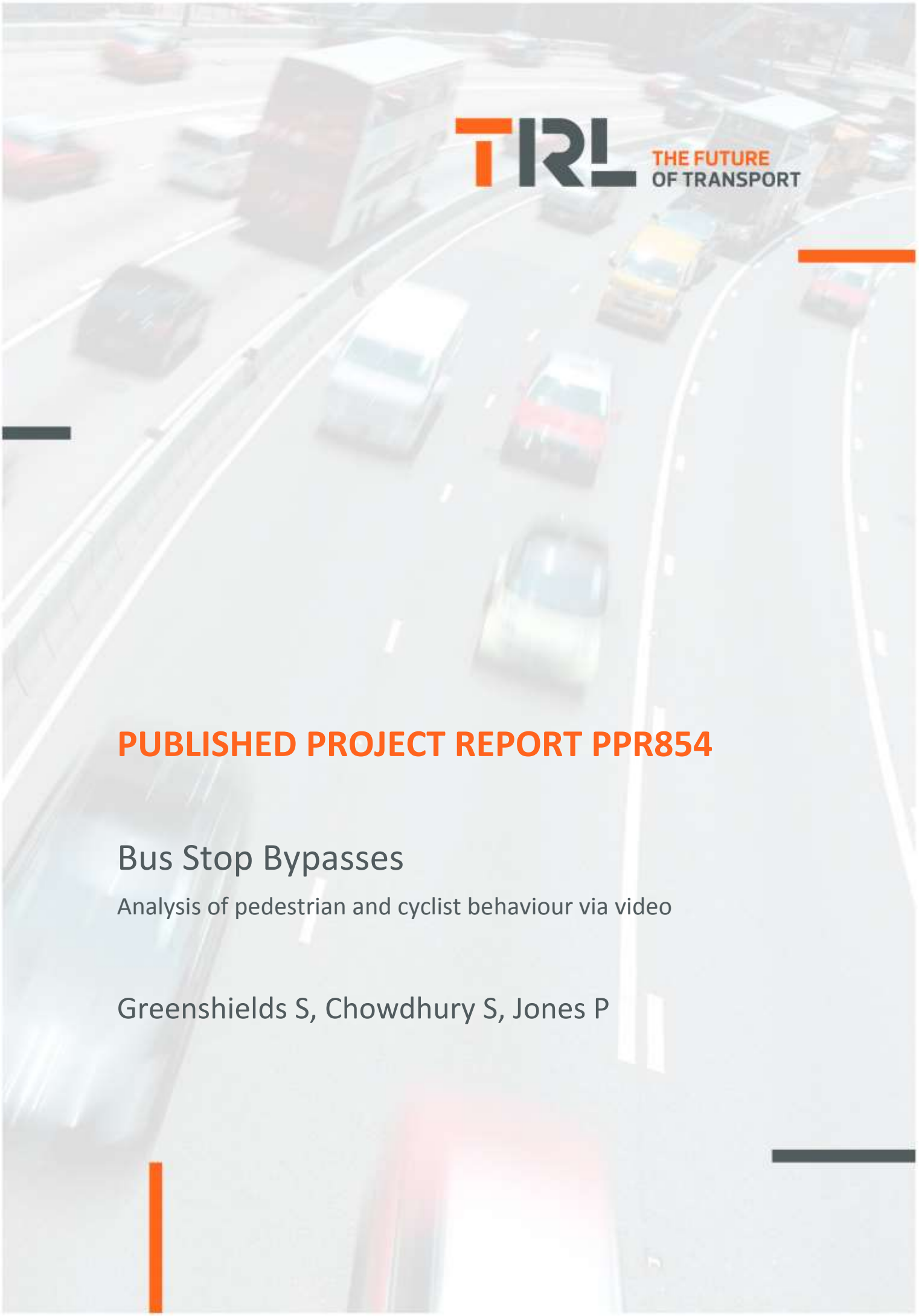

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Bus Stop Bypasses

Analysis of pedestrian and cyclist behaviour via video

Greenshields S, Chowdhury S, Jones P

Report details

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Contents amendment record

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Contents

Key findings

KEY FINDINGS

- A large majority of interactions between cyclists and pedestrians were of a low level, both with the uncontrolled crossing (92%) and with the zebra crossing (96%)
- Low level interactions between pedestrians and cyclists increased by 15% with the zebra crossing, however the higher level interactions fell (although the latter was not a statistically significant change)
- Across all sites the large majority (over 90%) of cyclists passed through the BSB without an interaction with a pedestrian with both crossing types
- The introduction of the zebra crossing encouraged more pedestrians to use the crossing zone from 39% with the uncontrolled crossing to 53% with the zebra crossing,
- There was a small but significant increase in the proportion of cyclists giving way at the zebra crossing compared to the uncontrolled crossing, from 33% to 40%;
- The majority (around 90% overall) of cyclists chose to use the cycle track through the BSB rather than the main carriageway
- Cyclist speed was not impacted by the introduction of the zebra crossing
- Cyclists' average speed at any given bus stop bypass does not appear to be correlated to higher level interactions with pedestrians
- Factors judged to be important in higher level interactions with cyclists were pedestrian inattentiveness, local features that constrained pedestrian movements or reduced inter-visibility, crowding and lack of space for manoeuvring

Executive Summary

Bus Stop Bypasses have been introduced over the past few years at sites on London's Cycle Superhighways to enable the continuation of segregated routes through bus stops. A Bus Stop Bypass (BSB) routes the cycle track behind a given bus stop. This physical layout requires that the path of cyclists and those pedestrians boarding and alighting buses will cross, leading to potentially new interactions between them where pedestrians cross the cycle track. This research compares the impact on pedestrian and cyclist behaviour of two different crossing types – uncontrolled crossings, and zebra crossings.

Observational (video) measurements of the behaviour of cyclists and pedestrians were made at six sites across London both in uncontrolled crossing and later zebra crossing configurations, which allows for comparative measurements to be made to understand the impact of this change. Furthermore each site was configured slightly differently to allow the layout to fit within the local area, and the differences in observed behaviour caused by this are also discussed. Separate reports address research questions related to surveys of pedestrians and cyclists, and accompanied visits to sites with disabled people.

The **total number of interactions increased** from 255 with an uncontrolled crossing to 293 with a zebra crossing, a 15% increase, although this was for low level interactions. **High level interactions fell** from 20 to 10, although the numbers are too small to be statistically significant.

Across all sites **the large majority of cyclists passed through the BSB without an interaction with a pedestrian**, for both the uncontrolled crossing (93%) and zebra crossing (92%) measurements. No statistically significant difference was found in the proportion experiencing an interaction following the introduction of the zebra crossing.

Interactions were measured using a 1 to 5 scale. In the uncontrolled crossing measurements 92% of the interactions were at the lower two levels, whilst for the zebra crossing measurements the figure was 97%.

The introduction of the zebra crossing **encouraged more pedestrians to use the crossing zone** (the area of cycle track designed for pedestrians to cross – typically the raised or zebra crossing and 1m either side), **from 39% with the uncontrolled crossing to 53% with the zebra crossing**, while the proportion of interactions at the crossing showed a smaller increase, from 46% to 53%, suggesting a reduced probability of interaction for pedestrians at the crossing. Belisha beacons were fitted to the zebra crossings at Blackfriars SA and Whitechapel J, but not to the other sites. The **Belisha beacon(s) appeared to have a statistically significant positive impact upon the propensity of pedestrians to use the crossing area** with use of the crossing rising from 31% (uncontrolled crossing) to 53% (zebra crossing) of pedestrians at the Belisha beacon sites, compared with 41% (uncontrolled crossing) to 48% (zebra crossing) of pedestrians at the non-Belisha beacon sites.

There was a small but significant **increase in the proportion of cyclists giving way at the crossing**, from 33% (uncontrolled crossing) to 40% (zebra crossing); however there was also an increase in the proportion of pedestrians that gave way, from 45% to 53% respectively, these increases largely coming from reduction in the "both gave way" category.

The **majority (around 90% overall) of cyclists chose to use the cycle track** rather than the main carriageway, and this choice was not significantly influenced either by the presence of

a bus at the stop or whether other cyclists are immediately in front of them. **Cyclist speed was not impacted by the introduction of the zebra crossing**, and showed greater variation between locations (the 2-way sites were faster than the 1-way sites) and gender (males were faster). **Cyclists' average speed at any given bus stop bypass does not appear to be correlated to high level interactions with pedestrians**.

Individual video examinations were undertaken of the small number of more serious interactions between cyclists and pedestrians (20 with the uncontrolled crossing, 10 with the zebra crossing). Factors judged to be important in these interactions were **pedestrian inattentiveness**, local features that **constrained pedestrian movements** or **reduced inter-visibility**, **crowding and lack of space for manoeuvring**. However, this was from a small sample of high level interactions and further research would be needed to investigate these factors quantitatively.

1 Introduction

1.1 Objectives of research

TfL is introducing innovative infrastructure for cyclists across the capital to improve safety and encourage increased demand for cycling from a wide demographic of cyclists.

The purpose of this report is to present the findings of on-street research into the bus stop bypass (BSB), a form of infrastructure in which cyclists pass between a bus stop island and the main pedestrian footway via a segregated cycle track. It is intended that research outputs will inform future design guidance and schemes.

Four variants of the design were created in collaboration with TRL and trialled at the TRL test track in 2013 via observational research of participants undertaking defined crossing movements. These trials informed the planning and design of new BSBs as part of the Mayor's Vision for Cycling. BSBs have since been subject to further on-street monitoring which is detailed within this report.

Three methods were used to monitor the BSBs: video observations, on-street user surveys and accompanied walks with vulnerable groups. This report focuses on the findings from the video observations; the findings of the other studies are reported separately.

The monitoring described in this report was undertaken with the following objectives:

- Gain a robust understanding of the benefit of the new infrastructure, by gauging the level of use by cyclists and pedestrians.
- Understand how user interactions with the infrastructure compare to predicted behaviours.
- Understand the impacts upon visually- and mobility-impaired users. Guided walks and structured discussions were undertaken to understand and address concerns from stakeholder groups and to comply with TfL's duties under the Equality Act 2010.
- Understand the impact on users of uncontrolled and zebra crossings.

Two of the zebra crossings (Whitechapel stop J and Blackfriars stop SA) were also fitted with Belisha beacons, with two Belisha beacons at Whitechapel stop J, and one Belisha beacon at Blackfriars stop SA, to test whether these could help users recognise or find the crossing.

It is intended that research outputs are beneficial for future design guidance and schemes. It is important that new designs are attractive, used appropriately, and contribute towards improved safety for all road users. This report provides supporting evidence for design decisions by providing details on how well the various features of the infrastructure work and the reasons for this.

There are two key types of layout explored. The first, found at the Stratford and Whitechapel sites, has a one-way cycle track which kinks around the back of a bus stop area including the bus shelter and bus flag. This was measured in both uncontrolled crossing and zebra crossing configurations. The crossing was relatively close to the bus flag and the rear exit doors of a bus would usually align with the crossing. The track is 1.5m wide. This layout,

with a zebra crossing, can be seen in Figure 1. Photographs of each site in each configuration can be found in Appendix B.

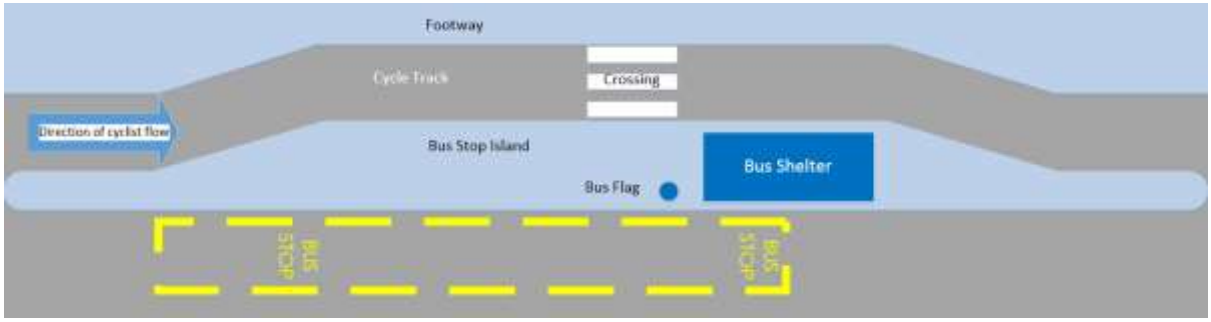


Figure 1 Bus Stop Bypass layout with one-way cycle track and zebra crossing

The second type of layout, found at the Southwark sites on Blackfriars Road, has a two-way cycle track which does not kink around the back of the bus stop area and is continuously straight. The track is 4m which is wider than the 1-way cycle tracks. The crossing point at these locations was slightly further away from the bus stop flag, and the islands were relatively wider too. This provided far more waiting space for pedestrians.

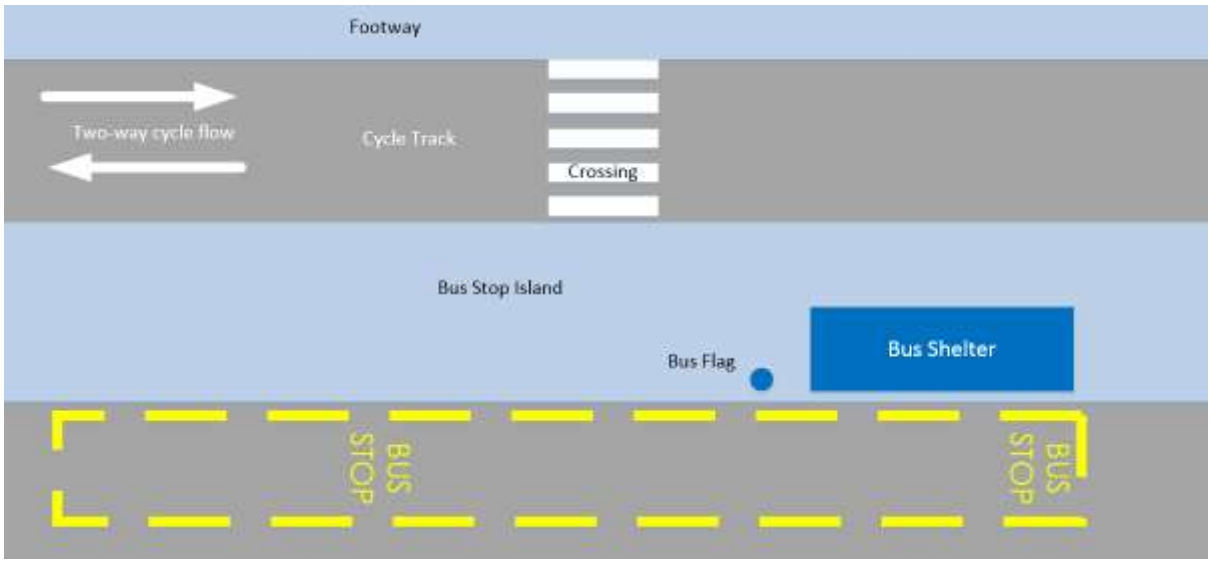


Figure 2 Bus Stop Bypass layout with two-way cycle track and zebra crossing

1.2 Overview of methodology

The study methodology was designed to understand the advantages and disadvantages of BSBs with uncontrolled crossings compared with zebra crossings by conducting observations at six bus stop bypass sites. This gives a wide range of variation of BSB type and location. Six research sites were chosen by the client for this project, and remained the same for both the uncontrolled crossing and zebra crossing measurements. The sites were in the following locations:

- Whitechapel Road (in Whitechapel)– two BSB sites (A and J)
- Stratford High Street (in Stratford) – two BSB sites (J and M)
- Blackfriars Road (in Southwark) – two BSB sites (SA and U)

Further details and exact locations are provided in Appendix A.

A set of research questions was developed on which the design of the data collection and analysis was based (see **Appendix C**).

Video cameras were placed for a week at each of the six bus stop bypass locations in order to record pedestrian and cyclist behaviours using the facility naturally, i.e. without external influence or guidance. In contrast to the off-road trials where pedestrian and cyclist manoeuvres were necessarily controlled in order to create an observable scenario, this trial observes people on street who were not recruited in any way to perform and are unlikely to be aware of the video cameras.

1.3 Details of video observation and analysis

1.3.1 Observation zones

The cycle track was divided in to five zones to assist an understanding of the location of any interactions. These zones can be seen in Figure 3 with the following descriptions:

- A = Approach angle start or next 10m
- B = Approach kink or 10m from crossing if straight
- C = Crossing + 1m either side
- D = Depart kink or 10m from crossing if straight
- E = Depart angle start or next 10m

Regardless of the BSB site, the zone definitions were always described as left to right when observed from the carriageway.

The crossing between the footway and bus stop island was always located in zone C of Figure 3, and this position remained unchanged between the uncontrolled crossing and zebra crossing measurements. The uncontrolled crossings were all raised platforms with tactile paving but with no markings. The zebra crossing was a zebra crossing (Blackfriars SA had two Belisha beacons and Whitechapel J had one) but without zig-zag markings. Following the publication of the Traffic Signs Regulations and General Directions 2016, Belisha beacons and zig-zag markings are not required for zebra crossings of cycle tracks. See **Appendix B** for images of all six BSB sites in uncontrolled and zebra crossing configurations.

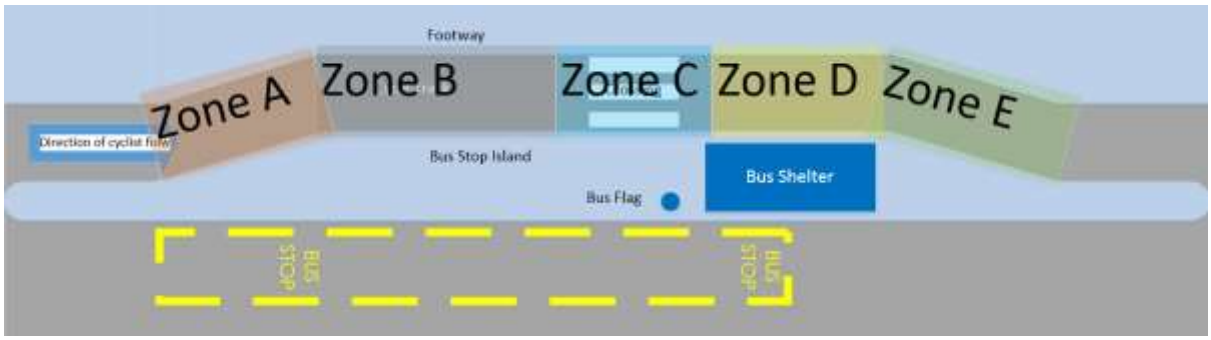


Figure 3 Zones along cycle track between the bus stop bypass island and the footway

1.3.2 Timing of observations

All video measurements were undertaken twice, the first time with the uncontrolled crossing and the second time with a zebra crossing. Both measurements were undertaken over a 7-day week, with the uncontrolled crossing measurements starting on Monday 13th June 2016 and zebra crossing measurements starting on 21st February 2017.

Video was recorded for 24 hours per day; however video extraction was conducted on a sample of video taken over the 14 hours between 7am and 9pm as this coincides with both the period of maximum cyclist activity and hours when daylight was sufficient for behaviour to be seen properly.

1.3.3 Data extraction

The sampling methodology was to take the first *X* number of observed cases of any given event from the start of any given hour from 7am to 8pm over a 7-day week. This allowed for a wide example range of cyclists, pedestrians, and potential conditions to be covered. The number of cases was chosen to ensure a likelihood that the whole sample would have a level of statistical reliability, based upon the amount of variance in observational responses found in the previous off-road trials undertaken by TRL in 2013. The introduction to each research question describes the sample size, which is also mirrored in the Research Questions within Appendix C and in Table 1. Note that at the two-way Blackfriars Road sites the sample for RQ1 observed the first cyclists seen in either direction, and in RQ6 split the sample evenly for each direction.

Table 1 Sample sizes per site

Research Question	Focus of research	Sample size per research site
RQ1	Interactions between pedestrians and cyclists	588
RQ4	Pedestrian movements at the bus stop bypass	784
RQ5	Cyclist use of the cycle track	588
RQ6	Cyclist speed at the bus stop bypass	294

The level of any given interaction between pedestrians and cyclists was measured by observing interaction behaviour and then coding as the appropriate level as per the descriptions below:

- Level 1: Precaution – For example, a pedestrian, or cyclist, markedly slowing down in carriageway in response to another user requiring the same space.
- Level 2: Controlled Action - Pedestrian, or cyclist, deviating from route.
- Level 3: Near Miss - Pedestrian, or cyclist, rapidly slowing down, stopping or changing direction to avoid collision.
- Level 4: Very Near Miss - Pedestrian, or cyclist, using emergency braking or violent swerve.
- Level 5: Collision – Contact between a cyclists and a pedestrian.

Levels 1 and 2 can be considered as an outcome of cyclists and pedestrians simply being in the same place at the same time (usually crossing each other's paths) and giving way to each other, and do not necessarily imply any adverse interaction. The total number of interactions is largely a function of how busy any given site is, whereas the levels describe those interactions.

2 Research Question 1 – Interactions between cyclists and pedestrians

The layout of bus stop bypasses requires that pedestrians cross a cycle track in order to access the bus stop from the footway or vice versa. This leads to the potential for interaction between pedestrians and cyclists, which was measured in terms of:

- Proportion of cyclists involved in some level of interaction with pedestrians
- The level of that interaction – utilising a 5-point scale used in previous studies
- The location of that interaction – using five zones A to E along the cycle track
- Give-way behaviour of pedestrians and cyclists
- Pedestrian movement at the time of interaction

The sampling technique used the first 6 cyclists seen using the cycle track from each start of 14 hours each day (7am start), irrespective of whether they interacted with pedestrians, giving a sample of 588 for each BSB site for the uncontrolled crossing and zebra crossing measurements.

2.1 Proportion of cyclists involved in some level of interaction with pedestrians

Figure 4 shows the proportion (%) of the 588 cyclists at each research site which interacted with any pedestrians, and the number that did so as an annotation.

- For all sites, a large majority of cyclists passed through without an interaction both in the uncontrolled crossing (92.8%) and zebra crossing (91.7%) samples.
- There was some variation between sites, with the lowest proportion (78.2% with the uncontrolled crossing, and 81.1% with the zebra crossing) passing through without interaction at the Whitechapel A BSB.
- The proportion that interacted increased slightly overall in the zebra crossing sample, by 1.1%, but decreased at two sites (Blackfriars U and Whitechapel A). However, a Chi-square test showed that the differences between the uncontrolled crossing and zebra crossing samples are not statistically significant ($p=0.09$).

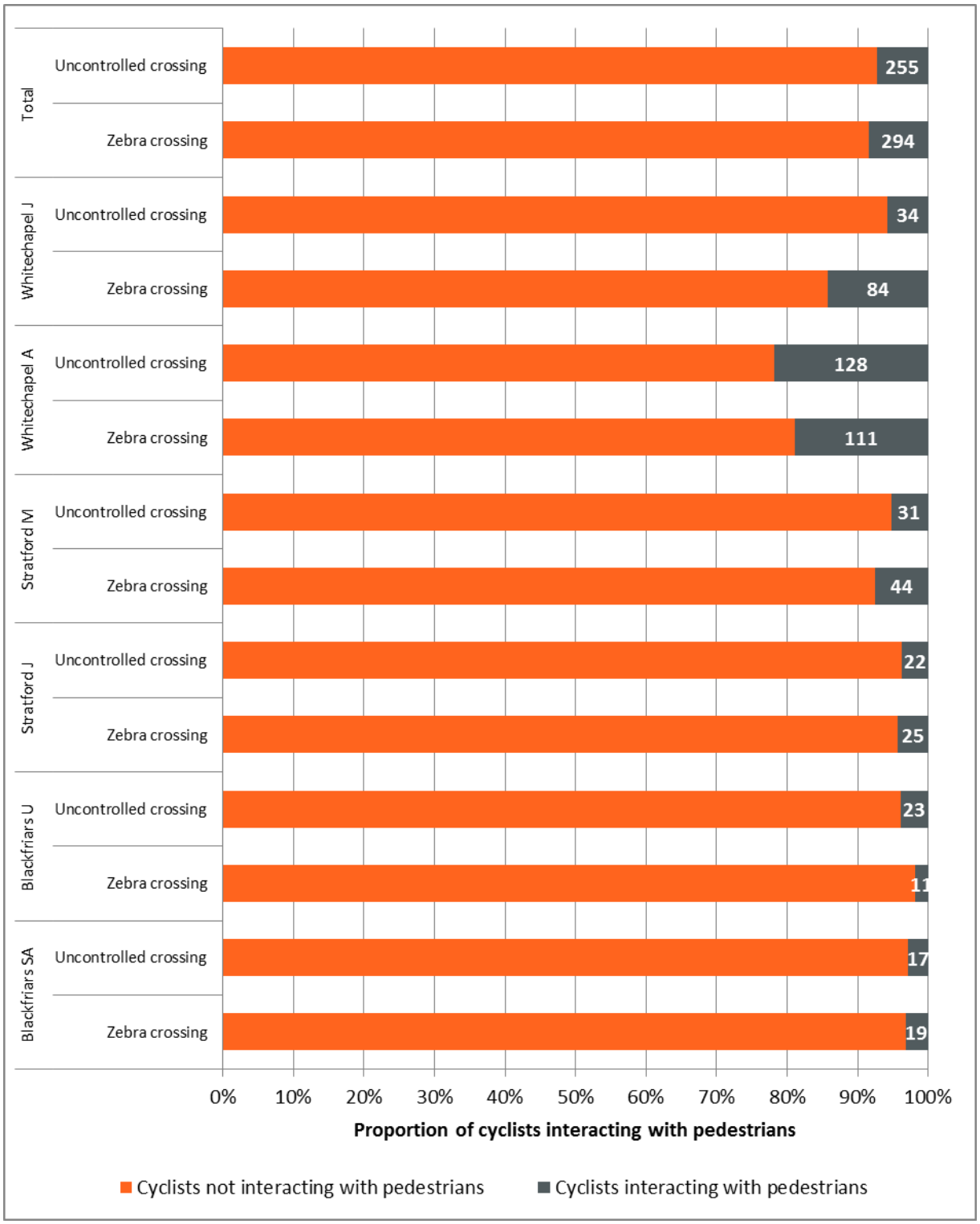


Figure 4 Proportion of cyclists interacting with pedestrians

2.2 Higher and lower level interactions

Lower level interactions (Level 1 and Level 2) could be described as pedestrians and cyclists negotiating space simply because the other party is there (such as slowing or gently stopping to let another party cross), therefore may be viewed simply as a function of presence/intensity of use. A large majority (92%) of interactions between cyclists and

pedestrians at the bus stop bypasses were lower level interactions. The breakdown of interactions by level is given in in Table 2, which indicates the location and level of interactions. Interaction totals are reported for all crossing zones, zone C only (the location of the crossing), and all the other zones.

Table 2 Location and level of interactions

		Level 1: Precaution	Level 2: Controlled Action	Level 3: Near Miss	Level 4: Very Near Miss	Level 5: Collision	Total
All zones	Uncontrolled crossing	180	55	18	1	1	255
	Zebra crossing	240	43	10	0	0	293
Zones A, B, D, E	Uncontrolled crossing	102	28	7	0	0	137
	Zebra crossing	114	17	7	0	0	138
C. Crossing + 1m either side	Uncontrolled crossing	78	27	11	1	1	118
	Zebra crossing	126	26	3	0	0	155

Comparing uncontrolled crossings and zebra crossings:

- There were 20 higher level interactions (levels 3, 4, and 5) with the uncontrolled crossing, and 10 with the zebra crossing - a fall of 50%.
- There were 235 lower level interactions with the uncontrolled crossing (92% of the total) and 283 with the zebra crossing (97% of the total)- an increase of around 20%
- The number of higher level interactions at crossing zones away from zone C remained the same for both the uncontrolled crossing and zebra crossing measurements with 7 in each.
- At the crossing (Zone C) higher level interactions reduced (from 11 with the uncontrolled crossing to 3 with the zebra crossing). Those remaining were only at level 3. However the numbers are too small to comment upon the statistical significance of any change.
- Lower level interactions in Zone C increased (105 to 152).
- Away from the crossing (i.e. zones A, B. D, and E) level 1 and 2 interactions remained largely similar (130 with the uncontrolled crossing and 131 with the zebra crossing).

2.3 Higher level interactions observations

The video recordings of the higher level interactions were examined in more detail to provide examples of the behaviours involved and any associated factors that might have influenced them. These more detailed observations and any conclusions that can be drawn are described separately for the uncontrolled and zebra crossings. A summary of common higher level interaction causation factors can be found in Table 3 and Figure 5 below. A more detailed description of each can be found in Appendix D. It is however important to bear in mind that the observations below are qualitative judgements made on small numbers of interactions, so caution is needed in interpreting more widely. Note that the meaning of "cyclist arriving from behind pedestrian" is that approaching cyclists are out of their field of vision (without rotating the head to a large extent) due to the direction of a pedestrian across the cycle track (Figure 6). Note that in all cases of this, the pedestrian was walking rather than waiting in the cycle track.

Table 3 Summary of higher level interaction causation factors

	Pedestrian appeared inattentive	Pedestrian distracted by companions	Cyclist arriving from behind pedestrian	Visibility obscured by bus shelter or other pedestrians
Uncontrolled crossing	13	8	11	7
Zebra crossing	8	4	6	1

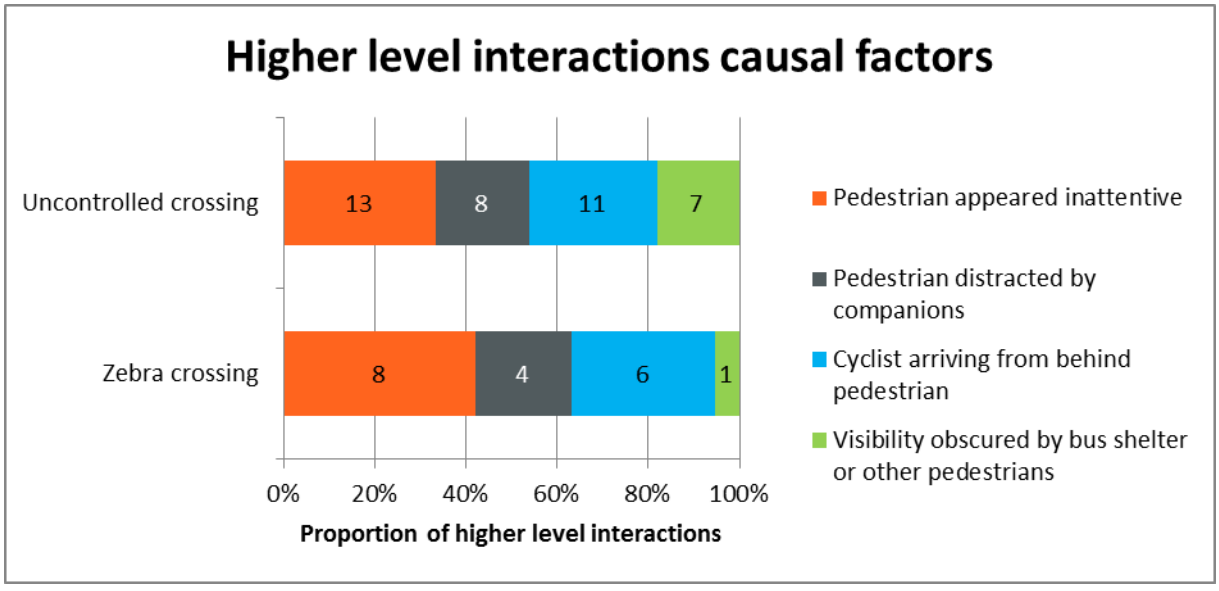


Figure 5 Causal factors

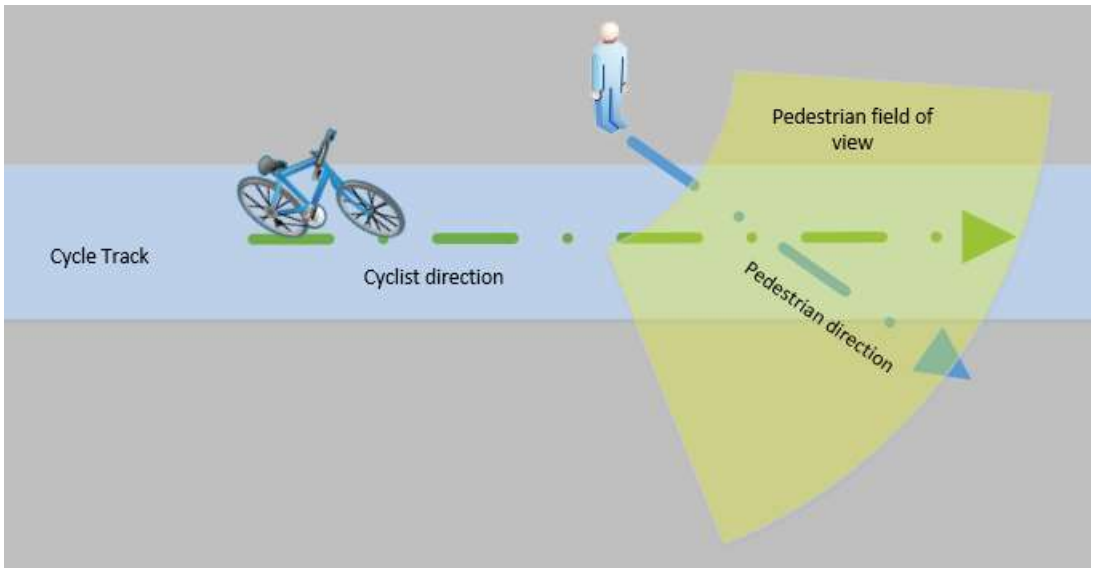


Figure 6 Cyclist arriving from behind pedestrian

2.3.1 Higher level interactions at uncontrolled crossings

There were 20 higher level interactions in the uncontrolled crossing observations (18 level 3, and 1 each at levels 4 and 5). The following observations were made.

- The design of the Whitechapel and Stratford sites, which places the bus flag close to the crossing, encourages pedestrians to congregate on the bus stop island near to the bus flag/crossing as this is where pedestrians expect the bus to stop (Figure 7 and Figure 8). This crowding of waiting pedestrians near the crossing was seen to reduce visibility between crossing pedestrians and cyclists. Pedestrians would leave the bus and head across the crossing but not be able to see oncoming cyclists
- The location and long length of the cycle stands at Whitechapel Bus Stop A appears to have been a barrier to passengers crossing the cycle track (in Zone B – see Figure 7) when they alighted from a second bus at the stop. As they walked around or through the cycle stands, pedestrians' exposure time to approaching cyclists was increased.
- Pedestrian behaviour, particularly from distraction whilst talking to friends (8), or from plain inattentiveness (13) appeared to be a core cause of many higher level interactions.
- The pedestrian crossing the cycle track in a direction which meant that approaching cyclists were behind them appeared as a factor in 11 higher level interactions. This is somewhat linked to pedestrian inattentiveness.
- The Blackfriars Road sites had no level 3 or above interactions; however these have the widest cycle tracks with the fastest speeds. This suggests that in this context the two-direction, wider lanes, and higher speeds are not a cause of concern.
- It is not known to what extent any reduction in higher level interactions can be attributed to cyclists and pedestrians becoming more familiar with the BSB and associated infrastructure.

Discussion

The Stratford sites are largely similar in layout to the Whitechapel sites, however they appeared to have far fewer level 3 and above interactions. Casual observation suggests that there are far more pedestrians both loitering or walking near the cycle track and crossing it at the Whitechapel Road sites compared to the Stratford sites. This suggests that interactions are related to exposure, i.e. more pedestrians therefore more likely that pedestrian and cyclist paths will cross, therefore more likely that interactions will occur. This coupled with decreased inter-visibility between cyclists and pedestrians because of the density of pedestrians and the relatively short distance between the bus doors and the cycle track, means that those interactions are more likely to be at a higher level. However, the number of observations is too small for quantitative analysis to be undertaken.

Figure 7 Cycle stands creating a barrier to pedestrians in zone B at Whitechapel A

Figure 8 Level 5 interaction with pedestrian at crossing (zone C) after leaving bus and passing through crowd of waiting pedestrians

2.3.2 Higher level interactions at zebra crossings

There were 10 higher level interactions in the zebra crossing observations, all at level 3. These occurred at Stratford M, Whitechapel A, and Whitechapel J sites. All occurred on the cycle track.

- Of the 10 incidents eight were considered to involve a level of pedestrian inattentiveness (i.e. appearing not to be looking for or otherwise expecting oncoming cyclists before crossing), and these all occurred at zones A, B, and E.
- Four of the incidents involved pedestrians distracted by companions.
- Six of the incidents involved pedestrians crossing in a direction which meant that the cyclist was largely behind them (which would require a greater turning of the head to make direct observation)
- Only one of the incidents involved obscured visibility

Table 4 indicates the scale and location of higher level interactions. Sites which are not listed have none of these interactions.

Table 4 Comparison of higher level interactions at the uncontrolled crossing (N=20) and zebra crossing (N=10) configurations

Phase	Site	A. Approach angle start or next 10m	B. Approach kink or 10m from crossing if straight	C. Crossing + 1m either side	D. Depart kink or 10m from crossing if straight	E. Depart angle start or next 10m	Footway
Uncontrolled crossing	Blackfriars SA						
	Blackfriars U						
	Stratford J			2			
	Stratford M			2			
	Whitechapel A	1	2	6	1	1	1
	Whitechapel J		1	3			
	Sub total	**1**	**3**	**13**	**1**	**1**	**1**
Zebra crossing	Blackfriars SA						
	Blackfriars U						
	Stratford J						
	Stratford M	2	1				
	Whitechapel A		2	2		1	
	Whitechapel J		1	1			
	Sub total	**2**	**4**	**3**	**0**	**1**	**0**

2.3.3 Impact of Belisha beacons on higher level interactions

Belisha beacons were fitted to the Blackfriars SA and Whitechapel J zebra crossings, and these might reasonably be compared with the similar crossings of Blackfriars U and Whitechapel A which did not have Belisha beacons. However caution should be exercised with the findings as the number of higher level interactions was small. Both Blackfriars BSBs had zero higher level interactions both before and after. Whitechapel J had 4 higher level interactions with the uncontrolled crossing, and two with the zebra crossing – therefore a half of the number, whereas the nearby Whitechapel A Bus Stop Bypass saw a reduction from 12 to 5 (less than half). It was not possible to draw statistically significant conclusions on the impact of Belisha beacons on the numbers of higher level interactions.

2.4 Give way behaviour

For each interaction an assessment was made of which party gave way to the other. It should be noted that this does not necessarily mean that cyclists stopped to let pedestrians cross, in many cases cyclists merely slowed down or manoeuvred around pedestrians. Give way behaviour was defined as any variance in action by a cyclist or pedestrian when pedestrians and cyclists met. This could be as subtle as stopping peddling for cyclists, or a slight alteration in path for pedestrians, as well as more obvious stopping or swerving. Not giving way would be to pass the other party as if they were not there. It is important to recognise therefore that this practical definition does not necessarily provide accurate measurements of legal compliance with the zebra crossing, which only requires cyclists to give way once a pedestrian has started to cross. The constrained space and short crossing distance did not make it practicable to restrict observations only to those where the pedestrian has put a foot on the crossing.

Figure 9 shows who gave way, as a number of all interactions (all zones), at the cycle track adjacent to the bus stop island (note that Appendix E indicates these as a proportion). Layered next to this is a split of the lower level (levels 1 and 2), and higher level (levels 3, 4, and 5) with a description of that interaction. A first observation is that there is a wide variation between sites, with giving way increasing at some sites while decreasing at others.

Overall there appears to be a small increase in the proportion of cyclists giving way with the zebra crossing in comparison with the uncontrolled crossing; however a Chi-square test showed that there was no significant difference ($p=0.2$) in the proportion of cyclists giving way across all zones.

The impact of the Belisha beacons fitted to Blackfriars SA and Whitechapel J were also considered, to understand if this increased the propensity of cyclists to give way to pedestrians. The proportion of cyclists giving way at these two sites in both configurations was compared with those of the other sites. Caution should be exercised with the result as absolute numbers are low (see Table 5) and other causal factors may be an influence, however the proportion of cyclists giving way fell from 49% of interactions to 28% of interactions at the two sites with Belisha beacons, and rose from 21% to 32% at the other sites. It is not possible to draw statistically significant conclusions on the impact of Belisha beacons on the proportion of cyclists giving way.

Table 5 Cyclist give way behaviour at Belisha beacons sites

Sites	Phase	Total interactions	Cyclist gave way	Proportion
With Belisha: Blackfriars SA and Whitechapel J	Uncontrolled crossing	51	25	49%
	Zebra crossing	102	29	28%
Without Belisha: Blackfriars U, Stratford J, Stratford M, and Whitechapel A	Uncontrolled crossing	204	43	21%
	Zebra crossing	191	62	32%

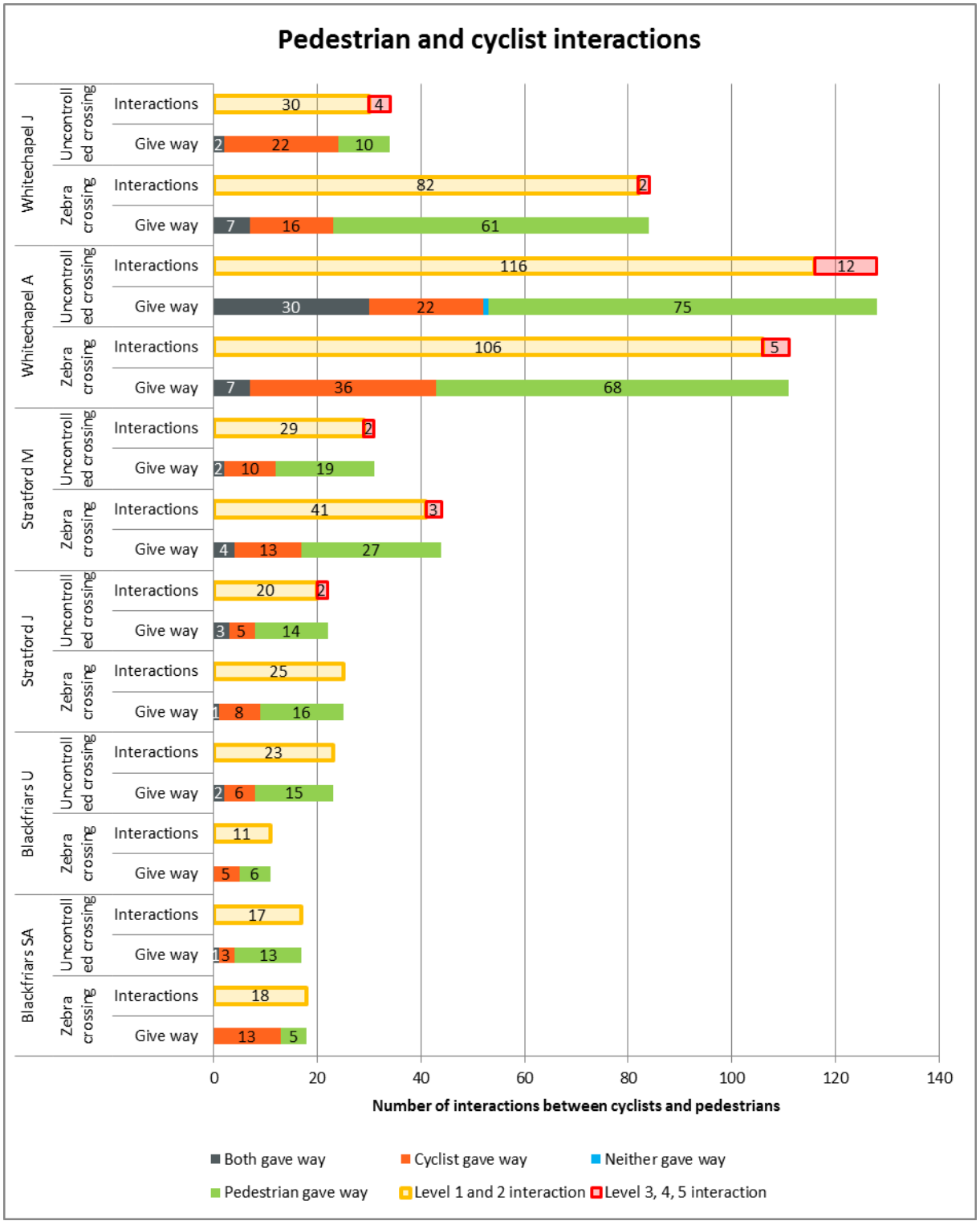


Figure 9 Comparison of give way behaviour of pedestrians and cyclists at each site (for all zones) with the uncontrolled crossing and after the installation of a zebra crossing, and the level of interactions

The results shown in Figure 9 are for all interactions in zones A to E at each site and therefore include both the crossing, where the cyclist would be expected to give way, and the rest of the track, where pedestrians would be expected to give way. Figure 10 provides a breakdown of give way behaviour when looking only at the crossing area (zone C). It was observed that:

- The proportion of cyclists giving way increased slightly from 33% with the uncontrolled crossing to 40% with the zebra crossing;
- The proportion of pedestrians giving way also increased slightly from 45% with the uncontrolled crossing to 53% with the zebra crossing;
- The proportion of interactions where both parties gave way fell from 21% to 7%;

As explained previously, the 38% of cyclists which did give way to pedestrians includes those who may have moderated their speed or swerved to avoid pedestrians, as well as those coming to a halt. It is also important to note that, as explained above, cyclists are not legally required to give way unless the pedestrian has started to cross. However, the measurements for the zebra crossing used the same methodology for give-way behaviour as the uncontrolled crossing to allow for direct cross-compatibility, which does not identify whether the pedestrian has a foot on the crossing.

A Chi-square test was conducted to test whether the observed changes were statistically significant. Analysis showed that there is very strong evidence of a relationship between the presence of a zebra crossing, and how pedestrians or cyclists behaved in terms of giving way to the other group ($p<0.005$).

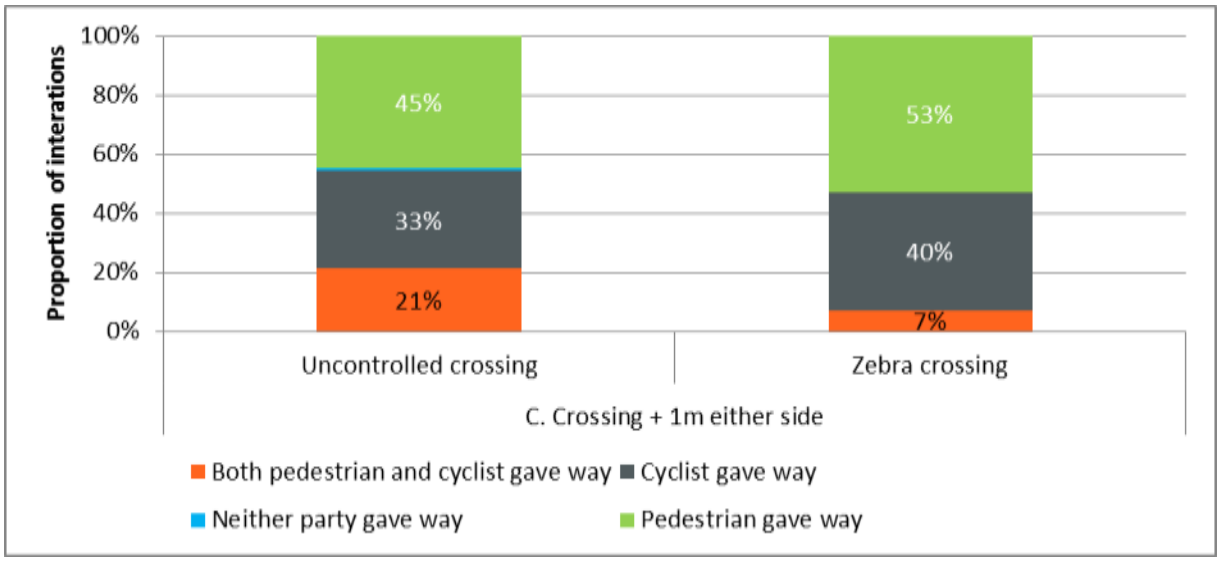


Figure 10 Comparison of give way behaviour at crossings with the uncontrolled crossing and the zebra crossing

Discussion

There are some important differences between zebra crossings at BSBs and zebra crossings found on a normal carriageway which may lead to differences in the behaviour of users of the zebra. These differences include:

- The lack of motor vehicles at the BSB crossing may result in it not being perceived as highway infrastructure and not therefore treated the same.
- The approach speed of motorised vehicles (potentially 30mph) compared to cycles (potentially 15mph).
- The distance from one side of the zebra crossing to the other - around 7.3m for a carriageway, and around 1.5 to 4m for a cycle track - impacting upon the time a pedestrian takes to cross.
- The distance of a motorised vehicle from the kerb, compared to the distance of a cycle from a cycle track kerb, and the impact this has on pedestrian comfort.

Assuming a 1m/s pedestrian speed, and a 30mph vehicle on a 7.3m road, a vehicle could travel 98m in the time a pedestrian takes to cross. This makes it likely in many cases that a vehicle would have to come to a complete stop to allow a pedestrian to cross. In contrast, a 15mph bicycle approaching a BSB zebra crossing will travel only 10m in the time a pedestrian takes to cross a 1.5m cycle track with. From observation, this seems to lead to cyclists being far more flexible in how they give way, potentially slowing and moving around pedestrians rather than stopping.

2.5 Pedestrian activity when an interaction occurred

Whilst cyclist movement is predominately uniform (travelling down the cycle track in the correct direction), pedestrian movements are far more varied, including both crossing movements and travel parallel to the direction of the cycle track. The movements being undertaken by pedestrians when interactions with cyclists occurred were recorded and categorised according to whether crossing (two directions) or walking through the area (on footway or in cycle track), as shown in Figure 11. The following observations were made:

- Most interactions occurred when pedestrians were crossing to or from the bus stop (84.7% uncontrolled crossing, 97.9% zebra crossing);
- Pedestrian interactions with cyclists when pedestrians are travelling to the bus stop from the footway increased with the zebra crossing; and
- Interactions between cyclists and pedestrians on the footway decreased (from 20 to zero). It should be noted that fewer cyclists were seen on the footway with the zebra crossing, however this is likely to be related to site specific factors unrelated to the BSB, such as building works downstream on the Stratford M bus stop footway. This prevented left-turning cyclists from using the raised crossing to enter the footway to allow for an easier turn at the next junction, which had previously been commonly observed.

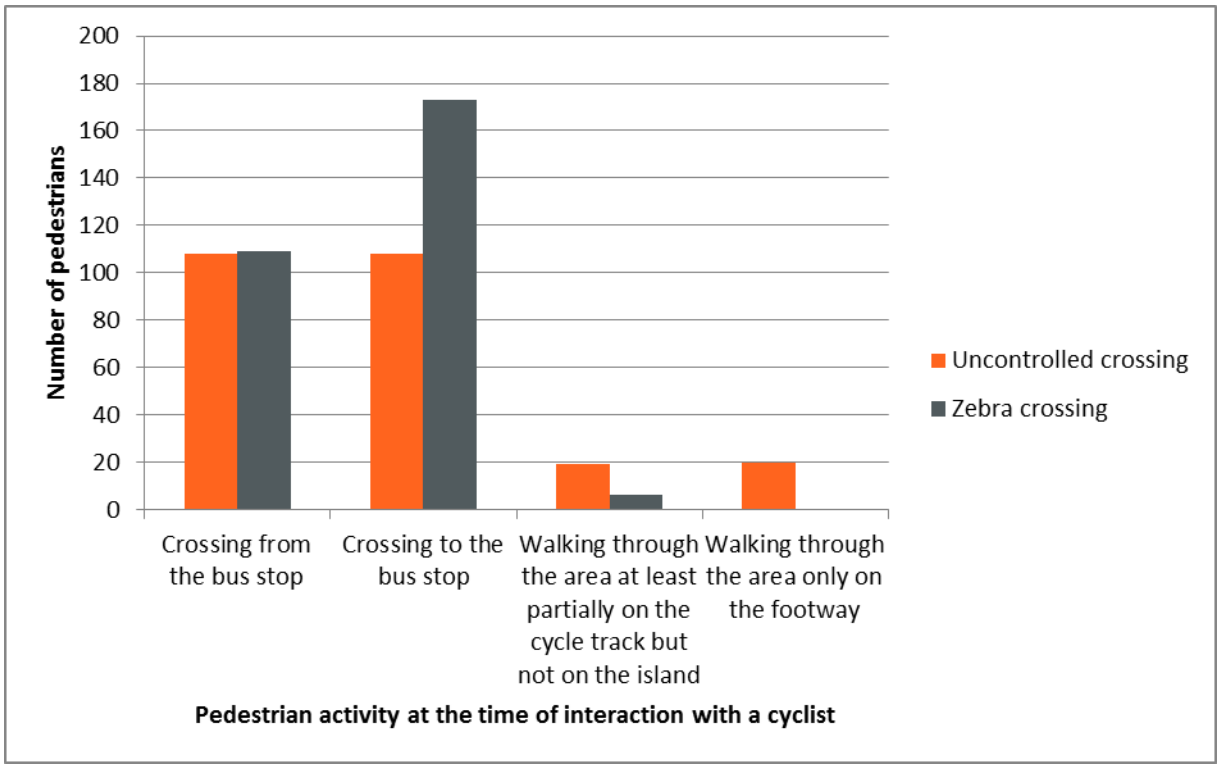


Figure 11 Pedestrian activity when interacting with a cyclist

The increase in interactions on the crossings to the bus stop may be partially explained by an increase in pedestrians using the crossing in this direction, this is discussed in section 3.2 later in this report.

2.6 RQ1 overall findings

No overall changes in the proportion of interaction between cyclists and pedestrians were found between the uncontrolled crossing and zebra crossing samples.

- The large majority (more than 90%) of cyclists pass without interacting with pedestrians at both the uncontrolled crossing and zebra crossing.
- More than 90% of the observed interactions were in the lowest two levels, both for the uncontrolled crossing and zebra crossing.
- Higher level interactions appear to fall at Zone C (the crossing area) between the uncontrolled crossing and zebra crossing samples, however the numbers are too small to comment upon the statistical significance of any change.
- Zone C attracts the highest proportion of pedestrians to cross, which increased following the introduction of the zebra crossing.
- The proportion of interactions in Zone C appears to be lower with the zebra crossing, suggesting a positive benefit of zebra crossings
- The design of the BSB appears to have an influence upon the level and severity of interactions. Whilst conclusive evidence has not been gathered, the findings initially

suggest that less dense spaces with more room for pedestrians and cyclists to both see each other and move appropriately have fewer and less severe interactions.

- The introduction of the zebra crossing led to a small but statistically significant increase in give way behaviour of cyclists at the crossing (Zone C) (noting that the observations made are likely to under-state strict legal compliance, given the methodology which compared directly with the uncontrolled crossing).
- The sample sizes were too small to draw statistically significant conclusions on the impact of Belisha beacons upon the level of higher level interactions or the propensity of cyclists to give way to pedestrians.

3 Research Question 4 – Pedestrian Activity

3.1 Pedestrian movements at the site

This observation measured how much pedestrian activity in the area relates to the BSB and how much was merely coincidental, as some people are in the area to use the bus stop whilst others are simply passing by. This research question explored pedestrian movement in the area, including those who crossed to and from the island, and those moving in other directions in the area. The sample size at each location was 784 (using the first 8 pedestrians from each hour of 7am to 8pm for seven consecutive days), giving a total sample across the six sites of 4,704. Note that those crossing the road via the island were included within the "crossing to or from the bus stop" sample. The results can be seen in Figure 12.

Key findings:

- Overall, more than 70% of pedestrians were just passing through on the footway.
- There is a significant range in the use of the bus stop across the sites, from around 10% of pedestrians at Blackfriars SA (zebra crossing) to over 45% at Stratford M (zebra crossing).
- There was little difference between the uncontrolled crossing and zebra crossing in the site average for the proportion crossing to or from the bus stop; however there was significant local variation, for example with increases in the proportion at Blackfriars SA but a decrease at Blackfriars U – this might suggest changes in use of either the bus stop or the surrounding area.

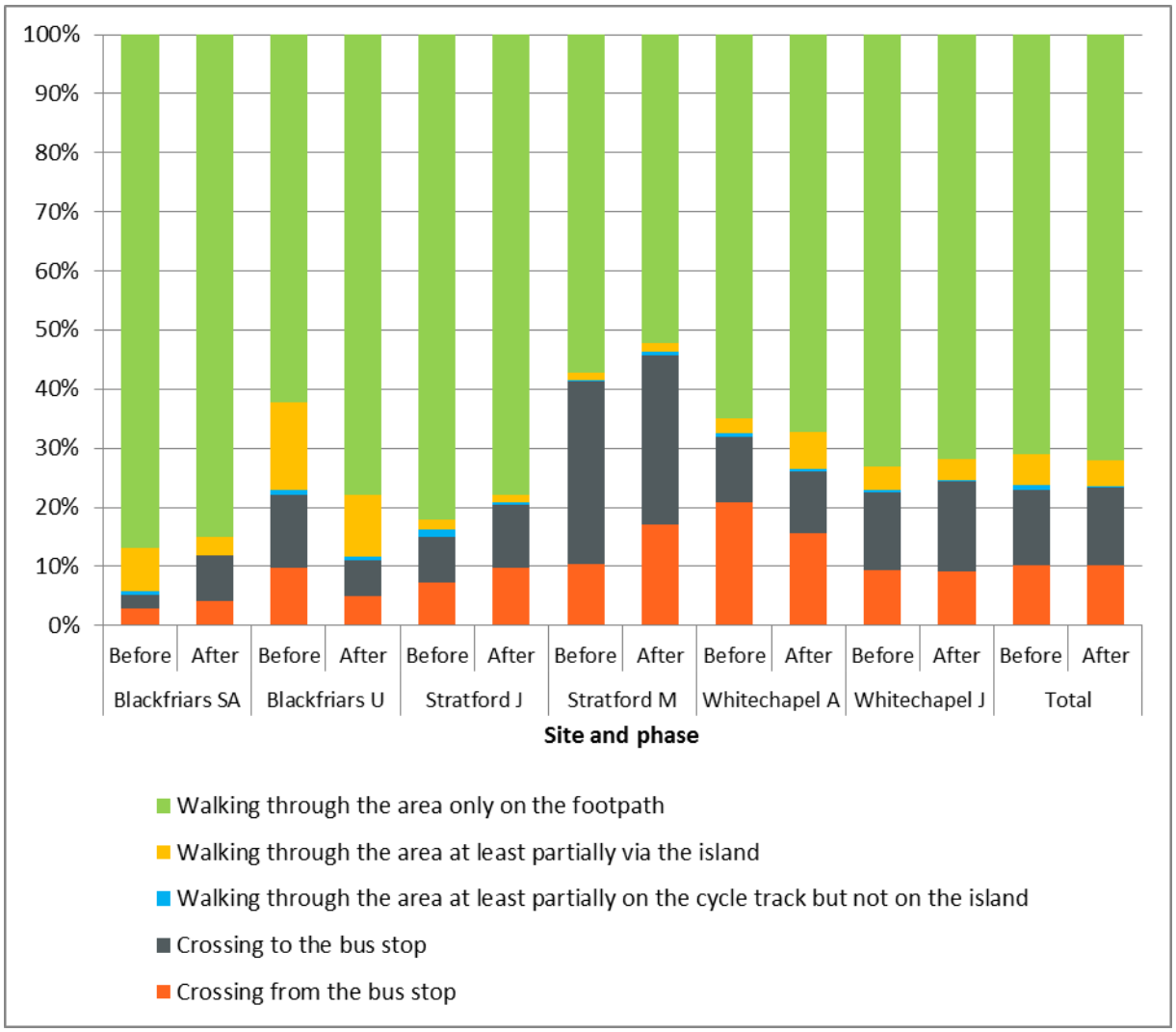


Figure 12 Movement activity of pedestrians observed in the bus stop bypass area (N for each site = 784)

3.2 Crossing zone depending upon direction of travel (to or from bus stop)

The movements of the pedestrians crossing to and from the bus stop were further categorised according to which of the zones A to E they crossed at. This breakdown is shown in Figure 13, combining totals for all the sites. Whilst percentages are shown, in absolute terms both the uncontrolled crossing and zebra crossing measurements were largely similar, with the "crossing from the bus stop" measurement being 476 in both the uncontrolled crossing and zebra crossing measurement, and the "crossing to the bus stop" measurement sample being 607 with the uncontrolled crossing, and 618 with the zebra crossing.

The observations show that, as a total for all sites:

- With the uncontrolled crossing, 32% used the crossing to the bus stop but 48% did so when crossing from the bus stop.
- With the zebra crossing, 40% used the crossing when going to the bus stop but 61% did so when crossing from the bus stop.

Hence, the availability of a zebra crossing had greatest impact on the decision of those alighting from a bus, with a majority choosing to use it.

Chi-square tests showed that the observed changes in pedestrian movement were statistically significant ($p<0.01$). This suggests that post the introduction of the crossing, pedestrians had a greater tendency to cross from zone C.

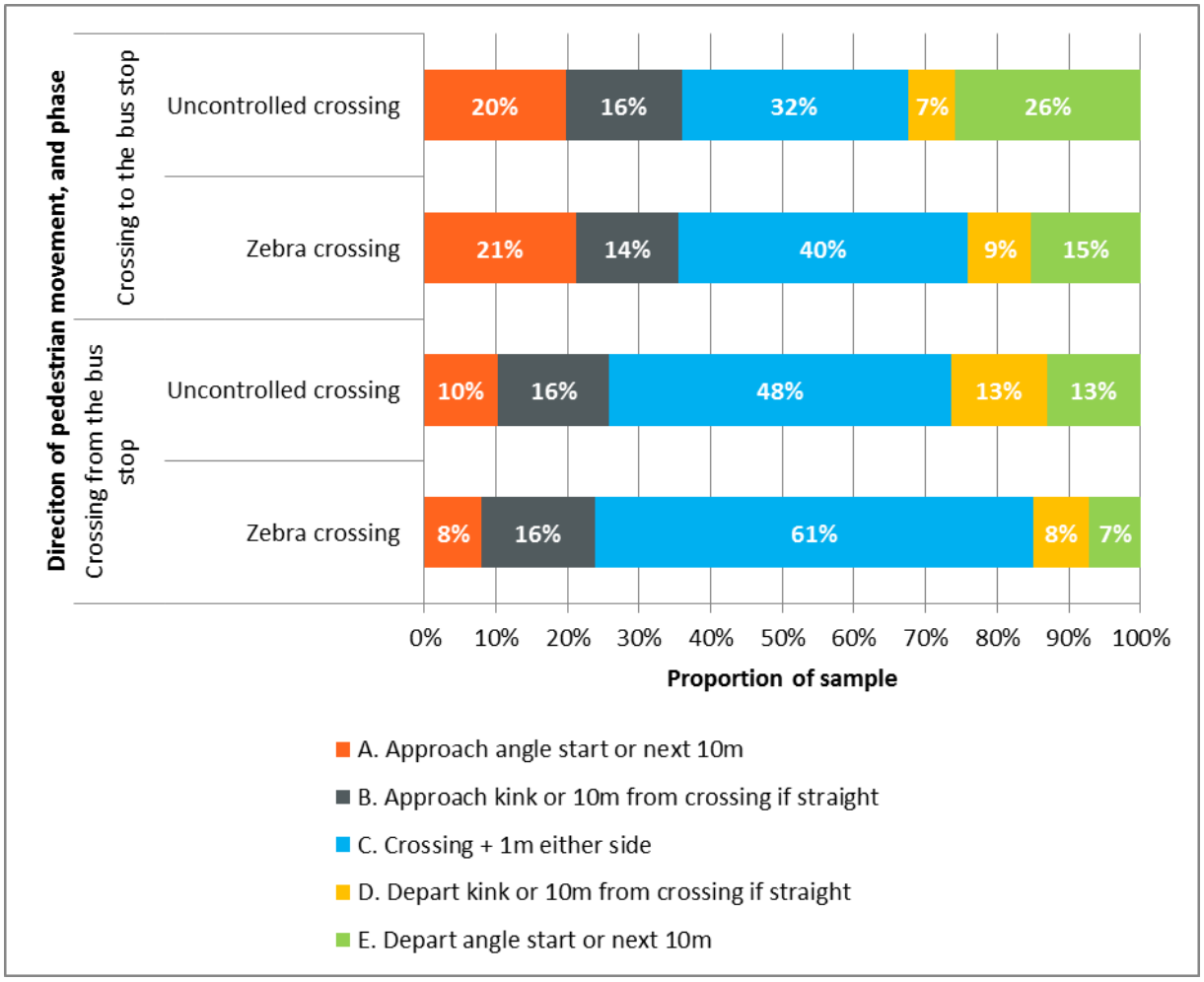


Figure 13 Pedestrian crossing location (all sites)

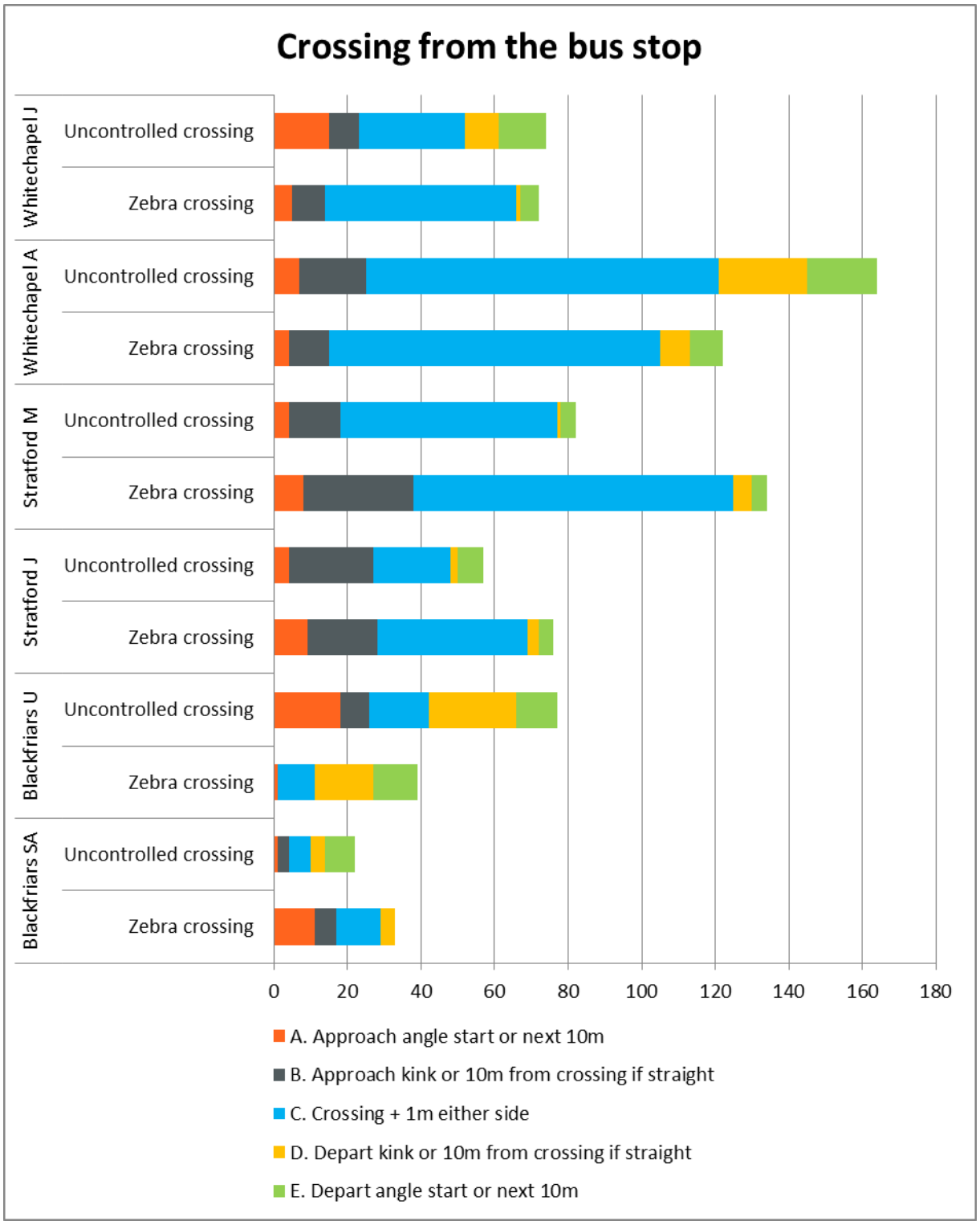


Figure 14 Pedestrians crossing from the bus stop by zone and site

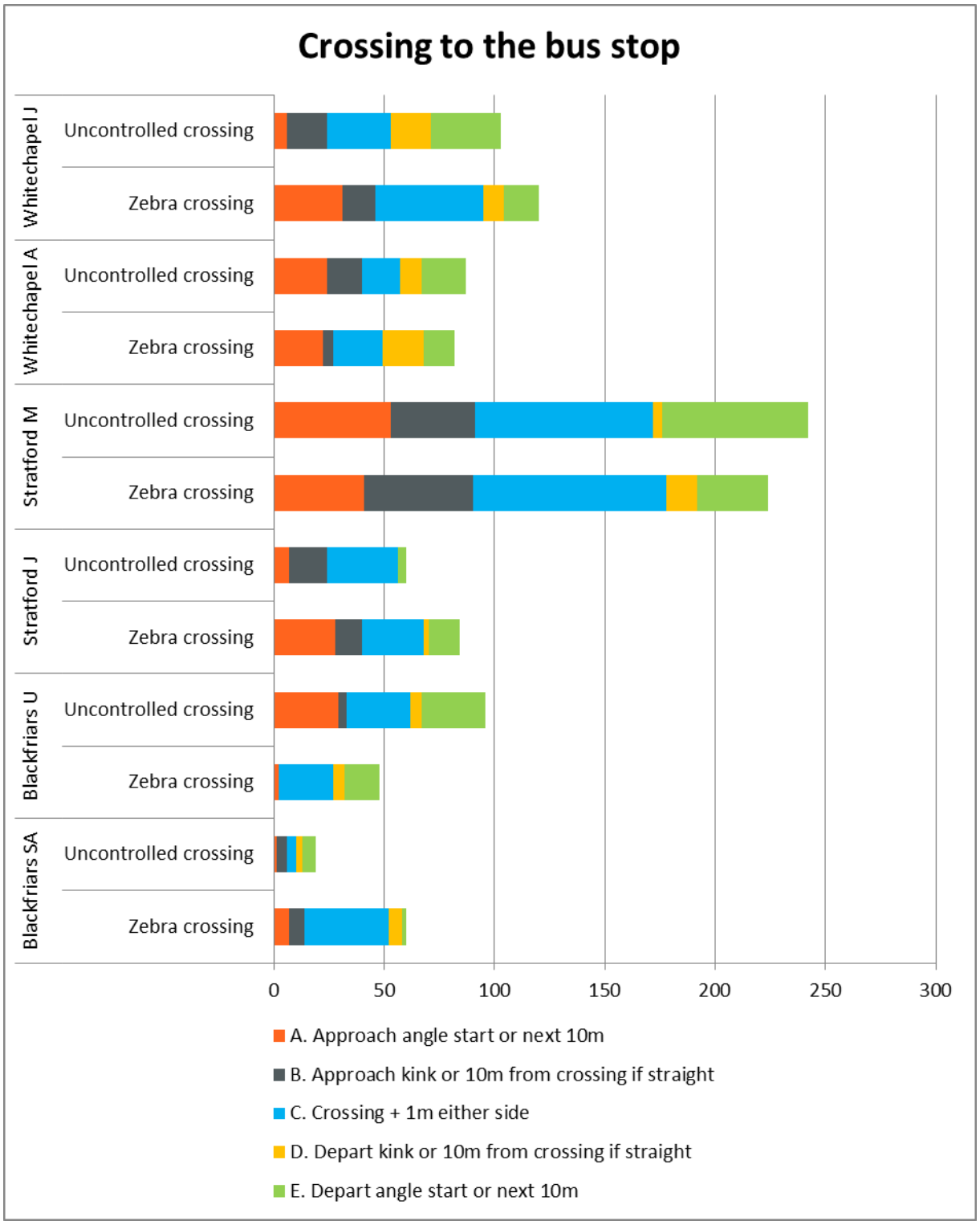


Figure 15 Pedestrians crossing to the bus stop by zone and site

Statistical calculations (Chi-squared) were undertaken to understand if the Belisha beacons fitted to Blackfriars SA and Whitechapel J in the zebra crossing configuration had a positive impact upon the propensity of pedestrians to use it, compared to those which did not. This found a significant difference between the two types of site ($p<0.001$). Sites with Belisha

beacons had a slightly higher proportion of crossing zone use and also had a greater increase in use compared to the uncontrolled configuration. It should be noted that no uncontrolled crossing was fitted with a Belisha beacon. These findings are indicated in Figure 16 (uncontrolled crossings which became zebra crossings with Belisha beacons on the left hand side, and uncontrolled crossings which became zebra crossings without Belisha beacons on the right hand side) and Table 6.

It is important to note that whilst one key difference between the sites was the presence of a Belisha beacon, there may have been other differences between the sites which also caused this significant difference. The result therefore is supportive of the Belisha beacon making a difference, but cannot confirm that the difference between the sites is influenced, or wholly down to the presence of the Belisha beacon.

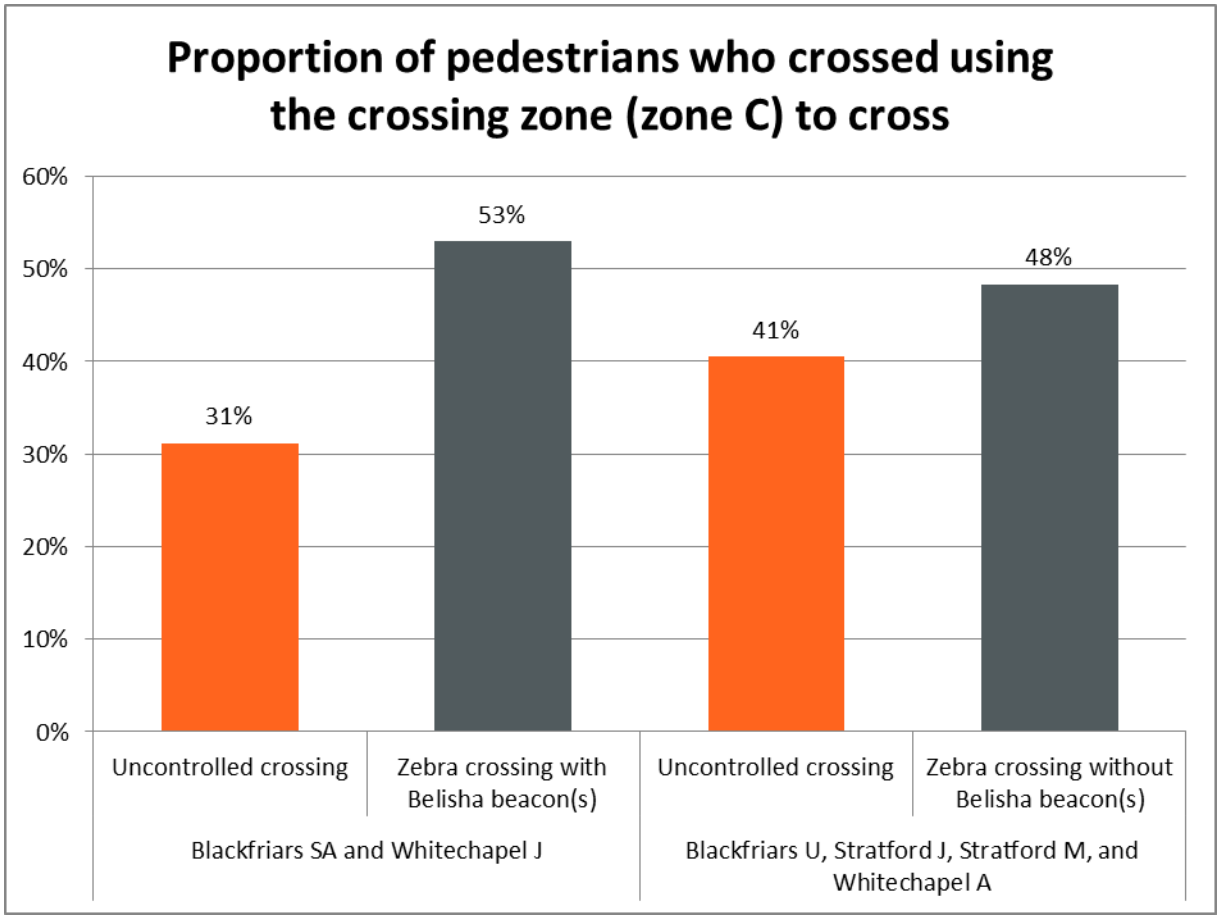


Figure 16 Pedestrian use of the crossing zone with and without Belisha beacons

Table 6 Pedestrian use of the crossing zone with and without Belisha beacons

	Blackfriars SA and Whitechapel J		Blackfriars U, Stratford J, Stratford M, and Whitechapel A	
Crossing type	Uncontrolled crossing	Zebra crossing with Belisha	Uncontrolled crossing	Zebra crossing without Belisha
Pedestrians who used the crossing zone (zone C) to cross	68	151	352	391
Total sample of crossing pedestrians	218	285	868	809
Proportion of pedestrians who crossed using the crossing zone (zone C) to cross	31%	53%	41%	48%

3.3 Gender

The presumed gender of pedestrians in the sample (who may or may not have been using the bus) was noted in order to understand the representativeness of the dataset and to understand any difference in actions between genders. Where the gender could not be reasonably assumed from the video then people were noted as 'unsure' and these individuals are excluded from Figure 17 below. The findings indicate a higher proportion of male pedestrians, however a key point is that it is matched in both the uncontrolled crossing (61%) and zebra crossing (62%) study which suggests that the sample is relatively constant. A Chi-square test showed there was no significant difference ($p=0.34$) in distribution of gender across measurements. This was broadly mirrored across all sites.

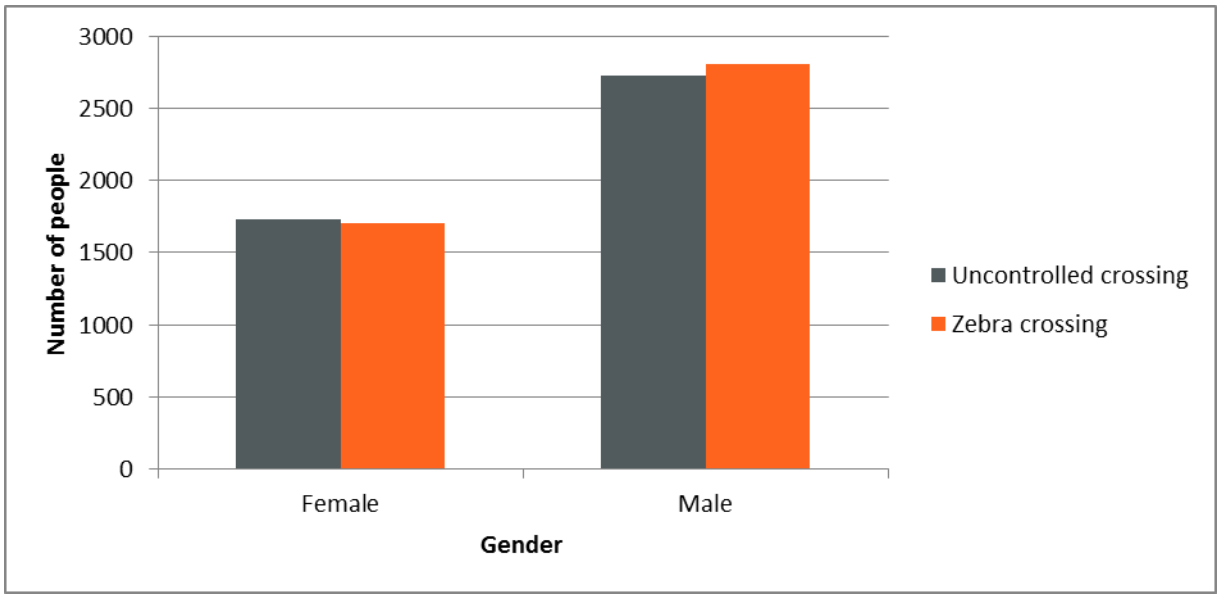


Figure 17 Gender of pedestrian sample

3.3.1 Crossing point by males and females

Overall findings note that whilst the choice of crossing point did increasingly favour the zebra crossing area ("C") in the zebra crossing measurement, there were few differences between male and female crossing area choice in both the uncontrolled crossing and zebra crossing measurements. However, the change was more pronounced in the female population. Note that people defined as 'unsure' are excluded.

A Chi-square test was performed to see if there was a relationship between number of females crossing from each zone, both with the uncontrolled crossing and the zebra crossing. Analysis showed there was a significant difference ($p<0.01$) in the number of females crossing from each zone in both sets of measurements. This analysis was repeated for males and also showed a significant difference ($p<0.01$) in both sets of measurements. This suggests that both males and females had a greater tendency to use zone C after the introduction of the zebra crossing.

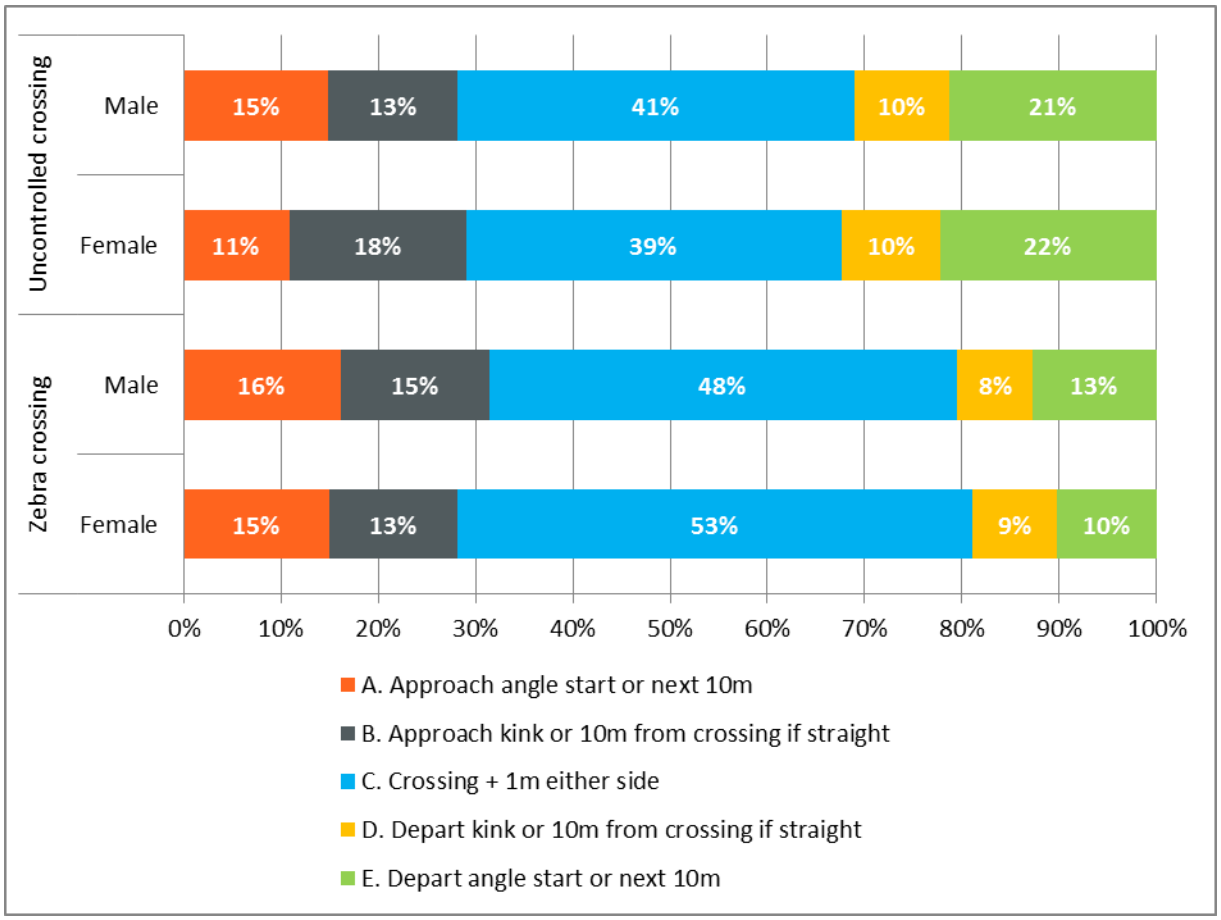


Figure 18 Choice of crossing location by gender

3.4 RQ4 overall findings

- The proportion of pedestrians passing through the general area varies widely depending upon the site.
- The zebra crossing increased the number of pedestrians using the crossing area (Zone C) to cross (regardless of direction of travel across the cycle track), and this was common amongst both males and females.
- Pedestrian gender splits (of all pedestrians) remained static in both sets of measurements, and largely skewed towards males. The reasons for this are unknown but are unlikely to relate to the bus stop location.
- Belisha beacons were fitted to the zebra crossings at Blackfriars SA and Whitechapel J, but not to the other sites. The Belisha beacon(s) appeared to have a statistically significant positive impact upon the propensity of pedestrians to use the crossing area.

4 Research Question 5 – Cyclist activity

4.1 Cyclist route choice

Cyclists are not mandated to use the bypass and may use either the cycle track or main carriageway. Cyclists were also observed to occasionally use the footway, and it should be noted that none of these were legally designated as shared-use. The cyclist's route was noted at the point at which any given cyclist passed the bus shelter. The first 6 cyclists were chosen from each of 14 hours from 7am to 8pm for a one week period, giving a sample size of 588 per site and 3,528 across all six sites, and this was matched in both sets of measurements.

It is important to note that cyclists' decision to choose the road or the cycle track will be influenced by the design of the infrastructure, as it is easier to move from cycle track to road (and vice versa) at some locations than others, depending upon the nature of the segregation. Cyclists may easily change between cycle track and the carriageway just before the bus stop bypass at the Stratford and Whitechapel sites, however this is less easily achieved on Blackfriars Road given the physical layout of the segregation.

Figure 19 indicates the uncontrolled crossing and zebra crossing data at each site. The findings for cyclists' route choice are:

- A large majority, around 90% overall, of cyclists chose to use the cycle track in both sets of measurements;
- Use of the cycle track increased slightly overall (to nearly 93%) in the zebra crossing measurements (from the uncontrolled crossing measurements), with increases at all sites except for Stratford J, where there was a very small and (statistically insignificant ($p=0.3416$) reduction.
- Use of the main footway by cyclists has decreased between the uncontrolled crossing (126) and zebra crossing (89) measurements.
- Use of the roadway decreased at all sites, except for Stratford J (14 to 22) and M (14 to 23) where small increases were observed. The latter may be due to localised building works.

There is a possibility that cyclists and pedestrians observed in the zebra crossing sample have had more time to get used to the BSB and associated cycling infrastructure, so that changes are influenced by greater familiarity. It was not possible to investigate this effect.

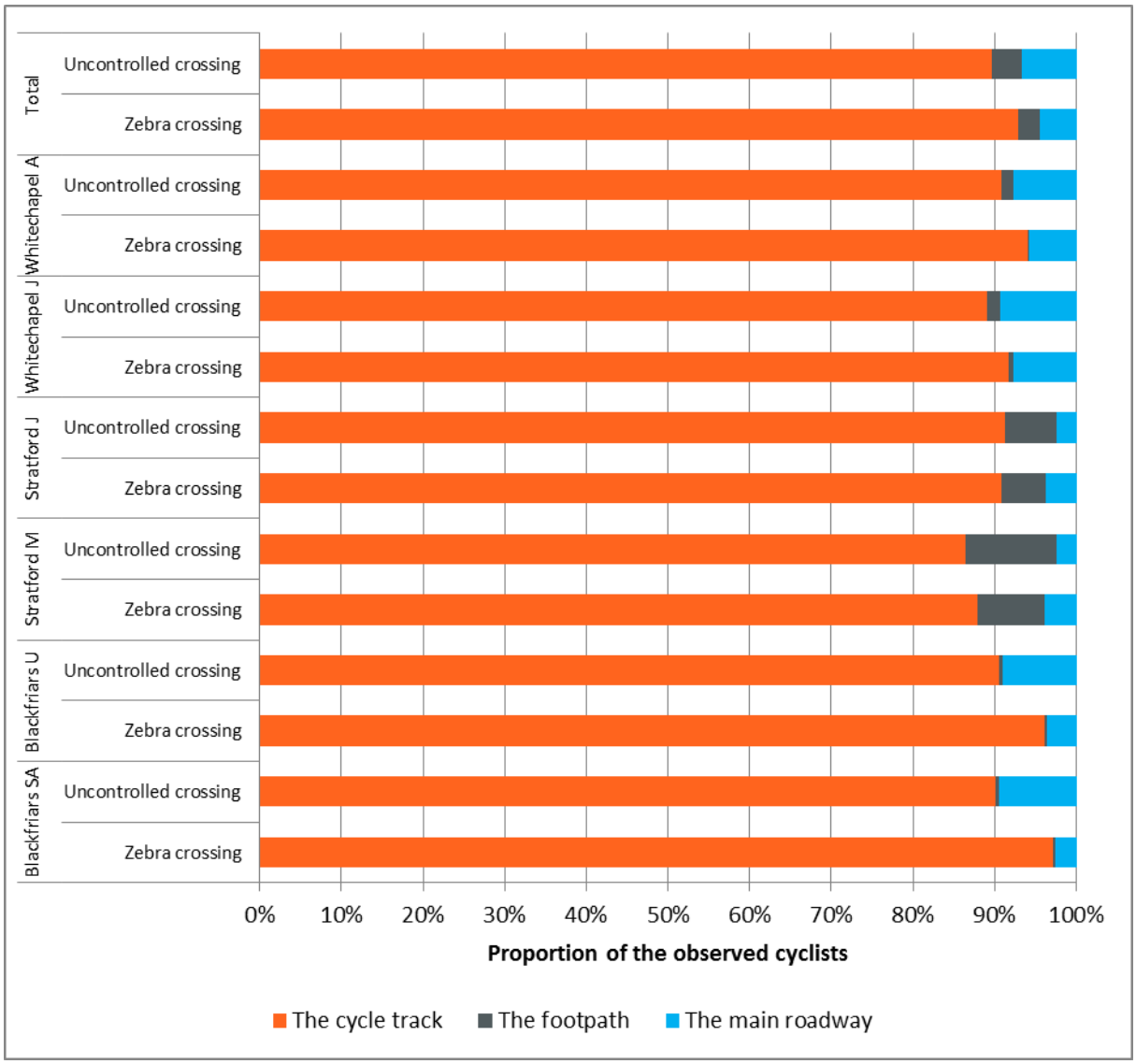


Figure 19 Cyclist route choice (Each site N = 588)

4.2 Direction of cyclist travel

On the two-way cycle track at Blackfriars Road, cyclists had the choice of northbound and southbound directions past both BSBs (see Figure 20 and Figure 21). As can be seen, there was a relatively large proportion of southbound cyclists using the carriageway in the uncontrolled crossing measurements (16.8% in total), which may relate to the southbound cycle track being placed upon the opposite site of the road. This reduced in the zebra crossing measurements (to 6.2%) of southbound cyclists. Use of the footway remained very low (uncontrolled crossing = 5, zebra crossing = 4 cyclists).

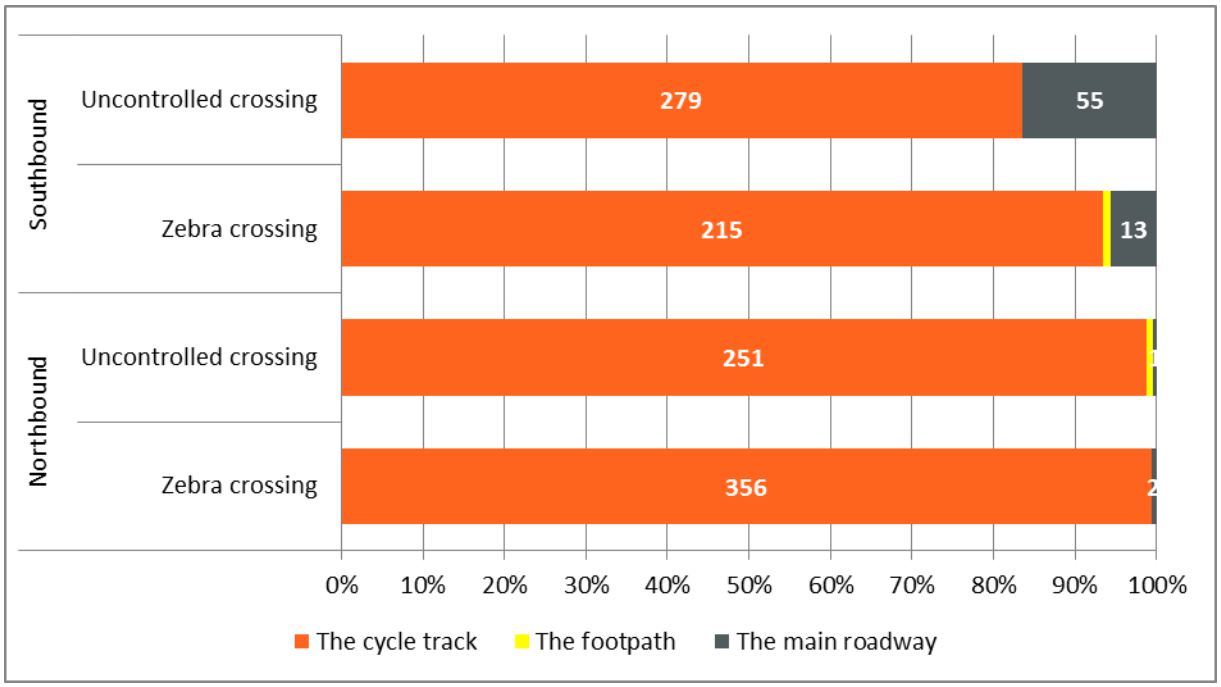


Figure 20 Blackfriars Road Bus Stop SA cycle track cyclists' route choice by direction of travel

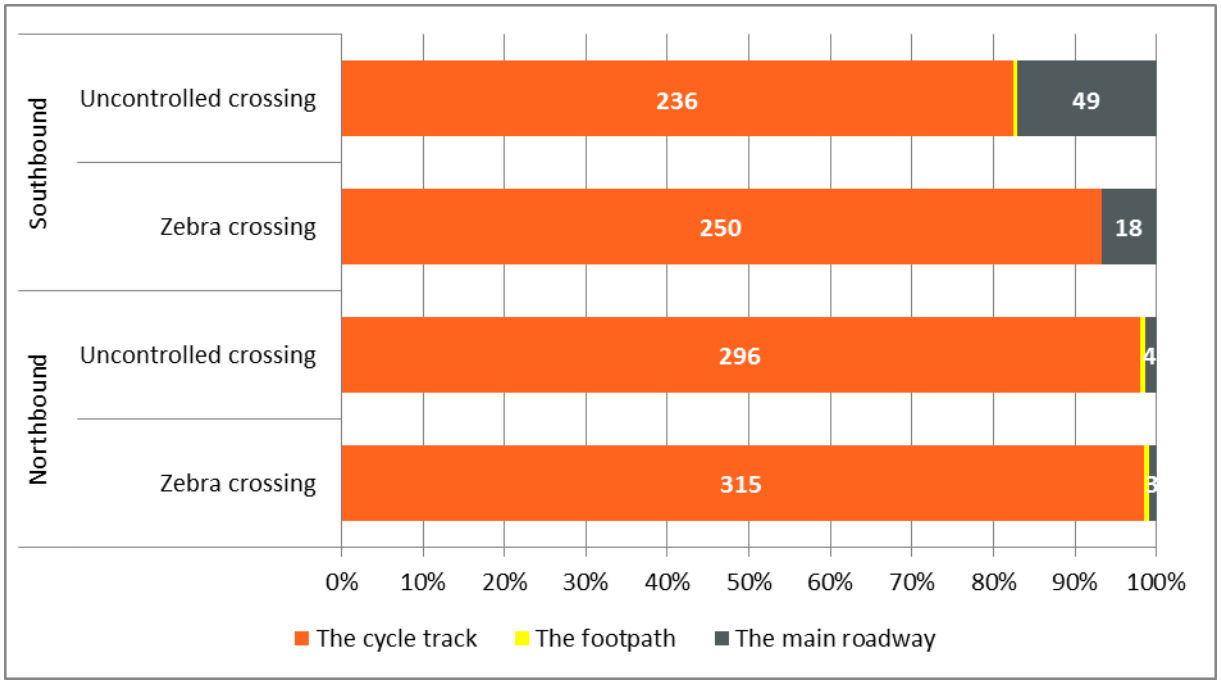


Figure 21 Blackfriars Road Bus Stop U cycle track cyclists' route choice by direction of travel

At other sites, cycle tracks were in one direction and there were small numbers of cyclists observed to either use the footway or travel in the incorrect direction.

4.3 Influence of the presence of buses at the bus stop on cyclist route choice

The presence of a bus at the bus stop was recorded when cyclists passed the bus shelter, to understand any influence of the buses presence on cyclist route choice (Table 7). The sample in each phase was 3,528 cyclists, which was repeated in the zebra crossing scenario. Initial findings do not suggest any difference in cyclist choice whether a bus is present or not. A statistical test shows the proportion of cyclists using the cycle track does not change significantly between the uncontrolled crossing and zebra crossing measurements (p=0.4). It is unclear if this is because cyclists are ambivalent to bus presence, and a potential hypothesis is that it reflects cyclists' desire to not change their route choice, or because of the lack of ability at some sites to change route easily.

Table 7 Cyclist route choice depending upon bus presence

Cyclist route	Phase	Number of buses at the bus stop	Yes, at least one or more buses at the bus stop
The cycle track	Uncontrolled crossing	89.8%	89.3%
	Zebra crossing	92.8%	93.4%
The footway	Uncontrolled crossing	3.3%	4.7%
	Zebra crossing	2.4%	2.9%
The main roadway	Uncontrolled crossing	6.9%	6.0%
	Zebra crossing	4.7%	3.7%

4.4 Influence of the track being busy on cyclist behaviour

Measurements were taken to understand how busy the cycle tracks were, and whether this had an influence upon cyclists' route choice. Route choices were compared according to whether cycle flows were 'congested', defined as there being a cyclist less than 4.5 seconds ahead of the cyclist being measured on 1-way cycle tracks, and 3.6 seconds on 2-way cycle tracks (which, being wider, provide more opportunities for overtaking). The research questions within the appendixes hold further detail on the derivation of this measure.

Table 8 shows the route choices, both for the uncontrolled and zebra crossing configurations, for the 1-way sites, and Table 9 for the 2-way sites.

Table 8 Cyclist route choice depending upon cycle congestion at 1-way sites

	Uncontrolled crossing		Zebra crossing	
	Not congested	Congested	Not congested	Congested
The cycle track	89.0%	91.2%	91.1%	91.0%
The footway	5.5%	3.7%	3.7%	3.1%
The main roadway	5.5%	5.1%	5.2%	5.9%
Sample size	1944	408	1961	391

Table 9 Cyclist route choice depending upon cycle congestion at 2-way sites

	Uncontrolled crossing		Zebra crossing	
	Not congested	Congested	Not congested	Congested
The cycle track	88.34%	95.60%	95.75%	97.68%
The footway	0.58%	0.00%	0.30%	0.39%
The main roadway	11.07%	4.40%	3.95%	1.93%
Sample size	858	318	659	517

A Chi-square test was conducted to test the proportion of cyclists using the cycle track or other (footway or main roadway) under congested conditions at 1-way sites, in both the uncontrolled crossing and zebra crossing measurements. Analysis showed there were no significant differences ($p=0.9$) in the distribution of cyclist route choice under congested conditions. Similar analysis for 2-way sites showed no significant differences ($p=0.1$) in cyclist route choice between the uncontrolled crossing or zebra crossing under congested conditions.

Key findings:

- 'Congested' conditions on 1-way cycle tracks affected 17.0% of uncontrolled crossing observations and 16.6% of zebra crossing observations; for 2-way tracks it was 27.0% for uncontrolled crossing and 44.0% for the zebra crossings. Statistical tests comparing the distribution of cyclists at the uncontrolled crossings and zebra crossings, depending on congested conditions, showed this change was not significant for 1-way tracks ($p=0.5$), but was significant for 2-way tracks ($p<0.01$).

4.5 RQ5 overall findings

- The vast majority (around 90%) of cyclists under all conditions chose to use the cycle track compared to using the carriageway or footway.

- Use of the cycle track rose slightly (p-value <0.01) with the introduction of the zebra crossing. This suggests that the crossing has not discouraged cyclists from using the cycle track.
- The Blackfriars Road (two-way cycle track) saw usage of the cycle track increase between the uncontrolled crossing and zebra crossing measurements (from 90% to 97% of cyclists), which may be an outcome of separate route changes rather than the introduction of the zebra crossing.
- A small number of cyclists continue to use the footway or travel in the wrong direction on the cycle track.
- The presence of a bus at the bus stop did not appear to have any influence upon cyclist route choice, which may be a function of site layout in some cases, i.e. it would make changing between the cycle track and carriageway an unattractive option.
- A cyclist faced with cyclists in front of them (within 4.5 seconds on a 1-way track, and 3.6 seconds on a 2-way track) 'congesting' the track will not alter their route choice.

5 Research Question 6 – Cyclist speed

Research Question 6 relates to cyclist speed through the BSB cycle track. This was measured using video recordings by recording the times at which cyclists passed fixed points separated by a known distance, generally 20m, on the approach to the crossing area. A sample of the first three cyclists from each hour between 7am and 8pm for 7 days travelling along the cycle track was taken, giving 294 cyclists per site and 1764 in total in each of the uncontrolled crossing and zebra crossing measurements. The sample was achieved and was identical for each site.

5.1 Average speed

The average speeds for each site, and the overall average, are shown in Figure 22. Key findings were:

- There were noticeable variances between sites in the uncontrolled crossing measurements, with cyclists at the Blackfriars Stop U site being on average 4.24mph faster than the Whitechapel Stop J site.
- Comparing uncontrolled crossings and zebra crossings, there is wide variation between sites with small reductions in speed at three sites and small increases at the other three.
- The average speed fell slightly overall between uncontrolled crossings and zebra crossings, from 14.4 to 14.3mph, although a t-test showed that there were no significant differences in average speed (p=0.567) between the two phases.

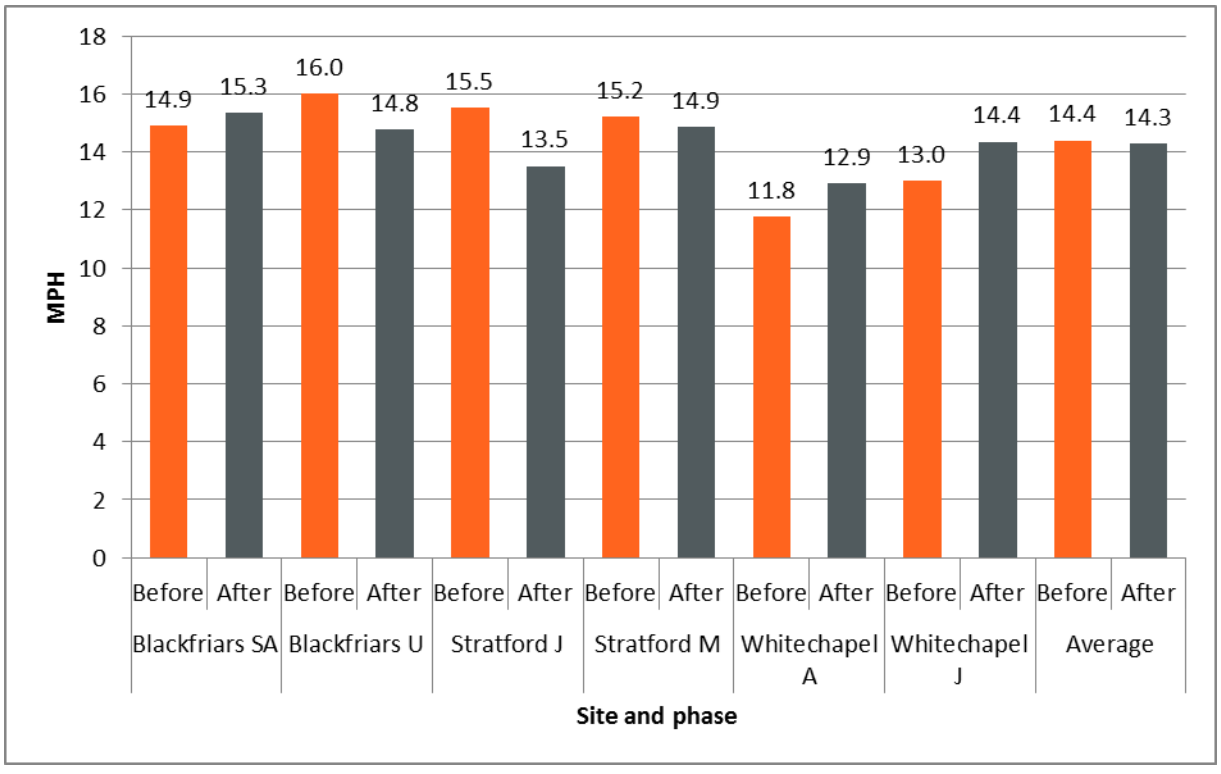


Figure 22 Average speed of cyclists per site and crossing type

Noticeable differences between the sites which might explain these differences relate to the design (Blackfriars Road is wide and straight with little furniture, whereas Whitechapel has bends and more street furniture), and to the number of pedestrians present (with Blackfriars Road appearing relatively quiet, and Whitechapel appearing busier).

A two-way Analysis of Variance (ANOVA) was conducted to explore differences in the average speed of cyclists between sites and in uncontrolled crossing/zebra crossing configurations. Analysis showed a statistically significant difference between sites ($p<0.001$) and a significant interaction of phase (i.e. the introduction of a zebra crossing) and site on the average speed ($p<0.01$); however phase as a main effect was not significant ($p=0.38$). Post-hoc comparisons showed that average speeds at Whitechapel A and Whitechapel J were lower than the other sites.

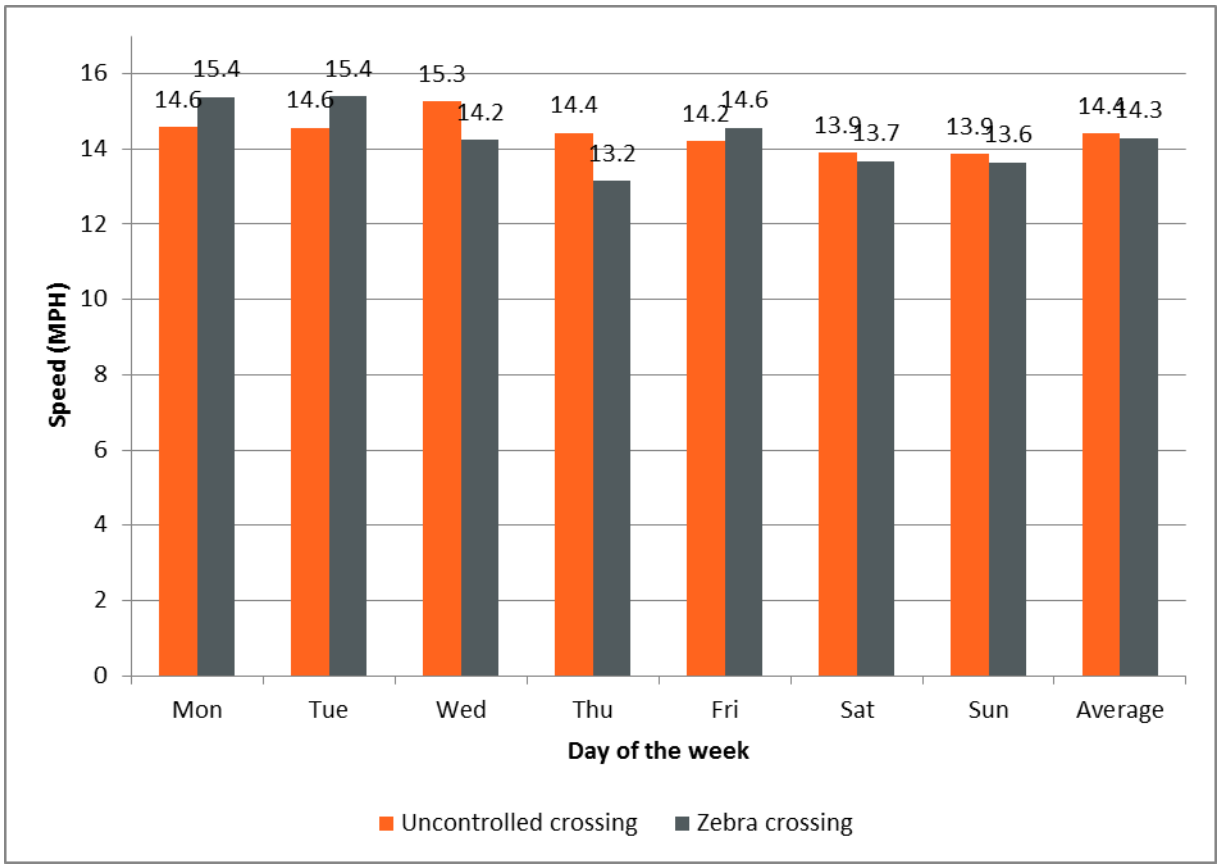


Figure 23 Average speed of cyclists by day of the week

There were also slight differences across days (see Figure 23), with the average speed of cyclists on weekends being marginally slower than weekdays. A two-way ANOVA was conducted to test changes in average speeds between phase and day of the week. Analysis showed significant differences in average speeds across days ($p<0.01$) and the interaction between phase and day was significant ($p<0.01$); however phase as a main effect was not significant ($p=0.44$). Post-hoc comparisons showed average speeds were mainly different on weekends compared to weekdays. Wednesday and Thursday in the zebra crossing measurements have slightly lower speeds and this may be due to the inclement weather that was recorded on those days.

5.2 Variance in observed cyclist speeds

The observed cyclist speeds largely follow a traditional bell curve in both the measurements as can be seen in Figure 24, which shows the number of cyclists seen at each 1mph speed band. The distribution of speeds in each measurement is largely similar between uncontrolled crossings and zebra crossings, suggesting the introduction of the zebra crossing has had little impact upon the general profile of cyclist speed.

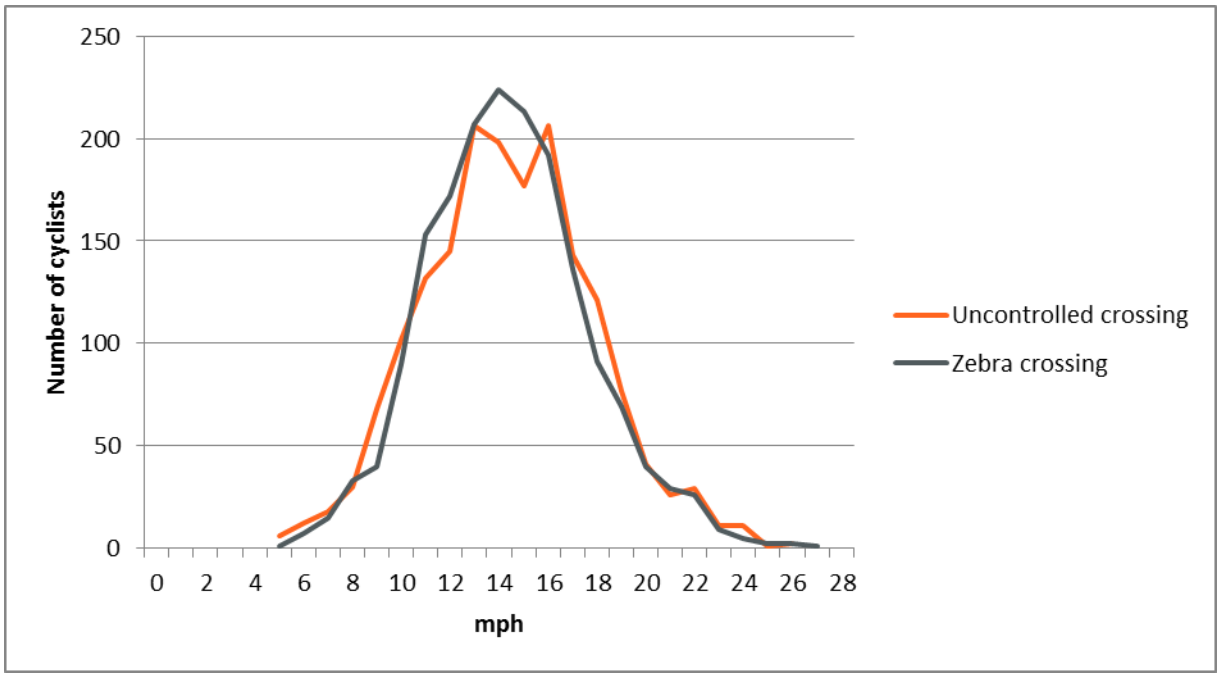


Figure 24 Observed cyclist speeds

5.3 Speeds at different times of day

There are slight differences between the speed of cyclists during peak commuting hours, and those outside of these times. Figure 25 indicates the average for both the uncontrolled crossing and zebra crossing measurements, which are similar. A two-way ANOVA was conducted to test changes in average speeds between construction phase and time of day. Analysis showed that average speed was significantly different across time of the day ($p<0.01$); however, phase (i.e. the installation of a zebra crossing) was not significant ($p=0.56$) and the interaction of phase and time was not significant ($p=0.58$). Post-hoc comparisons showed average speeds were higher during early hours (7am-9am) and peak time (6pm) compared to the rest of the day.

Figure 25 Speeds at different time of day

5.4 Cyclist demographics

The demographics of cyclists were taken from video with researchers estimating gender based upon their presentation. Due to the low light-level in some cases (in the zebra crossing measurements) the apportionment may not be entirely accurate. The results indicate a predominately male sample (Figure 26). The London Travel Demand Survey for 2013/14[1] indicated that around a 74% of cycle trips in London were undertaken by males, which broadly matches the sample seen at the bus stop bypasses.

[1] See male and female trips in "Trips" worksheet in MS Excel file "LTDS workbook 2014" at https://tfl.gov.uk/corporate/publications-and-reports/london-travel-demand-survey

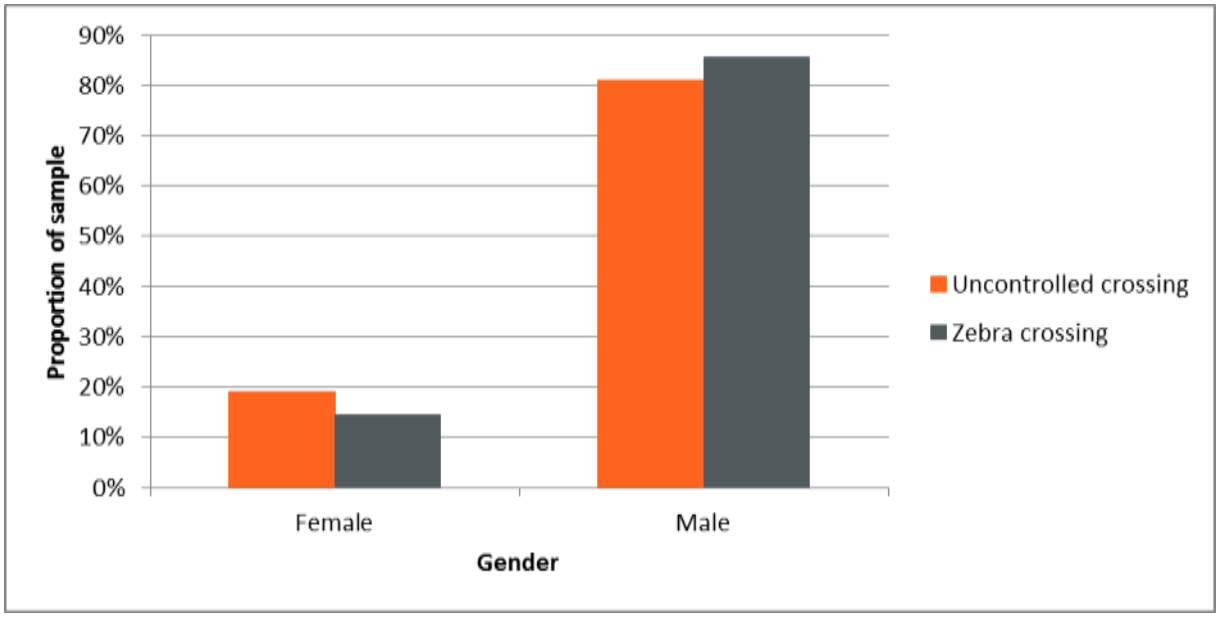


Figure 26 Estimated cyclist gender

Note that male cyclists were observed to be around 1-1.5mph faster on average than female cyclists (see Figure 27). A two-way ANOVA was conducted to test for changes in average speed between the phase (uncontrolled crossing and zebra crossing), and gender. Analysis showed that average speeds were significantly different between gender ($p<0.01$) i.e. male cyclists travel faster than female cyclists at these locations; however, phase and the interaction of phase and gender was not significant ($p=0.13$ and $p=0.30$, respectively) i.e. there were no real differences between the uncontrolled crossing or zebra crossing for either gender.

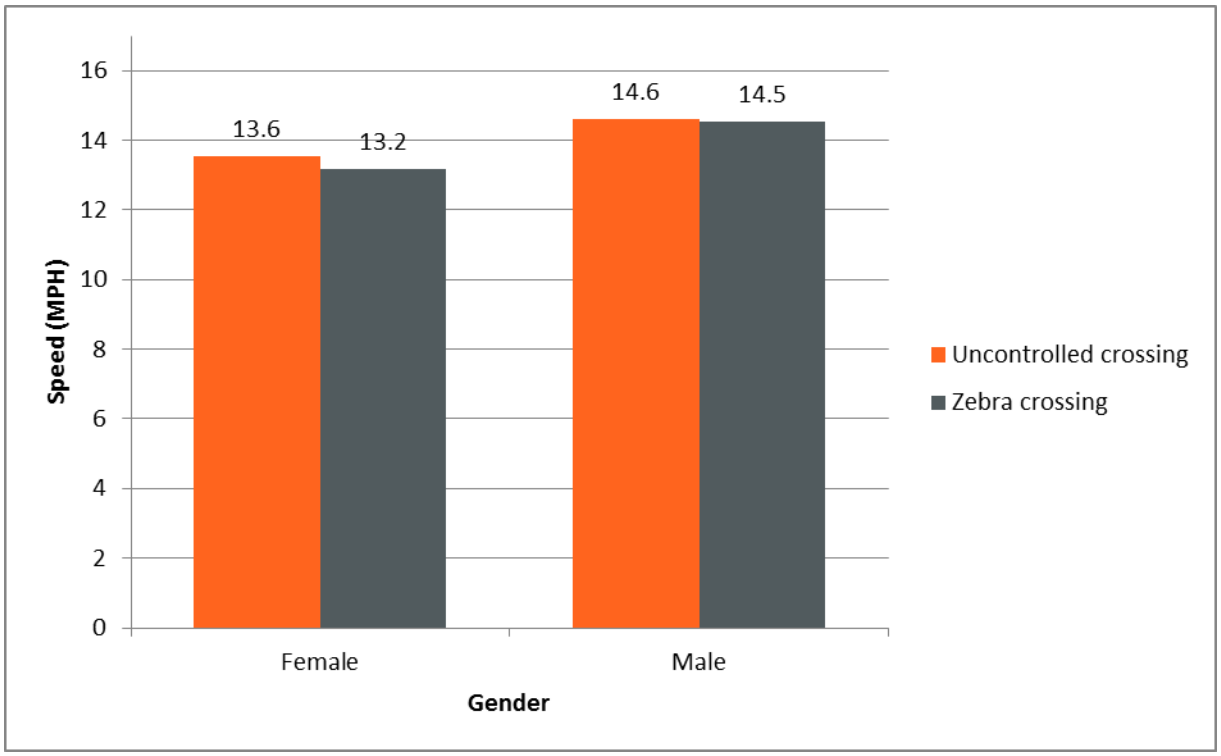


Figure 27 Cyclist speed by gender

5.5 RQ6 overall findings

- There were notable variances in cyclist speed across sites, with wider sites such as those on Blackfriars Road being faster than narrower more constrained sites such as Whitechapel.
- The introduction of the zebra crossing appears to have had no statistically significant impact upon average cyclist speed, or the distribution of speeds.
- Slightly faster cyclist speeds are correlated with typical commuting times of day.
- Cyclist gender is, in both the uncontrolled crossing and zebra crossing measurements, predominately male, with male cyclists being around 1-1.5mph faster than female cyclists.

Appendix A Research sites

Six bus stop bypass sites across London were chosen. These tended to be in pairs, in Stratford, Whitechapel, and Southwark (Blackfriars Road). The locations are shown in Table 10 and a site map is shown in Figure 28.

Table 10 Research site locations

Bus stop bypass	Coordinates	Description
Whitechapel Road – The East London Mosque – Stop J (EB)	51.518147,-0.064435	1-way track / busy location. Relatively simple to leave these tracks within a short distance before or after the bus stop bypass.
Whitechapel High Street A (WB)	51.518892, -0.060489	
Stratford High Street – Carpenters Road – Stop J (WB)	51.537343, -0.002644	
Stratford High Street – Warton Road – Stop M (EB)	51.534694, -0.006436	
Blackfriars Road – Stop SA (post office)	51.504720, -0.104647	2-way track / busy location. Cyclists commit themselves to the cycle track some distance before the bus stop bypass.
Blackfriars Road – St. George's Circus – Stop U	51.499997, -0.104808	

Figure 28 Site map

Appendix B Bus Stop Bypass study sites in uncontrolled crossing and zebra crossing configuration

The photographs below indicate (from video cameras) the uncontrolled crossing and zebra crossing configurations at each of the six BSB study sites.

Whitechapel J uncontrolled crossing

Whitechapel J zebra crossing

Whitechapel A uncontrolled crossing

Whitechapel A zebra crossing

Stratford J uncontrolled crossing

Stratford J zebra crossing

Stratford M uncontrolled crossing 	Stratford M zebra crossing 
Blackfriars Road SA uncontrolled crossing 	Blackfriars Road SA zebra crossing 
Blackfriars Road U uncontrolled crossing 	Blackfriars Road U zebra crossing 

Appendix C Research Questions

Note that this report only addresses research questions where the data source is video. Please see separate reports for surveys and accompanied visits.

Facility type/Workstream	ID	Research Question	Contextual issues to consider or 'observation only' issues	Data source	Methodology	Sample	Expected outcome
Bus Stop Bypass	RQ1	How many and what type of interactions (using the same definition of interaction as the off-road trials) take place between cyclists and pedestrians. What is the breakdown of interactions by 'zone' (relative to the crossing location)? Who gives way to whom (using a simple checkbox of pedestrian, cyclist, both, or neither) What is the breakdown of interactions by pedestrians: - crossing to the bus stop? - crossing from the bus? - walking through the bus stop area on the footway? - walking through the bus stop area on the track? - walking through the bus stop area on the island? * Using same definition of interaction types as off-street monitoring. This should include allowing us to identify who slows, stops and/or gives way.	Footway width, height difference between the crossing area and the rest of the track, contrast between materials/colour of footway and track, amount of frontage activity	Video	This will use the same cameras as RQ4. It is likely that cyclists will be less frequent than pedestrians, so should be based upon cyclists.	Use first 6 cyclists seen using the cycle track from each start of 14 hours each day (7am start), giving a sample of 588.	An understanding of the level of interactions between cyclists and pedestrians, and where this occurred, and what might have influenced this in terms of the local habitat.

Facility type/Workstream	ID	Research Question	Contextual issues to consider or 'observation only' issues	Data source	Methodology	Sample	Expected outcome
Bus Stop Bypass	RQ2	Compared to their usual experience of using bus stops, does the bus stop and cycle track crossing arrangement change the ability of visually and mobility impaired people to: - find the bus stop? - board the bus? - alight from the bus? For each of the three actions, how safe and comfortable do they feel, what difficulties arose, and what would help to overcome these difficulties? Note tactile tail on zebra	Presence or otherwise of Belisha beacon is important. Suggest having at least two sites with Belisha once the zebra crossing is added (subject to agreement with BSB working group).	Accompanied walks and discussion	Need to brief pre-arranged mobility and visually impaired street users on the bus stop bypass, then accompany them to it (followed by questions), allow them to board the bus and travel to the next stop (followed by questions), get on the opposite direction to the bus stop before the BSB, then return and exit at the BSB, then have a semi-structured interview which explores their views.	36 people over 32 sessions, with 18 Blind and partially sighted, 6 Mobility Impaired, 6 Deaf or hard of hearing, and 6 people with Learning difficulties. See table below for a split of this.	An understanding of the view of mobility and visually impaired street users towards these facilities, both with and without the Zebra.
Bus Stop Bypass	RQ3	For a) cyclists and b) pedestrians (whether or not they are accessing a bus) passing through the bus stop area: - how safe and comfortable do they feel? - how easy is it to use / pass through? - did they notice the crossing? - would they prefer an uncontrolled or zebra crossing? Compare details with CS2x questionnaire – to be provided by Katherine Blair		Questionnaire/survey	Will stop pedestrians and cyclists at the site and use pictures on a clipboard to ask limited questions.	Survey a minimum of 80 pedestrians (40 using the bus, and 40 passing along through the area) and 40 cyclists at each site.	An understanding of the views of pedestrians and cyclists towards the bus stop bypass.
Bus Stop Bypass	RQ4	How many pedestrians are: - crossing to the bus stop? - crossing from the bus? - walking through the bus stop area on the footway? - walking through the bus stop area on the track? - walking through the bus stop area on the island? For those crossing, how many cross in each 'zone' (relative to the crossing location)? This zone will be in 5 parts (as per the off-road trials). For 'angled' cycle paths, the zones will be the crossing plus 1 metre, the area up to the first kink, and then the angled zone. For 'straight' cycle paths will be the crossing plus 1 metre, and each zone will be 10 metres.	Any sampled pedestrians seen to trip on the kerbs will be recorded.	Video	Cameras will be set up to view the various zones. This will be viewed back at the office and a count made.	Use first 8 pedestrians seen from each start of 14 hours each day (7am start), giving a sample of 784.	An understanding of the proportion of pedestrian activity in the bus stop area.

Facility type/Workstream	ID	Research Question	Contextual issues to consider or 'observation only' issues	Data source	Methodology	Sample	Expected outcome
Bus Stop Bypass	RQ5	Through the bus stop area, how many cyclists were observed using: - the cycle track - the main carriageway - the footway What is the breakdown of the above between: - times when the stop was occupied by at least one bus - times when the stop was clear of buses	What difference does the type of cycle infrastructure on the approach and exit make, i.e. how easy it is to get on and off the track? i.e. Whether the cycle track was segregated significantly before the island? Were significant differences in cyclist behaviour observed during times when the cycle flow was high?	Video	Point cameras at the vicinity and observe and record what is occurring. Note a single-direction cycle track will be assumed busy if there is another cyclist less than 4.5 seconds ahead (based on 800 cyclists per hour being 'busy'). A two-direction cycle track will be assumed busy if there is another cyclist less than 3.6 seconds ahead (based on 1000 cyclists per hour being 'busy').	Use first 6 cyclists seen from each start of 14 hours each day (7am start), giving a sample of 588.	An understanding of the propensity of cyclists to use the various options available to them when buses are and are not at the stop.
Bus Stop Bypass	RQ6	What is the speed of cyclists on the approach* to the crossing-point? (e.g. what proportion are: below 10mph, 10-15mph, above 15mph?) Compare with speed question from off-street trials *approach to cover 20m distance ending at the start of the crossing (or any lowered kerb for crossing).	Note any contextual factors that appear to encourage cyclists to slow.	Video	Mark distances on video screen using acetates, measure the speeds of each cyclist between known points as a range of time (and therefore range of speed). Note time at 20m, 10m, and 0m to work out change in speed. This will use the same cameras as RQ4.	Use first 3 cyclists seen from each start of 14 hours each day (7am start), giving a sample of 294.	An understanding of cyclist speed, and what contextual factors are correlated to higher and lower speeds.

Appendix D Higher level interaction descriptions

Record	Phase	Site	Day	Pedestrian Activity	Crossing Zone	Who gives way?	Level of interaction	Description	Pedestrian appeared inattentive	Pedestrian distracted by companions	Cyclist arriving from behind pedestrian	Visibility obscured by bus shelter or other pedestrians
1	Uncontrolled crossing	Whitechapel J	Tue	Crossing to the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian (elderly with walking stick) appeared to use crossing without observing the oncoming cyclists. The two approaching cyclists changed their speed and route in response to this. The pedestrian did not take any action.	Yes		Yes	
2	Uncontrolled crossing	Whitechapel J	Wed	Crossing to the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian running for bus across crossing with cyclist to their back ran in front of oncoming cyclist. Both the pedestrian and cyclist changed their speed and route in response to each other.	Yes		Yes	
3	Uncontrolled crossing	Whitechapel J	Thu	Walking through the area at least partially on the cycle track but not on the island	B. Approach kink or 10m from crossing if straight	Cyclist	Level 3	Two pedestrians leaving bus and crossing cycle track with back to oncoming cyclist appeared to be distracted talking to each other and walked in to path of oncoming cyclist. The cyclist slowed in response to this, and when the pedestrians noticed this they moved back on to the island.	Yes	Yes	Yes	
4	Uncontrolled crossing	Whitechapel J	Sat	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian leaving bus and crossing cycle track at the crossing with his back to oncoming cyclists stepped out in front of oncoming cyclist. The cyclist slowed in response to this, and when the pedestrian noticed this they moved back on to the island.	Yes	Yes	Yes	
5	Uncontrolled crossing	Whitechapel A	Mon	Walking through the area only on the footpath	Footway	Both	Level 3	Cyclist using footway swerves around pedestrians. It is unclear if the pedestrian altered their behaviour in any way.				
6	Uncontrolled crossing	Whitechapel A	Mon	Crossing from the bus stop	D. Depart kink or 10m from crossing if straight	Both	Level 3	Pedestrian steps out from behind bus stop and looks for oncoming cyclists, then retreats back when a cyclist is seen. The cyclist appears to momentarily stop peddling (and may have braked slightly) but otherwise makes little noticeable reaction.				Yes
7	Uncontrolled crossing	Whitechapel A	Tue	Crossing to the bus stop	B. Approach kink or 10m from crossing if straight	Cyclist	Level 3	Pedestrian with their back to oncoming cyclists crosses away from crossing without looking. Cyclist comes to a full stop in reaction to this. The pedestrian was not seen to make any reaction which might suggest they were unaware of the cyclist even after they came to a stop.	Yes		Yes	
8	Uncontrolled crossing	Whitechapel A	Wed	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian with crutches leaves bus straight across crossing in to path of oncoming cyclist. The pedestrian (midway on crossing) becomes	Yes			

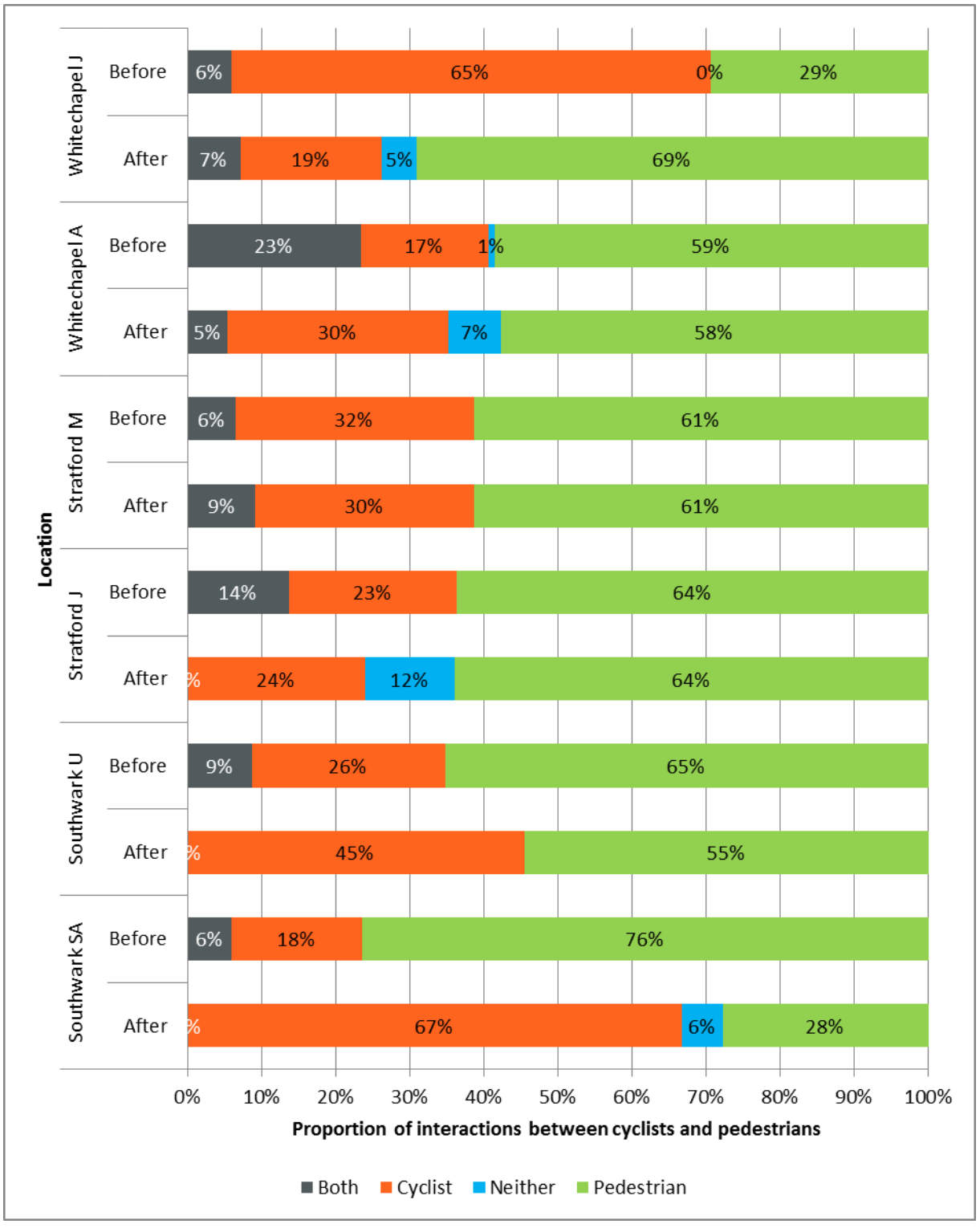
Record	Phase	Site	Day	Pedestrian Activity	Crossing Zone	Who gives way?	Level of interaction	Description	Pedestrian appeared inattentive	Pedestrian distracted by companions	Cyclist arriving from behind pedestrian	Visibility obscured by bus shelter or other pedestrians
								aware of the approaching cyclist and momentarily stops to look before proceeding. The cyclist brakes and swerves behind them.				
9	Uncontrolled crossing	Whitechapel A	Thu	Crossing to the bus stop	B. Approach kink or 10m from crossing if straight	Pedestrian	Level 3	Pedestrians distracted talking to each other walk along cycle track in to cyclist facing them. The cyclist comes to a full stop immediately in front of the pedestrian who then notices the cyclist and moves on to the island.	Yes	Yes		
10	Uncontrolled crossing	Whitechapel A	Sat	Crossing from the bus stop	A. Approach angle start or next 10m	Pedestrian	Level 3	Multiple pedestrians crossing in to cycle stand area block the cycle track for oncoming cyclists. The cyclists do not stop and instead swerve around some pedestrians whilst other pedestrians step out of their way back on to the island.	Yes		Yes	Yes
11	Uncontrolled crossing	Whitechapel A	Sat	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 4	Two pedestrians leaving bus and crossing cycle track at crossing with back to oncoming cyclist appeared to be distracted talking to each other and walked in to path of oncoming cyclist. The cyclist stops (and is joined by another who does not stop and follows the pedestrians) and it is some time before the pedestrians notice them and walk to the footway.	Yes	Yes	Yes	Yes
12	Uncontrolled crossing	Whitechapel A	Sat	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Elderly person with stroller uses raised crossing to enter the cycle track then walks down it with back to oncoming cyclists. Cyclists slow until she eventually notices and moves over within the cycle track to let them pass.				
13	Uncontrolled crossing	Whitechapel A	Sun	Crossing from the bus stop	C. Crossing + 1m either side	Both	Level 3	Multiple pedestrians leaving bus push their way across cycle track in front of oncoming cyclist who slows and puts their foot down for stability but does not stop.				Yes
14	Uncontrolled crossing	Whitechapel A	Sun	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrians with children leave the bus and stop on crossing in path of oncoming cyclist who comes to a stop. The pedestrians notice the cyclist after 3 or 4 seconds and move to the footway.	Yes	Yes	Yes	Yes
15	Uncontrolled crossing	Whitechapel A	Sun	Crossing from the bus stop	E. Depart angle start or next 10m	Pedestrian	Level 3	Pedestrian leaving bus behind bus shelter spots oncoming cyclist and steps back. The cyclist does not appear to alter their speed or path.			Yes	Yes
16	Uncontrolled crossing	Whitechapel A	Sun	Crossing from the bus stop	C. Crossing + 1m either side	Neither	Level 5	Pedestrian leaving bus cannot see oncoming cyclist due to crowd and crosses in to path of cyclist and connects with them. Both stop momentarily to talk with each other before proceeding on their way. Neither party				Yes

Record	Phase	Site	Day	Pedestrian Activity	Crossing Zone	Who gives way?	Level of interaction	Description	Pedestrian appeared inattentive	Pedestrian distracted by companions	Cyclist arriving from behind pedestrian	Visibility obscured by bus shelter or other pedestrians
								appeared to be injured as a result.				
17	Uncontrolled crossing	Stratford J	Tue	Crossing to the bus stop	C. Crossing + 1m either side	Pedestrian	Level 3	Two pedestrians, possibly distracted talking to each other, walk across crossing in front of oncoming cyclist. The pedestrians momentarily step back and the cyclist slows and swerves around to pass in front of them.		Yes		
18	Uncontrolled crossing	Stratford J	Wed	Crossing to the bus stop	C. Crossing + 1m either side	Pedestrian	Level 3	Two elderly pedestrians (both with walking sticks) walk to bus across crossing in front of oncoming cyclist. All parties stop and the cyclist is seen to gesture the pedestrians across before passing behind them.	Yes	Yes		
19	Uncontrolled crossing	Stratford M	Thu	Crossing to the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian walking to bus across crossing crosses in path of oncoming cyclist. Both pedestrian and cyclist slow before the cyclist then swerves in front of the pedestrian.	Yes		Yes	
20	Uncontrolled crossing	Stratford M	Thu	Crossing to the bus stop	C. Crossing + 1m either side	Pedestrian	Level 3	Pedestrian walking to bus across cycle track with cyclist behind them attempts to cross in front of cyclist. The pedestrian steps back on to the footway whilst the cyclist carries on.	Yes	Yes	Yes	
21	Zebra crossing	Stratford M	Wed	Crossing to the bus stop	B. Approach kink or 10m from crossing if straight	Pedestrian	Level 3	Pedestrian walking to bus across cycle track with cyclist behind them attempts to cross in front of cyclist. The pedestrian steps back on to the footway whilst the cyclist carries on.	Yes		Yes	
22	Zebra crossing	Stratford M	Thu	Crossing to the bus stop	A. Approach angle start or next 10m	Both	Level 3	Pedestrian walking to bus across cycle track with cyclist behind them attempts to cross in front of cyclist. The pedestrian momentarily stops in the cycle track whilst the cyclist slows a little and swerves in front of them.	Yes		Yes	
23	Zebra crossing	Stratford M	Sun	Crossing to the bus stop	A. Approach angle start or next 10m	Cyclist	Level 3	Pedestrian walking to bus across cycle track with cyclist behind them crosses in front of cyclist. The cyclist appears to have anticipated this long in advance as was slowing and then stopped to allow the pedestrian to cross.	Yes		Yes	
24	Zebra crossing	Whitechapel A	Mon	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Pedestrian walking from bus stop across crossing walks in front of oncoming cyclist. The cyclist appears to slow and swerve around the pedestrian.				
25	Zebra crossing	Whitechapel A	Wed	Crossing from the bus stop	C. Crossing + 1m either side	Cyclist	Level 3	Two pedestrians, possibly distracted talking to each other, walk across crossing in front of oncoming cyclist. The cyclist comes to a stop, whilst one of the pedestrians (a child) runs to the footway whilst the other moves back to the island.	Yes	Yes		Yes

Record	Phase	Site	Day	Pedestrian Activity	Crossing Zone	Who gives way?	Level of interaction	Description	Pedestrian appeared inattentive	Pedestrian distracted by companions	Cyclist arriving from behind pedestrian	Visibility obscured by bus shelter or other pedestrians
26	Zebra crossing	Whitechapel A	Wed	Crossing from the bus stop	B. Approach kink or 10m from crossing if straight	Cyclist	Level 3	Pedestrian leaving bus crosses in front of cyclist. The pedestrian quickly jumps to the footway when the cyclist is noticed, and the cyclist appears to slow slightly.		Yes		
27	Zebra crossing	Whitechapel A	Fri	Crossing from the bus stop	E. Depart angle start or next 10m	Cyclist	Level 3	Two pedestrians, possibly distracted talking to each other, walk down the cycle track in front of a cyclist with their backs turned to them. The cyclist slows and makes to swerve around them when they unexpectedly make to cross the road at the end of the island requiring the cyclist to swerve harder. At this point the pedestrians momentarily stop as the cyclist passes them.	Yes	Yes	Yes	
28	Zebra crossing	Whitechapel A	Sun	Crossing from the bus stop	B. Approach kink or 10m from crossing if straight	Both	Level 3	Pedestrian leaving bus crosses with back to approaching cyclist. The cyclist slows and swerves in front of the pedestrian, who moves backwards to let them pass.	Yes		Yes	
29	Zebra crossing	Whitechapel J	Mon	Crossing from the bus stop	C. Crossing + 1m either side	Pedestrian	Level 3	Pedestrian crossing from other side of the street crosses cycle track with back to approaching cyclist. The pedestrian notices the cyclist and steps back on to the island, the cyclist carries on.	Yes		Yes	
30	Zebra crossing	Whitechapel J	Thu	Crossing from the bus stop	B. Approach kink or 10m from crossing if straight	Pedestrian	Level 3	Pedestrian (pushing bicycle) from other side of the street crosses cycle track in front of approaching cyclist. Both slow before the pedestrian moves back on to the island and the cyclist passes in front of them.	Yes	Yes		
Totals									**21**	**12**	**17**	**8**

Appendix E Give way behaviour between cyclists and pedestrians

Comparison of give way behaviour of pedestrians and cyclists at each site (for all zones) for both the uncontrolled crossing and zebra crossing measurements.



Bus Stop Bypasses

Bus Stop Bypasses have been introduced over the past few years at sites on London's Cycle Superhighways to enable the continuation of segregated routes through bus stops. A Bus Stop Bypass (BSB) routes the cycle track behind a given bus stop. This physical layout requires that the path of cyclists and those pedestrians boarding and alighting buses will cross, leading to potentially new interactions between them where pedestrians cross the cycle track. This research compares the impact on pedestrian and cyclist behaviour of two different crossing types – uncontrolled crossings, and zebra crossings.

Observational (video) measurements of the behaviour of cyclists and pedestrians were made at six sites across London both in uncontrolled crossing and later zebra crossing configurations, which allows for comparative measurements to be made to understand the impact of this change. Furthermore each site was configured slightly differently to allow the layout to fit within the local area, and the differences in observed behaviour caused by this are also discussed. Separate reports address research questions related to surveys of pedestrians and cyclists, and accompanied visits to sites with disabled people.

The study found that whilst the total number of interactions between pedestrians and cyclists at BSBs were higher at those BSBs with zebra crossings (compared to those with uncontrolled crossings), those interactions were of a less serious nature. The zebra crossings also encouraged more pedestrians to use the crossing itself rather than cross elsewhere informally. More cyclists gave way to pedestrians at the zebra crossing. The cause of more serious interactions between pedestrians and cyclists was found to be largely due to pedestrian inattentiveness, local features that constrained pedestrian movements or reduced inter-visibility, crowding and lack of space for manoeuvring.

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

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