion of 'hierarchy of road users') presents an opportunity for driving lessons and the associate theory test to put more focus on vulnerable road users and foster a culture of 'shared space' from an early stage. Coupled with advanced or refresher training in cross-modal training like CRITICAL, there is little excuse for drivers (and cyclists) of the future to be intolerant of other road users. Elements of the CRITICAL training program for drivers focused on cyclist positioning, highlighting why a central position was safer and more convenient for all; this has been formalised in the

Highway Code update (rule 67), which has the potential to increase awareness and safety behaviours.

The question of training cyclists what it is like to be a driver is more challenging as there is no mandatory cycle training within which such cross-modal training could be embedded. Previous research suggests dedicated cycle training is beneficial (e.g., Teyhan et al. 2016), and our work shows that cross-modal training can (in most instances) improve inter-group awareness, understanding, and empathy. That said, we do not recommend mandatory cycle training to be implemented. Not only would this be difficult to enforce, but it would represent an additional barrier to cycling uptake. Rather, we recommend that the Cycling Proficiency and Bikeability schemes be expanded, and an element of cross-modal training included whereby cyclists are taught not only how to manoeuvre the bicycle, see and be seen, and position themselves on the road (the current foci), but also about what a driver sees and experiences when interacting with someone on a bicycle, and the challenges they face and expectations they hold.

Finally, we would argue that there is potential for wider public education and awareness campaigns to be useful in improving inter-group understanding; however, these would need to be very carefully designed and tested before wider dissemination. Stressing the importance of how to safely interact with vulnerable road users when driving a motorised vehicle would be unlikely to attract controversy. On the other hand, a public awareness campaign aimed at emphasizing the importance of a cyclist displaying understanding towards motorised vehicle drivers, and the need to behave courteously and conscientiously when on a bicycle, has the potential to be interpreted as victim blaming if not framed carefully. Placing excessive onus on the vulnerable user to protect themselves in an environment designed for fast-moving, heavy vehicles should be avoided; rather, education should focus on joint understanding and empathy in shared spaces.

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