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Tachistoscopic testing of different markings through a cyclist priority junction

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Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Referee
V1	19/08/14	Final version	R Robbins	M Jones

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Executive summary

Background

As part of a programme of off-street trials of innovative forms of cycling infrastructure, Transport for London (TfL) commissioned TRL to test alternative markings for use at through-junction priority cycle lanes (a cycle lane where it is continued with priority passed a side-road turning).

Trial Objectives

This research measured road user comprehension of road markings, the conspicuity of those markings, and road user compliance with the instructions of those markings.

Trial Methodology

Eight different markings were evaluated in this trial: seven of which are not currently permitted by the Traffic Signs Regulations and General Directions. ; and the current standard marking. A control image was also evaluated which contained no through-junction road markings. See Figure 1 for an example of a junction view.

Figure 1 – Example junction view

The evaluations were achieved by using two complementary methods: a 'tachistoscope based method' for assessing reaction times, and subjective questionnaires, to assess participants' reactions to a range of images (based upon photographs of a real junction) showing different versions of these markings.

The tachistoscope portion of the trial was administered on a computers using software designed to accurately record user performance. The methodology used a *choice reaction time* approach to explore the research questions. This method measures how quickly a choice is made by a participant, and what that choice was.

Trial Findings

Comprehension and conspicuity

A primary purpose of this research was to identify which marking options were easiest to comprehend and most conspicuous. This research examined participant reaction speed as an indicator of their comprehension of the markings and how conspicuous the marking options are. The data obtained showed that there were few differences in how quickly participants made their decisions, showing that the marking options were similar in their conspicuity and ease of comprehension.

Furthermore, participant comprehension was also examined by investigating whether they thought an approaching cyclist had priority over a driver waiting to negotiate the junction. The data showed cyclists were generally seen as having priority at the junction. None of the markings were significantly better or worse at communicating this priority.

Finally, the marking options were analysed to see if they influenced whether a participant thought there was sufficient space to negotiate the junction as a cyclist approached. Most markings increased the likelihood (compared to the 'control' image which showed no through junction markings) that a participant would decide there was enough space to turn right into side road at the junction. Only marking options 1 and 3 decreased the likelihood that a participant judged there was enough space to negotiate the junction. All other options showed an increased likelihood of turning in front of a cyclist in comparison to the 'control' layout

Compliance

Generally, junction users correctly complied with the markings when a cyclist was on approach: when viewing a static image of a junction they indicated that they would stop an average of 5cm after the start of the give way markings, and 90% of the time would not have stopped within the 'conflict zone'.

Where a driver would stop when emerging from side road was analysed to identify which markings would encourage drivers to stop furthest back and give cyclists the greatest safety margin. On average drivers indicated stopping positions which were just over the inner edge of the give way markings (5cm beyond it). However, marking option 6 was the best at encouraging junction users to stop furthest back when a cycle was approaching (2cm beyond the inner edge of the give way markings). Options 1, 5 and 3 also performed well (4cm each). Options 1 and 3 performed best when a vehicle rather than a cycle was approaching.

Furthermore, it was hypothesised that some options might encourage drivers to stop within the cycle lane, or 'conflict zone'. Those markings could pose greater safety risks to cyclist. The results showed marking option 8 was the worst marking for encouraging junction users to stop within the 'conflict zone' as 30% of junction users indicated that they would stop within the conflict zone if this marking was present. Excluding marking option 8, only 9.8% of the stopping positions selected were within the conflict zone.

Overall conclusions

For most of the criteria evaluated there was little difference in how participants responded to the different options. Options 1 and 3 were found to encourage the best stopping position in terms of giving space to approaching cyclists or motor vehicles. Option 8 was found to be associated with the greatest potential level of encroachment into the cycle lane by stopping vehicles, a risk factor that would need to be investigated further if it were decided to conduct any on-street trials of these markings.

1 Introduction

As part of a programme of off-street trials of innovative cycling infrastructure, Transport for London (TfL) commissioned TRL to test alternative markings for use at through-junction priority cycle lanes (cyclist priority junction).

This is the report of the trial from Workstream 1 of the trials programme: Kerb segregated cycle lane– Tachistoscopic testing of different markings through a cyclist priority junction.

1.1 Background

The Traffic Signs Manual (TSM) Chapter 5 (2003) - Road Markings specifies Diagram 1004 road markings for use as through-junction cycle lane markings.

The TfL London Cycling Design Standards (2005) Chapter 4 recommends the traffic signs and road markings to be used in London for cycle lanes through road junctions, an example of which is shown in Figure 2. This shows Diagram 1004 or 1010 markings for the cycle lane, noting that Diagram 1010 must conform to TSRGD or have site approval. Diagram 1010 markings were used for this purpose at a small number of sites across London.

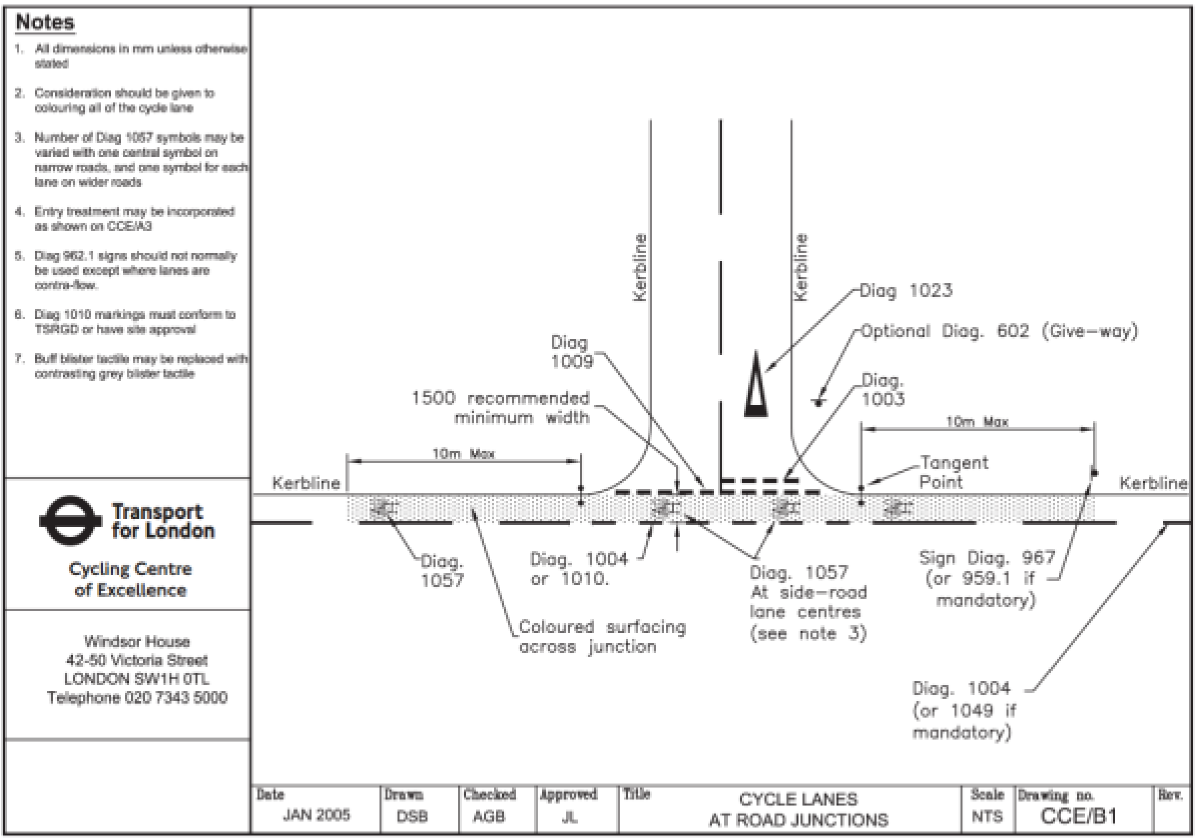


Figure 2 - Drawing CCE/B1, taken from London Cycling Design Standards (referred to as Option 1)

In 2013, DfT authorisation was given to TfL for the use of a minor variant to Diagram 1010 to mark the edge of cycle lanes through junctions. TfL anticipate that Diagram

1010 will be authorised for this purpose in the revised TSRGD which is expected to be issued for consultation in 2014 and brought into force in 2015

1.2 Marking options tested

A variety of approaches to the delineation and marking of a cyclist priority junction have been tried in different countries. This study sought to compare the performance of a selection of these alternative markings. Furthermore, several novel designs were tested which were based on adaptations of markings present in UK regulations. Full diagrams for all options can be found in Appendix A; (see Figure 4 for examples of markings added to junction images).

2 Objectives and research questions

2.1 Trial objectives

Creating segregated cycle lanes within the carriageway offers cyclists greater protection and separation from traffic while avoiding the loss of priority that is a problem with off-carriageway forms of segregation (e.g. shared-use footways). However, segregated cycle lanes pose a challenge at junctions where physical segregation cannot be provided and where the hazards to cyclists from turning vehicles can be increased if the segregated approach places cyclists in positions that put them at greater risk of conflict. For example, on the approach to a side road cyclists will be positioned on the inside of vehicles in the main carriageway intending to turn left.

It is therefore essential that when vehicles and cyclists reach the junction that priorities are fully understood by all road users so that cyclists are able to continue past the side-road without increased risk or loss of priority. Identifying the most effective method for defining the cyclists' path through the junction will help improve the safety of such layouts and so facilitate the installation of cycle networks using segregated cycle lanes in the carriageway.

The objective of this trial was therefore to measure road user comprehension of, conspicuity of, and road user compliance with, a range of alternative markings for continuing a cycle lane past a side road.

2.2 Research questions

To design a trial that can meet the research objectives a set of research questions have been posed which define the required experimental variables and observations than need to be made. **Quantitative research questions:**

- **Speed -** Is there a difference in the speed with which road users judge a range of segregation markings?
- **Understanding** - Is there a difference in what they understand the road markings to mean? For example, do they understand who has priority, where they should stop?, etc.
- **Safety** - Does the design of the road markings affect the minimum distance a driver would be willing to turn in front of an approaching cyclist?
- **Compliance** – How likely would drivers be to comply with the road markings?

3 Methodology

The purpose of the trial was to distinguish between the performance of a large number of alternative marking options. For reasons of practicality, static images of junctions were to be tested (full-motion video, or live testing would be time consuming and resource intensive). Furthermore, testing the options would require a large number of participants to view a large number of junction images to achieve statistical power. Given these requirements, TRL identified a choice-reaction time methodology as the best approach for gathering the data required. This would use a tachistoscopic (t-scope) procedure whereby an image is presented for a brief moment and participants must react to the image as quickly as possible.

3.1 Overview

Participants viewed a set of junction images which contained a car in the apparent process of negotiating the junction and a cyclist on approach to the junction. The images varied by:

- view point;
- cyclist and car type;
- cyclist distance to the junction, and finally;
- the marking options showing cyclist priority through the junction.

Participants were asked to judge whether it was appropriate for the car to negotiate the junction given the distance of the cyclist. It was hypothesised that participants' decisions would be influenced by the marking options present.

3.2 Trial sites and setup

The trial was administered on a suite of laptop PCs using E-Prime software. E-Prime is a program designed to accurately measure user choices and reaction times and is commonly used in psychological research. The images were viewed on a separate screens which had a response time[1] of 1ms (screen response time is critical in the measurement of visual reaction time; 1ms is the fastest that a commercially available screen can typically respond). Six testing stations were available for parallel testing. See Figure 3 for an example testing station.

Testing was undertaken at three sites: Croydon, Lewisham and Ilford.

[1] Until recently, most screens were CRTs and the speed with which they could update their image was referred to refresh rate; however, LCD screens no longer refresh the entire image, rather they only change the portions which require updating, hence the term 'response rate'.

Figure 3 – Testing station

3.3 Data collected

Two types of data were collected:

- Objective – response type (*would turn* or *would not turn*) and the speed of that decision
- Subjective – questionnaire examining participants understands of marking options.

3.4 Images

The images presented varied across several categories:

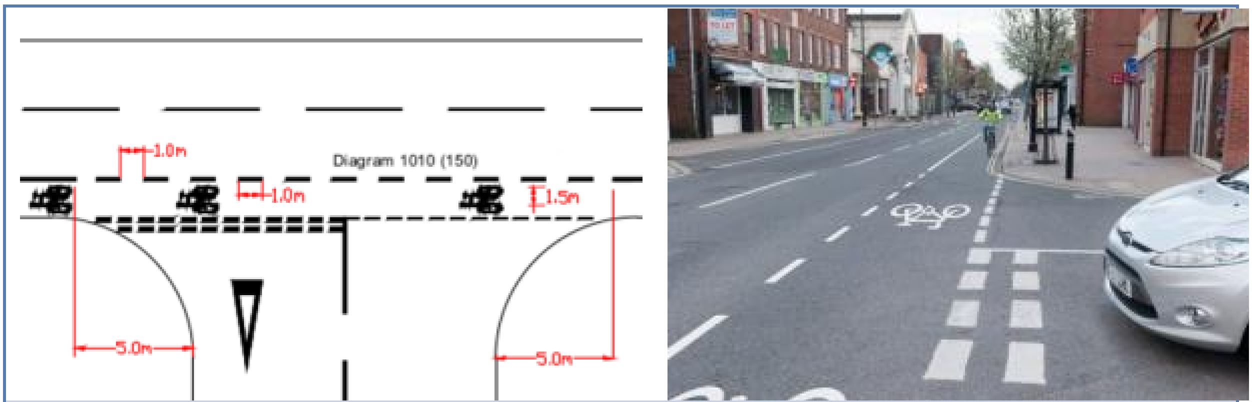
Variable	Description	Number of options
Markings	Segregated cycle lane markings within the junction	9
Cyclist distance	The distance an approaching cyclist appeared to be from the junction	4
View perspectives	The junctions were viewed from multiple angles	5
Car and cyclist types	Each image was duplicated with alternative cars and cyclists	2
	Total	**360**

In order to avoid fatigue effects (where participant concentration and willingness to engage with task diminishes as the length of the trial increases) each participant was only presented with a quarter of the images. Therefore, each image was viewed by 50 participants.

3.4.1 Marking options

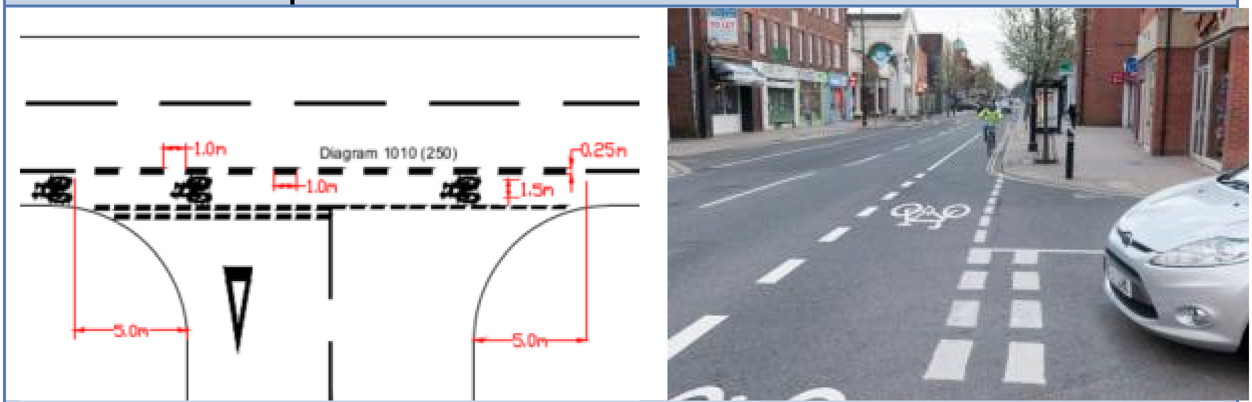
Nine different marking options were tested. These can be seen in Figure 4. Note, the reference numbers of the markings used are not sequential; this is intentional as several candidate markings were eliminated before the trial commenced. The numbering system was kept consistent to avoid confusion with previous markings which were excluded.

The markings were added to a 'base' image using photo editing software. The markings were recreated to exactly match the specifications shown in Appendix A.

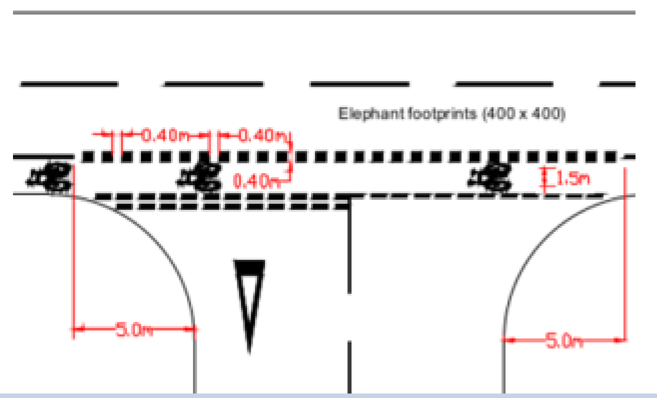


Option 1

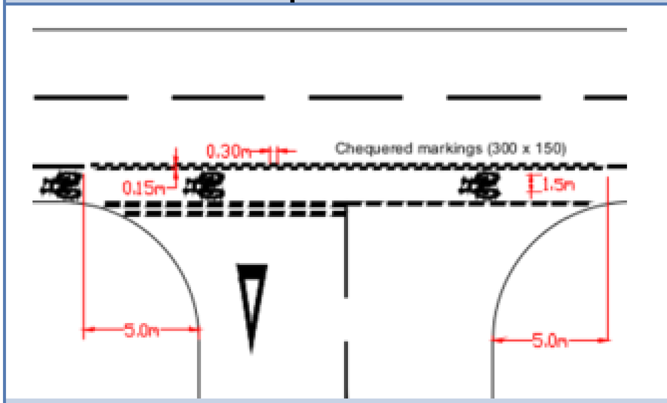
Option 2



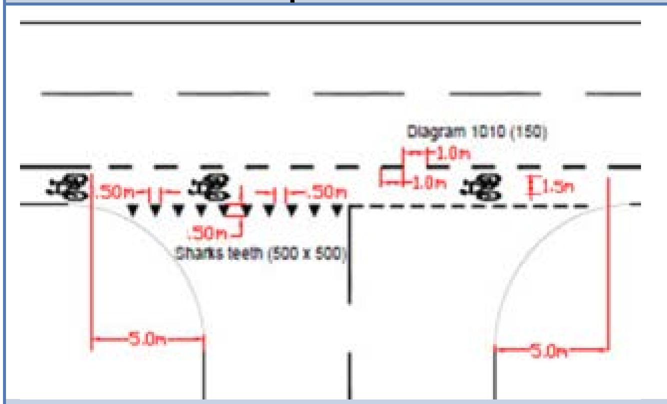
Option 3



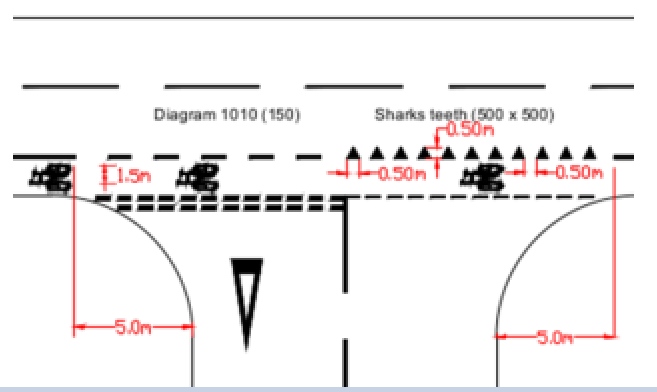
Option 5



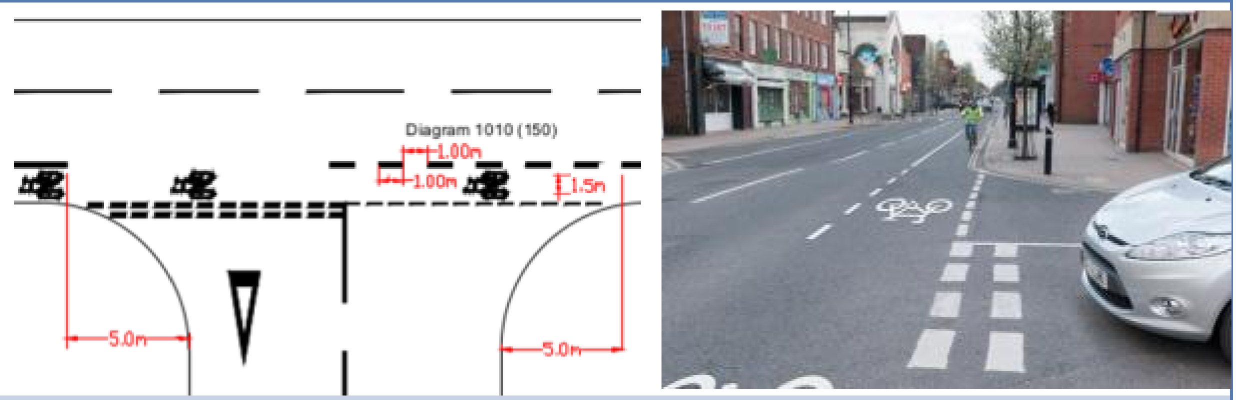
Option 6



Option 8



Option 9



Option 10

Control

Figure 4 - Marking options

3.4.2 Cyclist distance

In each image a cyclist could be seen approaching the junction. The distance the cyclist was from the junction was one of four fixed values: 5m, 10m, 15m, or 20m. See Figure 5 for an example view with a cyclist at all four distances.

All distances were approximate: due to the difficulties of photographing an open public junction it was not practical to use precisely the same stopping positions for each view. However, they key purpose of the distances was to test four broad categories, rather than exact values, so this had no impact on the analyses.

Distance 1 (5m)	**Distance 2 (10m)**

Distance 3 (15m) | Distance 4 (20m)

Figure 5 - Cyclist distance

3.4.3 View perspectives

In order to eliminate any biases due to the perspective shown, five separate views were captured (see Figure 6). Each of these views shows a car in the process of negotiating the junction and a cyclist on approach. Views 1, 3 and 4 were taken from a road user's perspective, roughly similar to that of a driver or a cyclist who was approaching the junction. Views 2 and 5 are from a pedestrian's perspective, however, it was felt that they offered a good view of the junction and the key features of the junctions therefore they were included.

View 1

View 2

View 3

View 4

View 5

Figure 6 - Junction views

3.4.4 Car and cyclist types

Finally, all images were duplicated with a different cyclist and/or car to reduce the probability that any effects were due to the different conspicuity of these features (see Figure 7).

Car and cyclist version 1	Car and cyclist version 2

Figure 7 - Examples of different car and cyclist types

3.5 Procedure

The trial consisted of three phases:

- Recruitment and pre-screening
- T-scope testing
- Questionnaire

Each of these phases is described below.

3.5.1 Recruitment and pre-screening

Two hundred members of the public were recruited to complete the trial. Participants had to either describe themselves as regularly driving or cycling (or both) in London to be to be eligible to participate in the trial. London was defined as Greater London.

Potential participants were approached by a team of experimenters positioned outside the testing venue. Those who completed the pre-screening questionnaire and were eligible for the main trial were then escorted into the testing facility and taken to the first free testing station. An experimenter stayed with any participant they recruited throughout the trial.

3.5.2 T-scope procedure

The main part of the trial consisted of presenting 90 junction images to each participant and asking them if the car 'should have turned'. To keep the trial brief and reduce fatigue effects, participants only saw a quarter of all possible images (see 3.4).

The t-scope part of the trial consisted of instructions, a practice section and then the main trial.

Instructions

Initially, participants were shown an example junction image showing only a give-way marking. The image did not show any cycle lane markings across the junction. This was to familiarise them with the task they were about to undertake. Figure 8 shows the example image presented.

Figure 8 - Screenshot showing the example junction image shown to participants

Practice

Participants were given a chance to practice the main trial. This consisted of viewing 10 junction images, randomly selected from the 360 used in the main trial, and deciding whether the car shown should have turned. Other than the number of images presented, the procedure for the practice was identical to that for the main trial.

At the end of the practice participants were asked whether they understood the task and were comfortable proceeding to the main trial. If they were not ready to proceed the experimenter would restart the practice.

Main trial

A sequence of 90 junction images were displayed in each trial; and each one was presented for 2 seconds.

Firstly, an instruction asked the participants to prepare for the next image. A fixation screen was then displayed which consisted of a cross in the centre of the screen which participants were required to fixate on. Following this a junction image was displayed showing a car negotiating the junction and a cyclist on approach. This was then followed by a decision screen where participants were asked: “should the car have turned?” They had to respond Y for “yes” and N for “no”. Finally a blank screen was shown, before the cycle started again at the “get ready for next image” screen. This timeline can be seen in Figure 9.

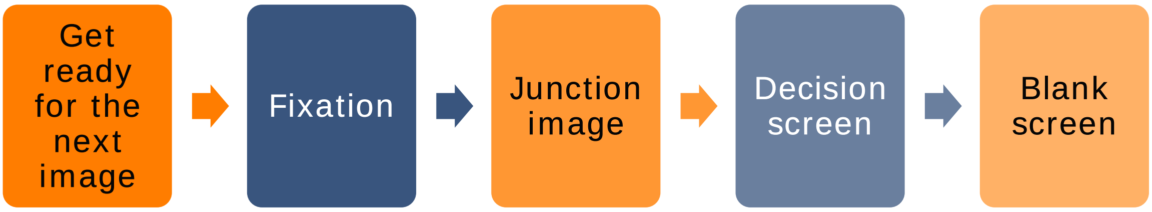


Figure 9 – Experiment procedure

3.6 Questionnaire

Participants were asked for their subjective impressions and understanding of a selection of the marking options. Four versions of the questionnaire were produced, each one showing two of the eight junction marking options. Therefore, each marking option was assessed by 50 participants.

In particular, their understanding of where it was appropriate to stop and which road user (car driver or cyclist) had right of way was obtained. They were also asked to rate how confident they would be in navigating the junction as both a cyclist and a car driver. See Appendix B for an example of the questionnaires.

4 Results

4.1 Demographics

Of the 200 participants who completed the trial, 11 were excluded as they reported completing less than 50% of their journeys in London.

All participants had to state they had a UK driver's licence. As recruitment was done 'on-the-spot' and participants might not have had their licences with them, proof of this was not demanded.

Participants were asked if they had to describe themselves as mainly a driver or mainly a cyclist, 115 (61%) described themselves as mainly drivers, 74 (39%) as mainly cyclists. Whilst there were more drivers than cyclists, the sample tested was acceptably representative of both road user groups.

Furthermore, participants were asked what percentage of their journeys was completed in London to ensure that the responses obtained would be generalizable to the London road user population. This proved to be the case as most participants spent 90% to 100% of their time travelling in London (135 out of 189) (see Figure 10).

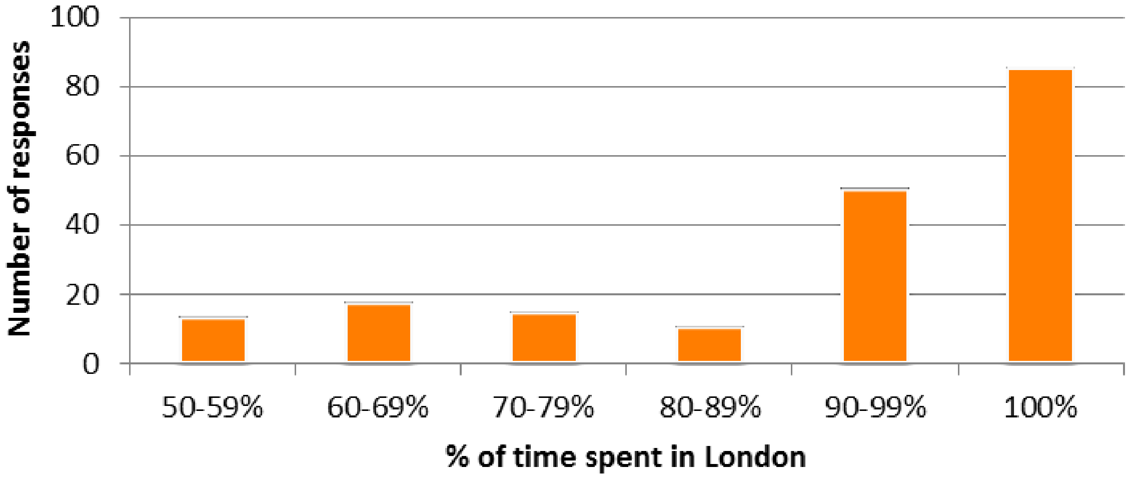


Figure 10 - Percentage of journeys completed in London

Finally, the project also sought to understand how frequently drivers and cyclists undertook journeys in their preferred transport mode. Data showed a difference in behaviour between cyclists and drivers, with drivers tending to drive on more days of the week than cyclists (see Figure 11).

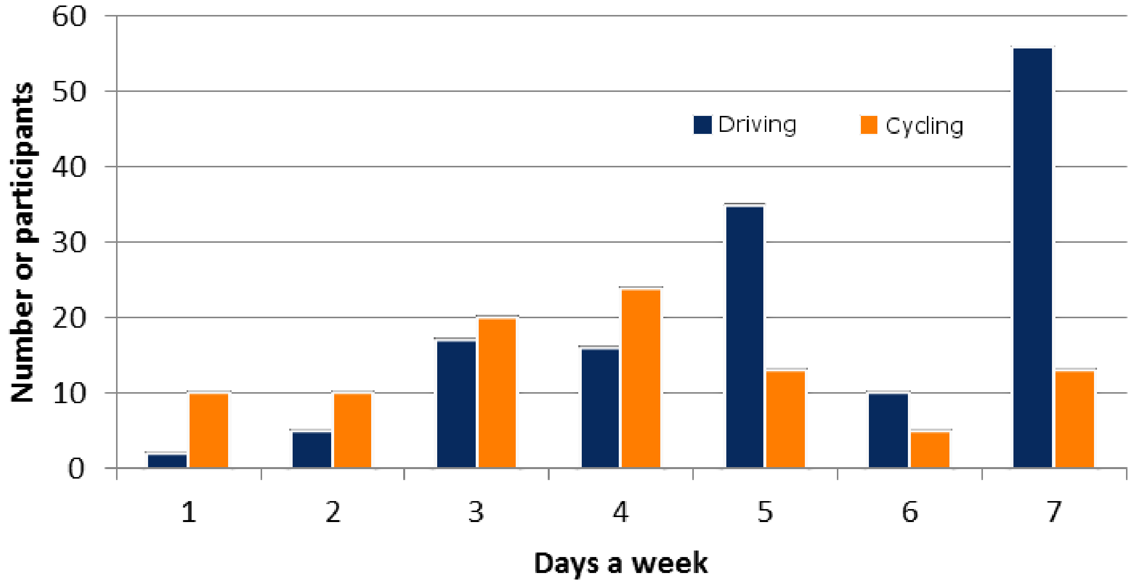


Figure 11 - Number of days a week spent cycling or driving

The 189 participants who were suitable for analysis were reasonably split between cyclists and drivers (39% and 51%, respectively), and most undertook a large majority of their journeys in London (typically over 90%). Drivers tended to drive on more days of the week than cyclists cycled.

4.2 Comprehension of scene – speed of decisions

The time taken to make a decision reveals how quickly the scene can be comprehended; participant reaction time (RT) is a function of the conspicuity and comprehension of the markings.

The mean RTs for all marking options were calculated and are displayed in Figure 14. Visual inspection of these mean RTs appeared to show that participants reacted more quickly when there were road markings than the control for almost all designs, with Marking 2 producing the fastest RTs; nearly 40ms faster than the control.

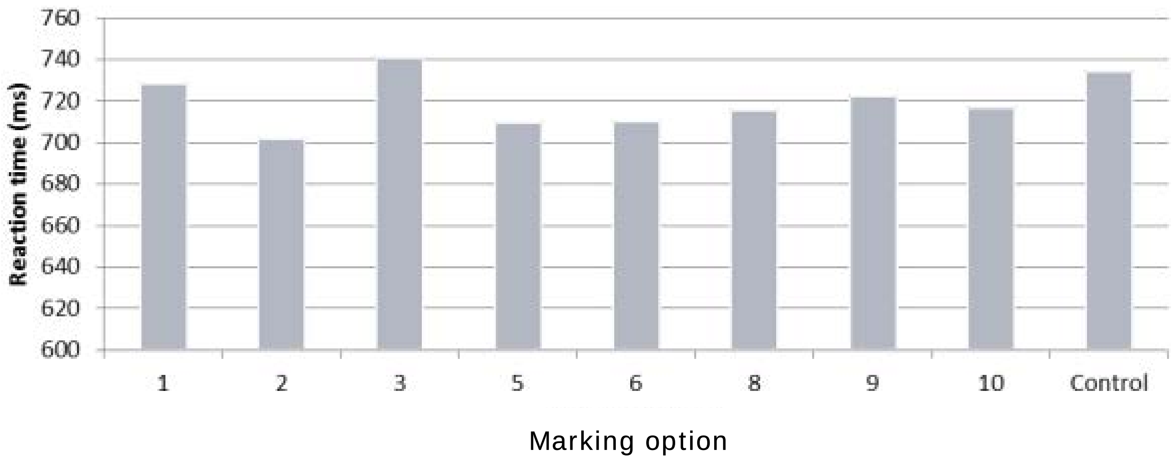


Figure 12 – Reaction time of 'yes' responses

However, the magnitude of the differences between all the markings was small and consequently this apparent trend did not reach statistical significance ($F(98)=.74$, $p=.66$)[2]. It can therefore be concluded that there are no statistically significant differences in how drivers respond to the different markings.

There was no statistically significant difference in the speed with which participants decided if it was appropriate to turn between the marking options. Therefore, it can be concluded that all markings were similar in their conspicuity and comprehension.

4.3 Priority at junctions

In all images the cyclist had priority through the junction. It is critical that road users understand this to prevent collisions; therefore, participants were asked who had priority at junctions when presented with the different road markings, (see Figure 13). The control, standard, marking was not shown in this part of the trial. As can be seen in Figure 13, approximately 90% of drivers thought that cyclists had priority at junctions and there was no statistically significant difference between the markings ($H(7) = 3.78$, $p=.80$)[3]. It can therefore be concluded that the type of marking does not affect drivers' perception of priority.

Note, the purpose of the questionnaire was to compare the relative effectiveness of the markings to each other, and not their effectiveness compared to 'no markings', therefore participants only viewed junction images which contained one of the marking types. In other words, the 'no marking' control image used in the tachistoscopic portion of the trial was not presented in the questionnaire. This approach was agreed as the current regulations already mandate markings (see Figure 2), therefore, the value of comparing to no marking was not sufficient to extend the duration of the trial.

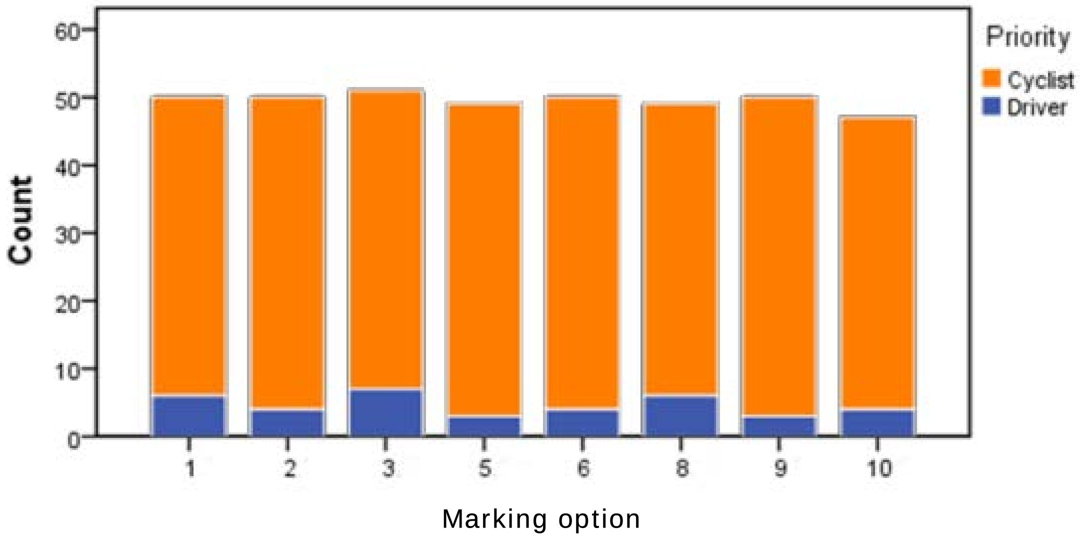


Figure 13 – Which road user had priority at the junction?

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[2] A repeated measures ANOVA was performed on these data. This test looks for differences between related sets of data (i.e. when participants have contributed to more than one set of data)

[3] These data were not normally distributed; therefore, a non-parametric Kruskall-Wallis test was conducted. This tests for the differences between independent groups.

Cyclists were generally seen as having priority at the junction. None of the markings were significantly better or worse at communicating this priority.

4.4 Likelihood of turning in front of cyclist

The effects of different markings on the likelihood of a participant deciding it was appropriate to turn were analysed.

Only 'yes' responses were analysed as these decisions were the only ones which could place a cyclist at risk.

Responses which were too slow (>3000ms – indicating inattention) or too fast (<150ms – indicating they did not have sufficient time to fairly judge the image due to limits of human visual perception) were excluded.

Due to the data being filtered to only include responses within this 'acceptable' window, the number of responses analysed for each marking was unequal. Therefore, the percentage of responses which were *yes* out of all responses was calculated and analysed (see Figure 14).

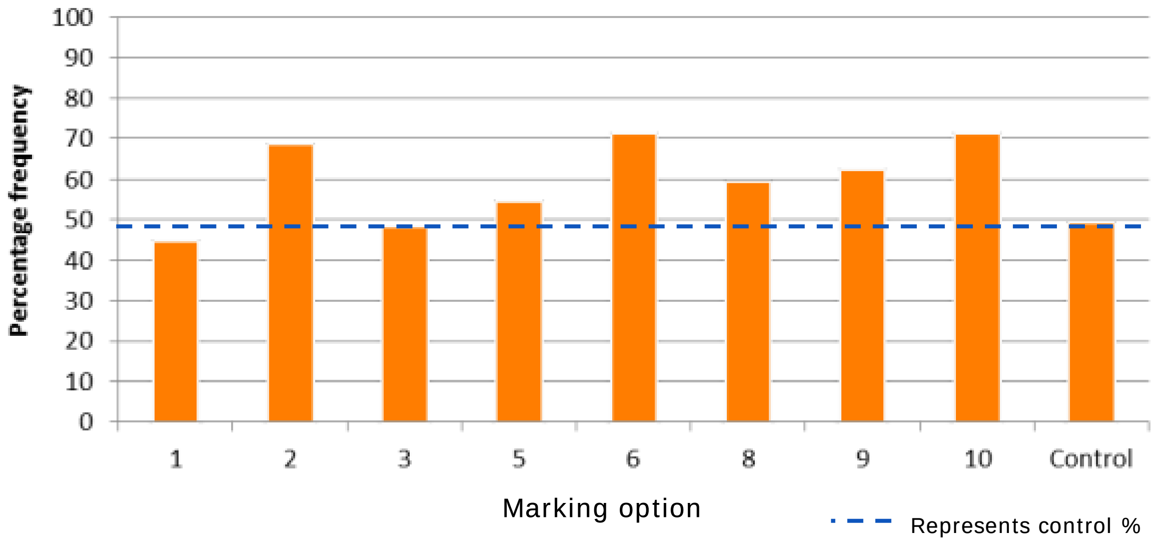


Figure 14 - Percentage frequency of 'Yes' responses

These data suggest that, for 6 out of 8 markings (2, 5, 6, 8, 9, 10), participants were more likely to decide they had enough space to move out of a junction than they did when viewing the control (no markings) image.

The presence of Marking 1 made participants slightly less likely to move out of the junction.

Most markings increased the likelihood that a participant would decide there was enough space to turn at the junction. Only marking options 1 and 3 reduce the likelihood that a participant would judge there was enough space.

4.5 Stopping position

Participants were asked to judge where they would stop when giving way to either a cyclist or a motor vehicle. They did this by marking an X or an O on a line on the junction image: X for motor vehicle and O for cyclist (see line marked "A" in Figure 15 for example). They were told that the markings could overlap if they liked by circling the X.

Figure 15 – Example junction image with added line upon which preferred stopping position was marked

Analysis of the data considered three questions:

- Did participants choose a different stopping position when a cyclist or a car was approaching?
- Was there a difference in stopping positions between the marking options?
- Did any of the marking options produce significantly more 'dangerously wrong' stopping positions, namely beyond the give way markings?

4.5.1 Stopping positions for cyclist and traffic

The positions where participants would stop were analysed; any differences in those positions between cyclists and traffic were of particular interest. Figure 18 (in 0) was drawn to illustrate the mean stopping positions for all marking options. Two suggestions can be drawn from this figure: firstly, there was little difference in stopping position between the marking options, and secondly, stopping positions were slightly further back when a cyclist was approaching than when a motor vehicle was approaching.

4.5.2 Frequency of stopping positions leading to conflict

It is interesting to investigate the proportion of road users who would stop in the 'conflict zone' (i.e. beyond the outermost edge of the give way markings), where a cyclist would be at a greater risk of collision with a vehicle emerging from the side road. See Figure 16 for an illustration of the conflict zone.

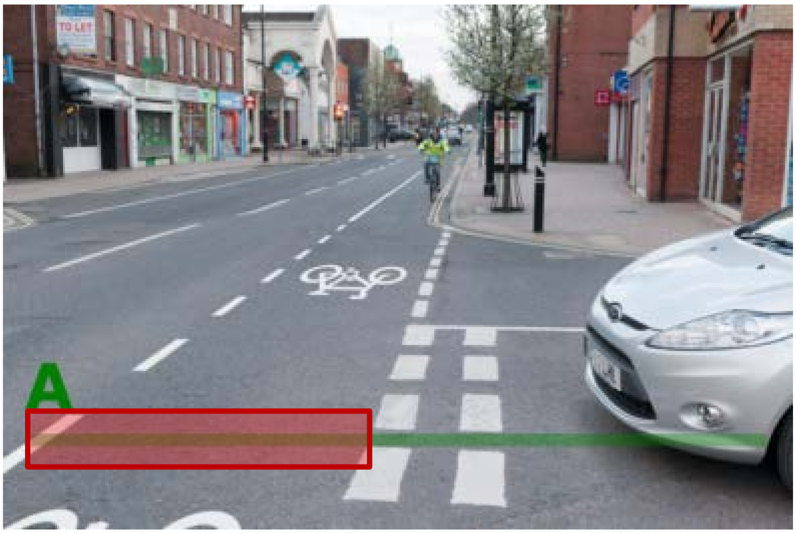


Figure 16 – Stopping positions judged to be dangerous

This study was not primarily designed to perform this analysis. The analysis is therefore indicative and a full understanding (i.e. ranking) of the markings using robust statistical test was not possible.

The number of instances where a participant indicated they would stop in the conflict zone was derived from the data and can be seen in Figure 17. It appears that some drivers would stop in a position that could lead to a conflict with all markings, and more would do so with traffic than cycles: although this could have occurred by random chance.

Marking 8 particularly stood out as it produced more conflicting stopping positions than any other marking, for both traffic and cyclists. This marking was the only to use 'sharks teeth', suggesting that for a significant proportion of the time, the 46 participants who judged this marking would expect to stop within the conflict zone (22% of the time when stopping for cyclists, and 28% of the time when stopping for motor traffic). Unfortunately, it is not possible to validate this interesting hypothesis[4]. However, it is included as it may be helpful to take this into account in any future trials.

[4] These are derived categorical responses collected in a factorial design. The statistical design was not developed for this analysis, which resulted in a full analysis of this derived variable being impossible. This was owing to the transformed variables not having fully independent samples, and therefore they did not satisfy the requirements of the required statistical tests.

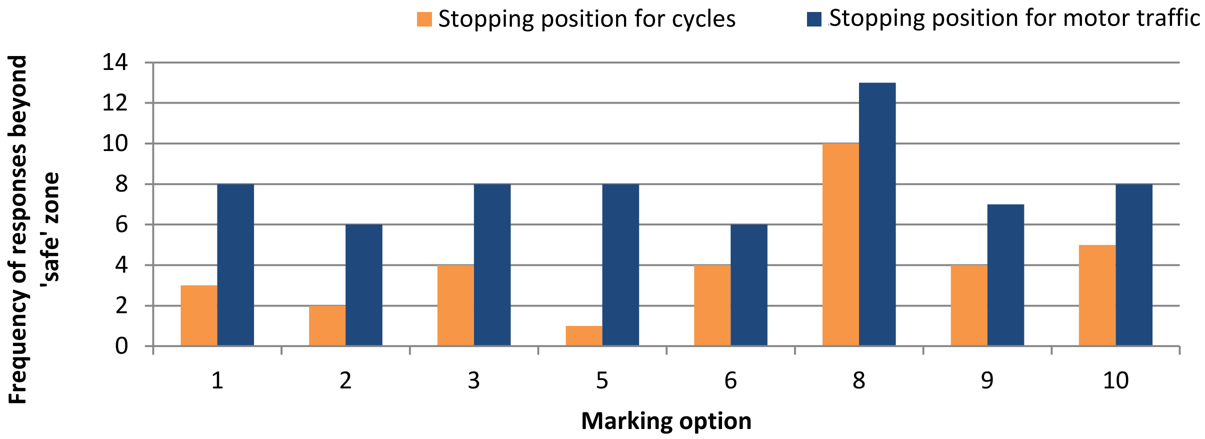


Figure 17 - Number of stopping positions within the conflict zone

Marking option 8 was the worst marking for encouraging junction users to stop within the 'conflict zone'.

5 Conclusions

5.1 Findings against each research question

Research question 1: Speed

Is there a difference in the speed with which road users judge a range of segregation markings?

There was no difference in the speed with which participants decided if it was appropriate to turn between the marking options. Therefore, all markings were similar in their conspicuity and comprehension.

This suggests that the selection of a road marking option to be used in further research or even on live roads does not depend on the clarity or comprehensibility of the options: there was no meaningful difference between the designs tested.

Research questions 2 and 4: Understanding and compliance

Is there a difference in what the participants understand the road markings to mean? For example, do they understand who has priority, where they should stop.

How likely would drivers be to comply with the road markings?

A driver's understanding and compliance are closely related; in order to correctly comply with the markings the driver must also understand them. Therefore, conclusions for research questions 2 and 4 shall be combined.

There were few differences revealed in user understanding of the marking options.

Cyclists were generally seen as having priority at the junction. None of the markings were significantly better or worse at communicating this priority.

If we consider compliance to include choosing an appropriate stopping position which does not infringe the cycle lane, we can see that, generally, junction users correctly complied with the markings when a cyclist was on approach: they stopped an average of 5cm after the start of the give way markings, and 90% of the time would not have stopped within the 'conflict zone'.

Marking options 5 and 6 encouraged drivers to stop further back from the junction when a cycle was approaching than when a car was approaching.

Marking option 6 was the best at encouraging junction users to stop furthest back when a cycle was approaching. Options 1, 5 and 3 also encouraged users to stop back from the junction, although not as far back as marking option 6.

However, with marking option 8 a higher proportion of drivers stopped within the 'conflict zone' in comparison with the others.

Research question 3: Safety

Does the design of the road markings affect the minimum distance a driver would be willing to turn in front of an approaching cyclist?

It was shown that participants were more likely to decide there was enough space to turn at the junction when most of the markings were present, compared to the control. However, when viewing options 1 and 3 participants were less likely to turn in front of a cyclist than in the control situation with no markings.

This indicates that marking options 1 and 3 give drivers decreased confidence at the junction, resulting in them being less likely to decide to pull out of the junction in front of an approaching cyclist.

5.2 Further research

The results of this study can be used to predict how road users will react to the eight marking options considered under good visibility conditions. In other words, the data was collected in a laboratory setting under a single visibility condition: good visibility. The extent to which the results can be generalised to road user behaviour in a live setting when visibility is reduced (such as at night or in rain) is not clear.

Marking options 1 and 3 are superficially similar; the only difference is the markings are much thicker (25cm) in option 3. This study showed there was little difference between the performance of marking options 1 and 3, however, given the greater thickness of the markings in option 3, we might hypothesise that they would be the most conspicuous in poor visibility. Further research would establish if road user behaviour changes when visibility is reduced and help to distinguish between the effectiveness of marking options 1 or 3. This could be achieved by putting a selection of marking options forward for live testing, either through a controlled track trial, or an on-street trial.

A track trial could test different marking options (at least options 1 and 3) under controlled, and safe, conditions. This approach provides the opportunity to investigate a wider range of conditions and provides statistical confidence in the findings for the range of conditions tested.

Alternatively they could be tested by installing the markings at a live junction and analysing road user behaviour by analysing video recordings. This provides a greater insight into naturalistic of behaviour, and will permit the investigation of stopping positions, paths used and interactions.

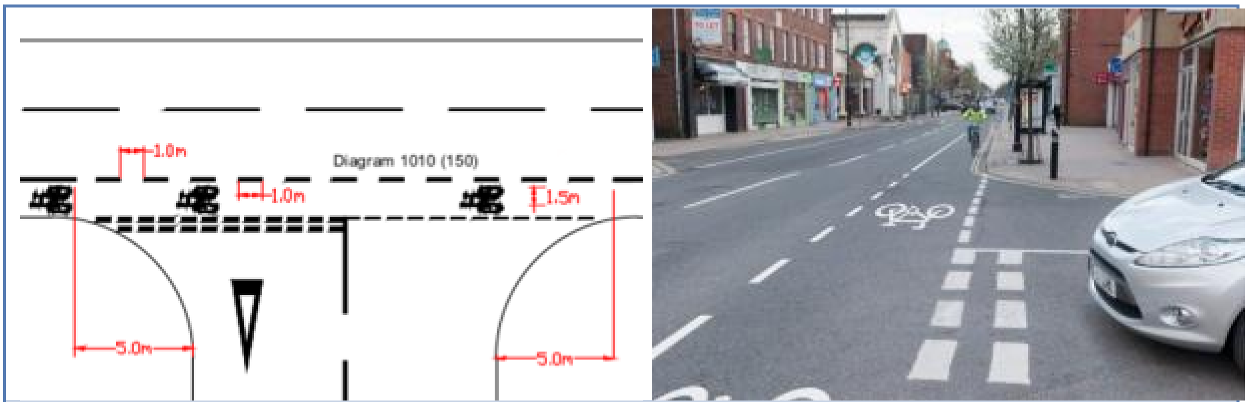
The correct approach will depend upon the trial's requirements. Therefore, further discussion with TfL is required to develop a cost-effective approach to meet any identified needs.

5.3 Overall conclusions

The purpose of this study can be summarised as:

How can the outcomes of this study be used to guide further research addressing cyclist priority junctions?

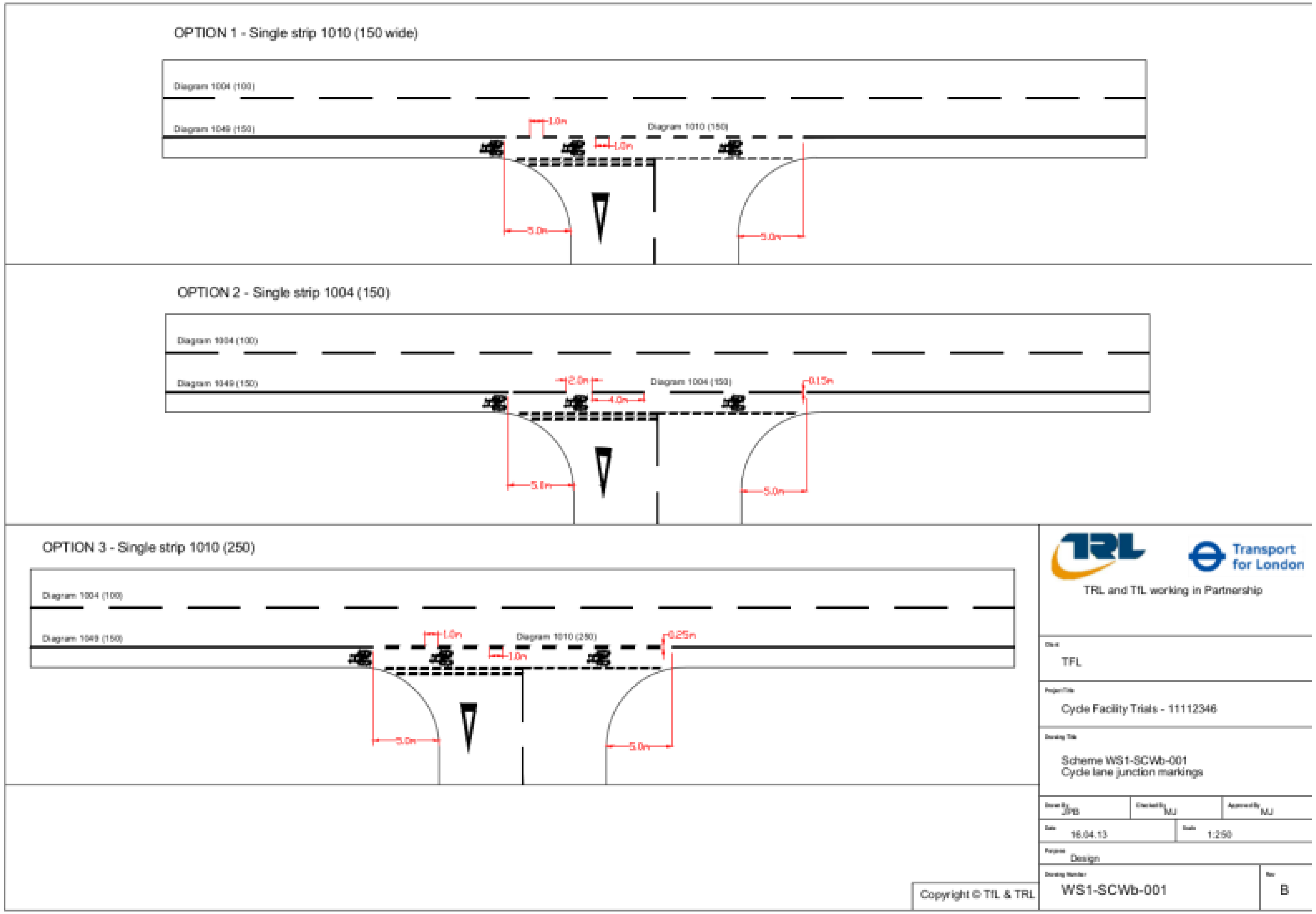
The data analysed suggests that there are few differences between the marking options, especially in terms of conspicuity and comprehension. However, more differences were found when examining the safety and compliance aspects of the options. In particular, a subset of markings were found to be slightly preferential to the rest: namely options 1 and 3 which made participants less likely to pull out in front of a cyclist, and options 6, 1, 3 and 5 which encouraged participants to stop furthest back from the junction when giving way to a cyclist. Taken together, the results suggest that options 1 and 3 were the best performing markings in this study, with no negative characteristics.

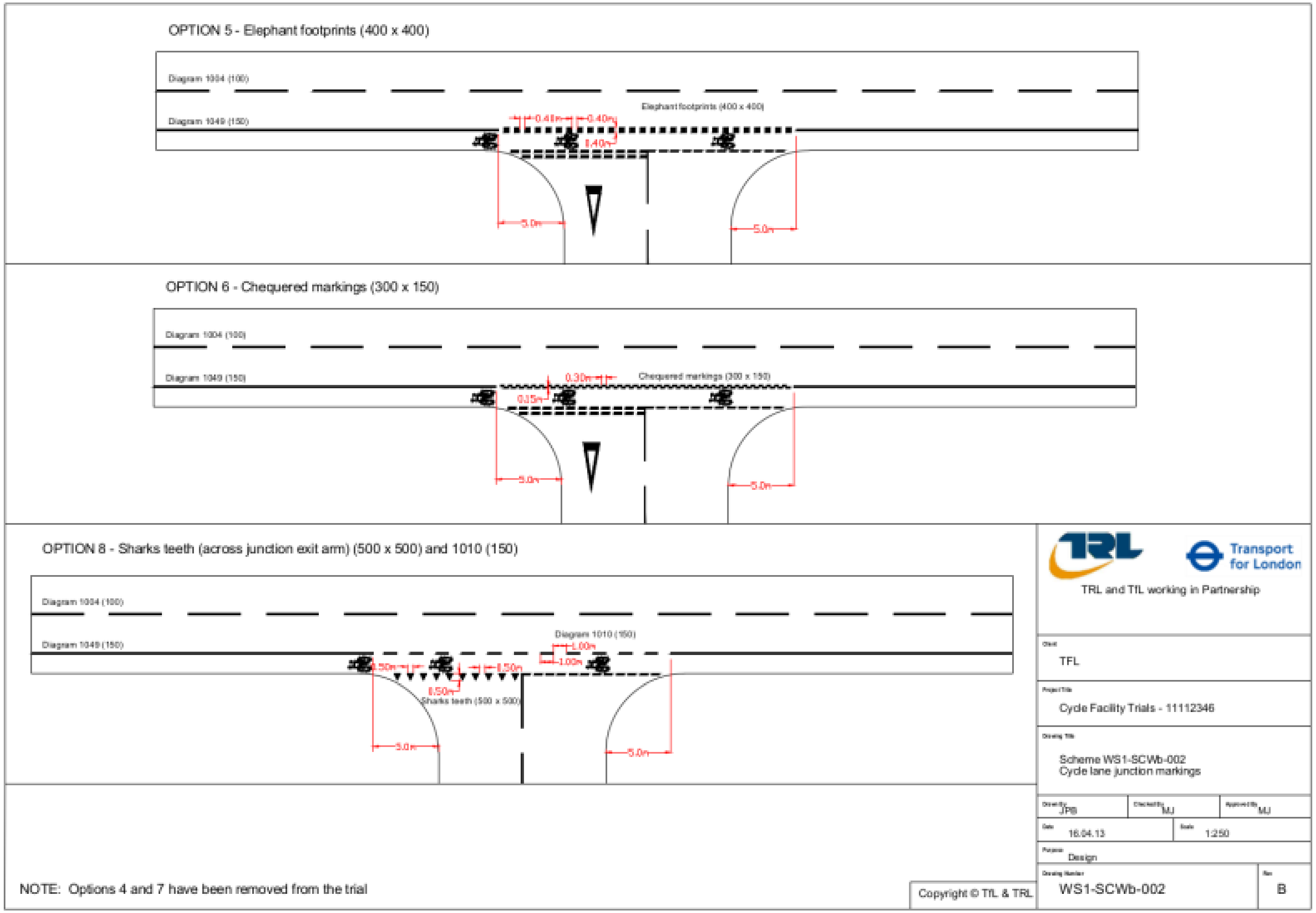


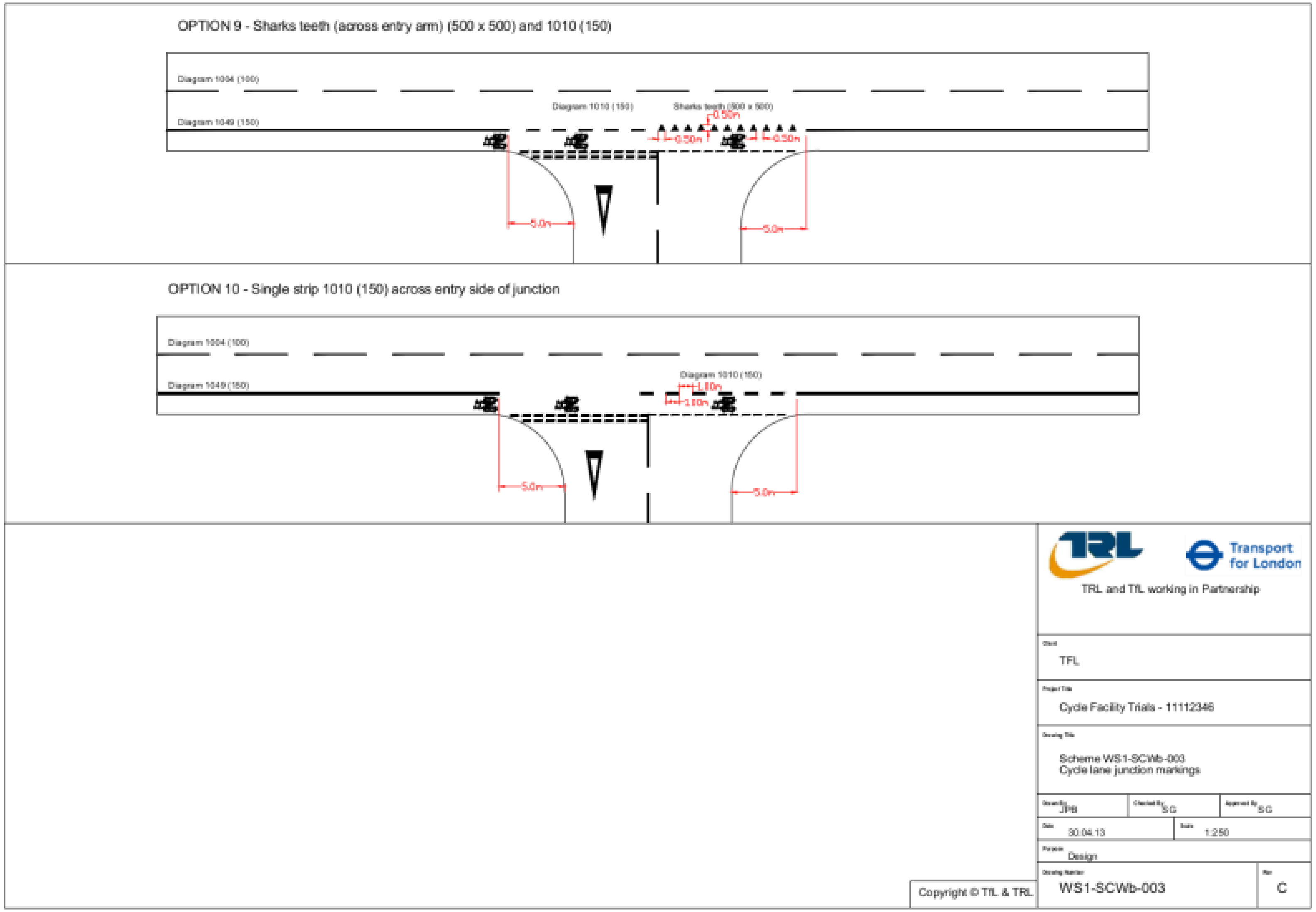
Option 1

Option 3

Appendix A Marking option drawings




OPTION 5 - Elephant footprints (400 x 400)
Diagram 1004 (100)
Diagram 1049 (150)
Elephant footprints (400 x 400)
0.40m
0.40m
1.40m
5.0m
5.0m
OPTION 6 - Chequered markings (300 x 150)
Diagram 1004 (100)
Diagram 1049 (150)
0.30m
Chequered markings (300 x 150)
0.15m
5.0m
5.0m
OPTION 8 - Sharks teeth (across junction exit arm) (500 x 500) and 1010 (150)
Diagram 1004 (100)
Diagram 1049 (150)
Diagram 1010 (150)
1.00m
1.00m
1.50m
1.50m
0.50m
Sharks teeth (500 x 500)
5.0m
5.0m
TRL and TfL working in Partnership
TFL
Cycle Facility Trials - 11112346
Scheme WS1-SCWb-002
Cycle lane junction markings
JPB
MJ
MJ
16.04.13
1:250
Design
WS1-SCWb-002
B
NOTE: Options 4 and 7 have been removed from the trial
Copyright © TfL & TRL


OPTION 9 - Sharks teeth (across entry arm) (500 x 500) and 1010 (150)
Diagram 1004 (100)
Diagram 1049 (150)
Diagram 1010 (150)
Sharks teeth (500 x 500)
0.50m
0.50m
0.50m
5.0m
5.0m
OPTION 10 - Single strip 1010 (150) across entry side of junction
Diagram 1004 (100)
Diagram 1049 (150)
Diagram 1010 (150)
1.00m
1.00m
5.0m
5.0m
TRL and TfL working in Partnership
TFL
Cycle Facility Trials - 11112346
Scheme WS1-SCWb-003
Cycle lane junction markings
JPB
SG
SG
30.04.13
1:250
Design
WS1-SCWb-003
C
Copyright © TfL & TRL

Appendix B Questionnaire

To be completed by TRL Participant Number: ____________ Time slot: ________ Date: _____/_____/_____	
Post-trial questionnaire – TfL T-Scope, May, 2013	

SECTION A. Background information

1.	If you have a full UK drivers licence, how old were you when you obtained it?	
2.	What is your approximate annual mileage?	
3.	Roughly what percentage of your journeys by car and/or bicycle take place in London?	%

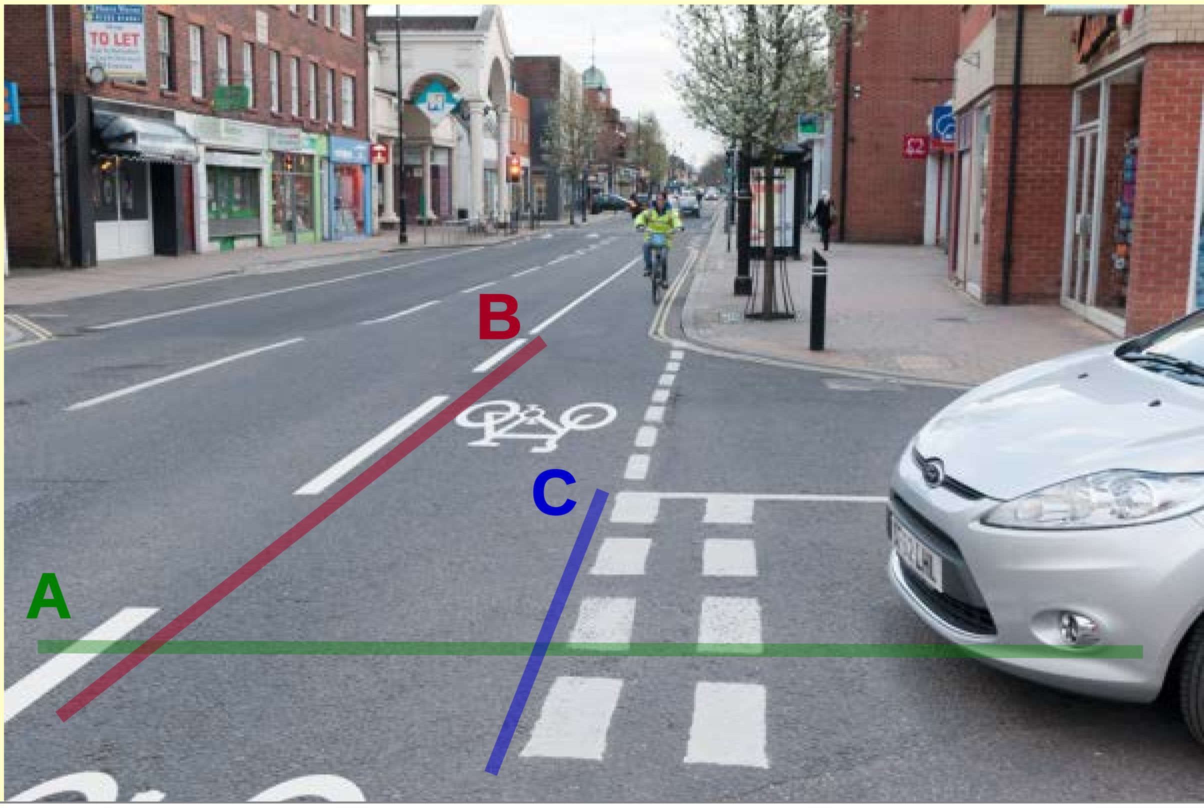
SECTION B. Opinions of road markings

You will now see a few pictures of road markings and be asked some questions regarding those road markings. Our research is not concerned with whether you are 'right' or 'wrong', all we are interested in is your opinion about the markings, so please do not worry about your answers, or deliberate over them for too long; your first impressions are of the most interest to us.

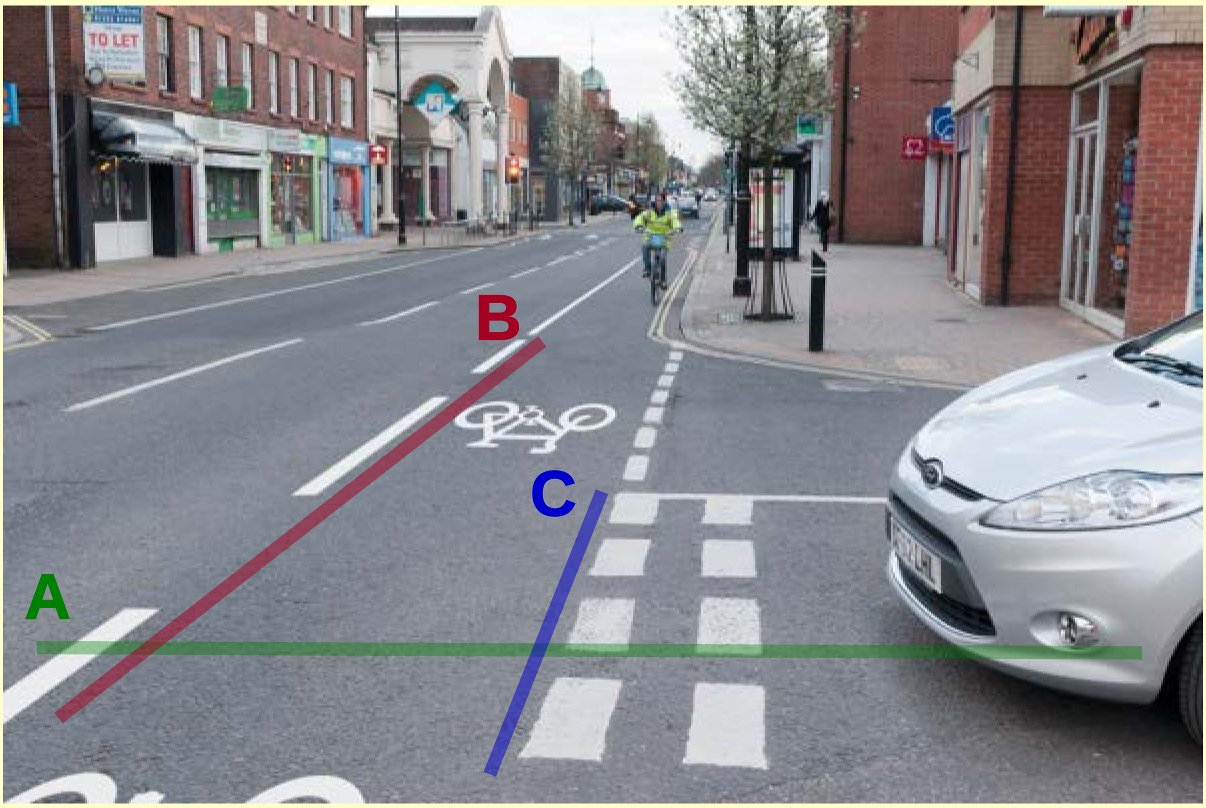
Please turn over when you are ready to begin.

Marking number	**2**	**P number**		**Date**	

Please inspect the junction images below and answer the following questions. The first picture shows the junction as it would appear in real life, the second image is exactly the same except it also has **red, blue** and **green** markings and letters which are there to refer you to specific parts of the scene; they would not appear on the actual road.




TO LET
TO LET
B
C
A



4. Imagine the cyclist is approaching at a reasonable speed. Who has the right of way?							
	Cycle		Car		Don't know		
5. If you were driving the **car** and giving way to a **stream of traffic** but could not see any cyclists coming in the cycle lane where would you stop? Please mark the green line **A** shown on the photograph with an **X** are the point where you							

	would place your front bumper.
6.	If you were driving the **car** and giving way to a **cyclist using the cycle lane** (and there was no other traffic) where would you stop? Please mark the green line **A** shown on the photograph with an **O** are the point where you would place your front bumper. If it is the same point as your answer to 5 above, please just circle the X, i.e. ⊗
7.	Please look at the part of the road markings next to the red line **B**. What do you think:
	(a) a driver wishing to turn from the main road into the side road would think he/she should do in response to the markings?
	(b) a driver wishing to turn from the side road into the main road would think he/she should do in response to the markings?
8.	Please look at the part of the road markings next to the blue line **C**. What do you think these markings represent to a driver wishing to turn from the side road into the main road?
9.	If you were a driver how confident would you be when deciding where to stop to give way? Please tick the box that most closely fits your answer.

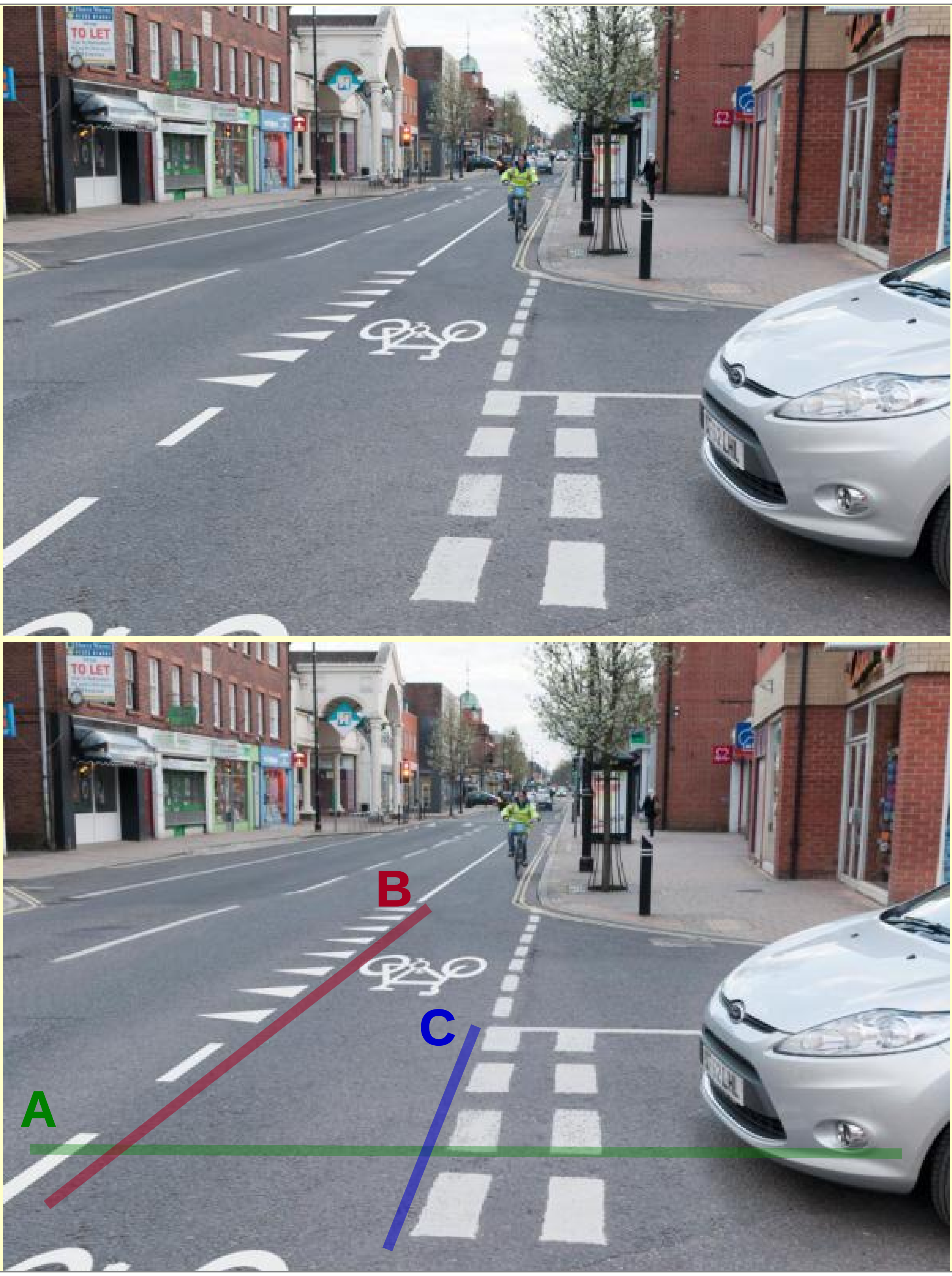
	Not at all confident	Slightly confident	Fairly confident	Very confident	Totally confident	

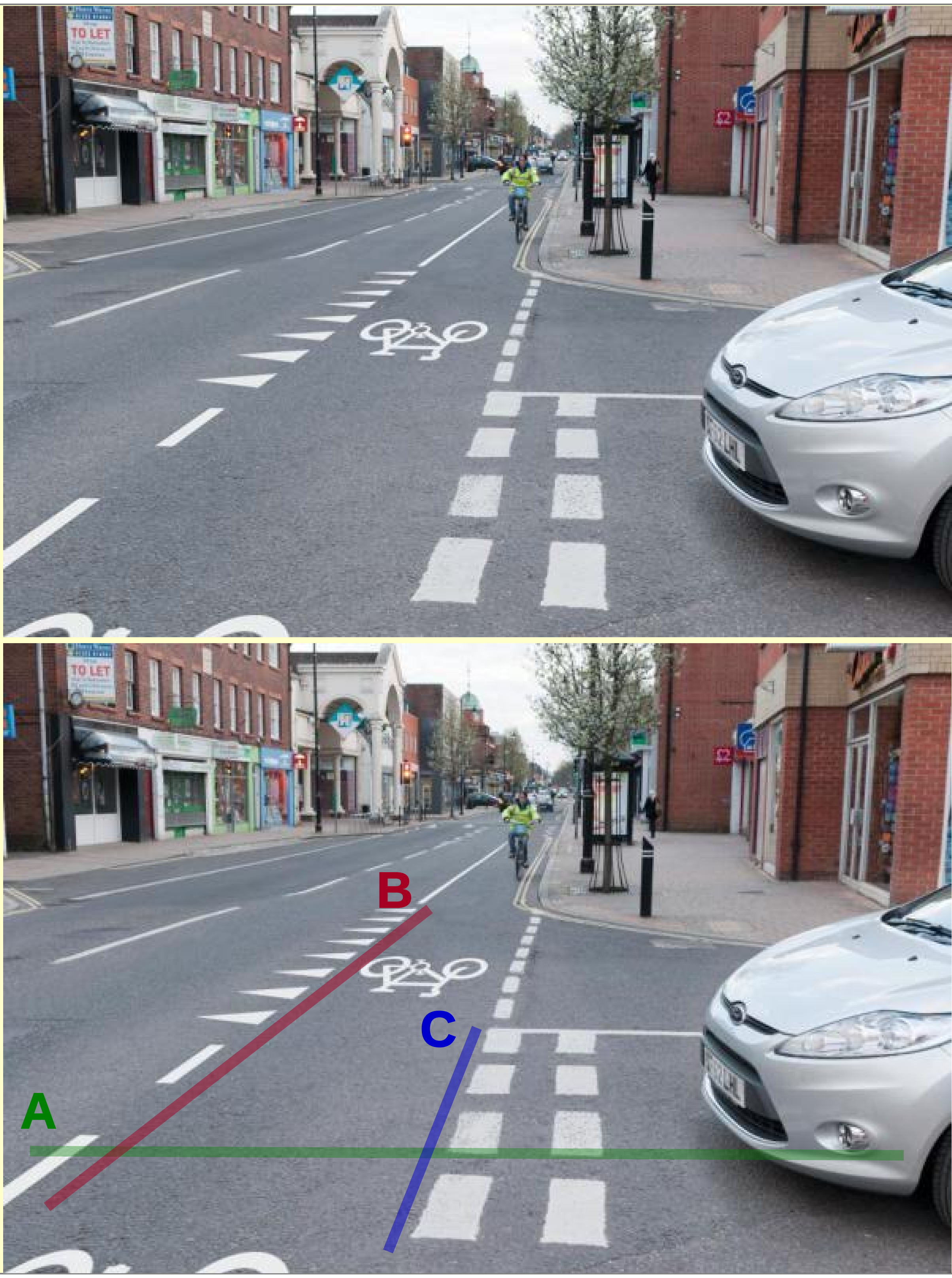
10. If you were a cyclist how confident would you be when passing across the junction without stopping if there was a car waiting to turn?

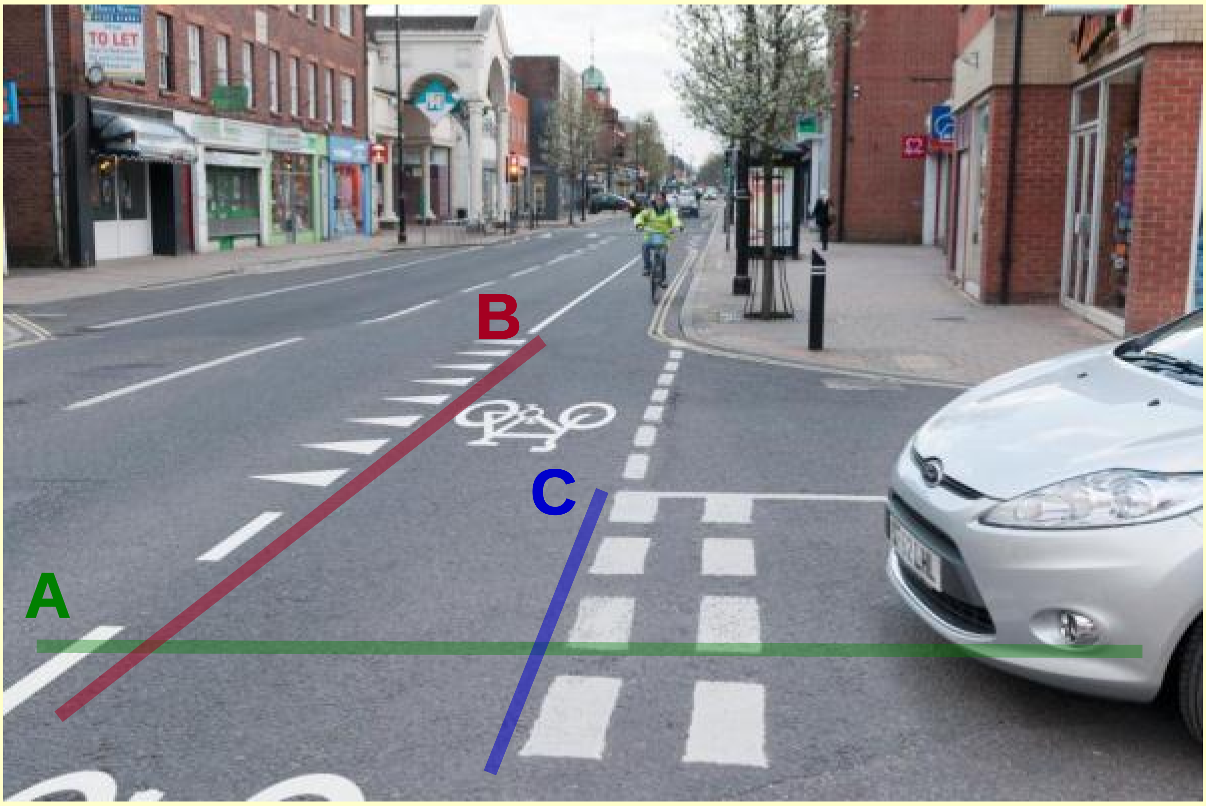
	Not at all confident	Slightly confident	Fairly confident	Very confident	Totally confident	

Marking number	**9**	**P number**		**Date**	

Please inspect the junction images below and answer the following questions. The first picture shows the junction as it would appear in real life, the second image is exactly the same except it also has **red, blue** and **green** markings and letters which are there to refer you to specific parts of the scene; they would not appear on the actual road.


B
C
A


TO LET
TO LET
B
C
A



11. Imagine the cyclist is approaching at a reasonable speed. Who has the right of way?							
	Cycle		Car		Don't know		

12. If you were driving the **car** and giving way to a **stream of traffic** but could not see any cyclists coming in the cycle lane where would you stop?
Please mark the green line **A** shown on the photograph with an **X** are the point where you

would place your front bumper.

13. If you were driving the **car** and giving way to a **cyclist using the cycle lane** (and there was no other traffic) where would you stop?
Please mark the green line **A** shown on the photograph with an **O** are the point where you would place your front bumper.
If it is the same point as your answer to 5 above, please just circle the X, i.e. ⊗

14. Please look at the part of the road markings next to the red line **B**. What do you think:

(c) a driver wishing to turn from the main road into the side road would think he/she should do in response to the markings?

(d) a driver wishing to turn from the side road into the main road would think he/she should do in response to the markings

15. Please look at the part of the road markings next to the blue line **C**. What do you think these markings represent to a driver wishing to turn from the side road into the main road?

16. If you were a driver how confident would you be when deciding where to stop to give way? Please tick the box that most closely fits your answer.

	Not at all confident	Slightly confident	Fairly confident	Very confident	Totally confident	

17. If you were a cyclist how confident would you be when passing across the junction without stopping if there was a car waiting to turn?

	Not at all confident	Slightly confident	Fairly confident	Very confident	Totally confident	

Appendix C Statistical Analysis of stopping positions for cyclist and traffic

C.1 Mean stopping positions

Figure 18 was drawn to illustrate the mean stopping positions for all marking options. Two suggestions can be drawn from this figure: firstly, there was little difference in stopping position between the marking options, and secondly, stopping positions were slightly further back for cyclists than for traffic.

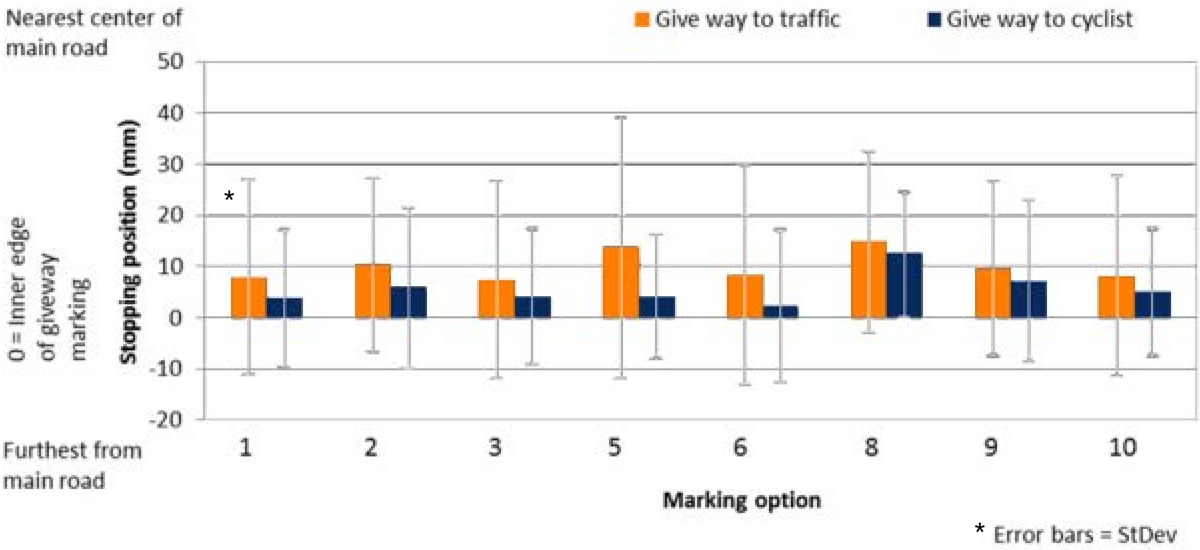


Figure 18 – Mean stopping positions for all marking options

The difference between these means were tested for significance using a Wilcoxon Signed Ranks test[5] which revealed that participants stopped significantly further back for cyclists when viewing marking option 5 ($z = -2.80$, $p = <.01$) and marking 6 ($z = -2.55$, $p <.01$). See Table 1 for a list of results for all marking options.

Table 1 – Differences in stopping positions between marking options: Results of Wilcoxon Signed Ranks tests

Marking	1	2	3	5	6	8	9	10
Z	-1.726	-1.634	-1.423	-2.797	-2.552	-1.352	-1.308	-1.820
Sig	.084	.102	.155	.005	.011	.176	.191	.069

Marking options 5 and 6 encouraged drivers to stop further back from the junction when a cycle was approaching than compared to a car.

[5] A Wilcoxon Signed ranks test is used when two sets of data from the same participant need to be compared, but this data is not normally distributed (i.e. when it is non-parametric).

C.2 Differences in stopping positions between markings

As shown in Figure 18 above, the differences in stopping positions between marking options was slight. Summary statistics for the stopping positions can be seen in Table 2. A control image (showing none of the test markings) was not presented to keep the questionnaire within the required length).

Table 2 – Summary statistics for stopping positions

Marking	Road user	N*	Stopping position values			
			Minimum	Maximum	Mean	Std. Deviation
6	Cyclist	49	-47	32	2.27	14.81
1	Cyclist	47	-19	33	3.81	13.36
5	Cyclist	46	-14	31	3.87	12.1
3	Cyclist	50	-16	34	4.1	13.3
10	Cyclist	48	-21	31	4.92	12.5
2	Cyclist	50	-16	76	5.92	15.72
9	Cyclist	48	-14	74	7.13	15.78
8	Cyclist	50	-6	30	12.2	12.09
3	Traffic	50	-13	93	7.48	19.34
1	Traffic	47	-12	77	7.87	19.16
10	Traffic	48	-21	81	8.1	19.5
6	Traffic	49	-47	84	8.23	21.45
9	Traffic	48	-14	81	9.5	17.12
2	Traffic	50	-16	81	10.3	16.93
5	Traffic	46	-11	81	13.22	25.43
8	Traffic	50	-14	81	14.58	17.48

* N = number of participants

A Kruskal Wallis test was performed on the data to determine whether these differences were significant. It revealed that there was a significant difference between the markings for cyclists ($H(7) = 23.70$, $p < .01$), and the result for traffic approached significance ($H(7) = 13.58$, $p = .06$). This demonstrates that the differences found in stopping positions between the marking options were meaningfully different, especially when participants were giving way to a cyclist; therefore some of the marking options 'performed' better than others.

Due to the number of marking options tested, post-hoc analysis was felt to be too unreliable, therefore a simple ranking of the markings was preferred as a method for identifying the best performing options. This ranking shows that option 6 was particularly effective at encouraging junction users to stop the furthest back when a cyclist was on approach. Markings 1, 5 and 3 also performed well, with little difference between them

Marking option 6 was the best at encouraging junction users to stop furthest back when a cycle was approaching. Options 1, 5 and 3 also performed well.