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# Diversifying and normalising cycling in London, UK: an exploratory study on the influence of infrastructure

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## Abstract

This article examines the extent to which protected infrastructure is associated with greater diversity and normalisation of cycling. In the UK, cyclists are predominantly male and often wear distinctive cycle clothing rather than everyday clothes. This is not the case in higher-cycling countries such as the Netherlands and Germany. It has been argued that the UK's demographic skewing may be partly due to poor quality infrastructure which can be off-putting for many, but particularly for women, children and older people. Route choice studies tend to confirm that women are more likely than men to choose routes with greater levels of separation from motor traffic. Other work suggests that if cycling feels unsafe, cyclists may wear specialised cycle clothing such as helmets, which then may itself support a perception of cycling as dangerous.

This small-scale exploratory study examines age, gender, and use of specialist clothing in relation to infrastructure type, comparing a recently improved route with separate space for cyclists to parallel busy streets without protected cycle infrastructure. The separated route showed better, though still unequal, demographic balance and a reduced tendency for cyclists to wear helmets and sporty clothing, though not high-visibility items. Infrastructure type is only one factor in route choice, particularly if there is relatively little good infrastructure along key desire lines. However this paper suggests that infrastructure for cycling could help to improve perceptions of safety and the need to wear specialist cycle clothing. In turn this could promote a better demographic balance and normalise cycling.

# 1. Background

Cycling has substantial potential to improve population health, with a Public Health England/Local Government Association report commenting (2013:4): 'Creating an environment where people actively choose to walk and cycle as part of everyday life can have a significant impact on public health and may reduce inequalities in health.' Such environments help make physical activity more inclusive because many people lack time and/or money to participate in alternative, commodified forms of exercise like attending a gym. Older people reap larger benefits from becoming more physically active, because they are at relatively high risk of developing inactivity-related diseases (Woodcock et al 2014).

Within countries and cities where cycling is low, it is also demographically skewed. Women tend to be under-represented, as do older people and children (Aldred et al 2016). This is often assumed to be a natural phenomenon; with a Transport for London cycling potential analysis (2010) excluding trips made by people over 65, for example. However, in higher-cycling cities and countries these inequalities are much reduced or absent. In the Netherlands, women cycle a higher proportion of journeys than do men, and cycling remains a major mode into older age (Pucher and Buehler 2008).

Many cyclists in the UK wear specialist clothing. Specialist clothing may be 'safety clothing' (e.g. high-visibility vests and helmets) and/or 'sporty clothing' (e.g. elastane shorts and leggings). While these can be distinguished there is overlap, with both relatively rare in countries and cities where mass cycling exists (Goodman et al 2014). Safety clothing may directly indicate a perception that cycling is dangerous (Aldred and Woodcock 2015) while sporty clothing may suggest it is an activity requiring much exertion, which may be related to a need to cycle at high speeds to keep up with motor traffic (Daley et al 2007).

Recent research on cycling near misses (Aldred and Crosweller 2015) suggests women tend to cycle at lower speeds than men. Hence, the perceived need to cycle fast may be disproportionately off-putting to women, and to older people and children, who may be less physically able to reach and maintain higher speeds (Bernhoft and Carstensen 2008). Research suggests women are disproportionately affected by cycling being perceived as a dangerous activity, although they are not in general at higher risk than men (Krizek et al 2005)[1].

In general, a preference for safe and comfortable cycling environments is common across ages and genders (Misra et al 2015). Such environments are understood to involve separation from motor traffic, which can be achieved in a range of ways (e.g. greenway routes away from motor traffic, physical separation on busy roads, reduction of motor traffic volumes and speeds on minor roads). However, a recent systematic review (Aldred et al in press) found such preferences stronger among women, and most likely also among older people.

Route choice studies have investigated 'revealed' infrastructural preferences by gender. While some have found demographic differences paralleling those found in stated preference studies (e.g. Beecham and Wood 2014) others (e.g. Broach et al 2012) have not. One might expect such studies to show weaker results than those found by stated preference work. For one thing, route choice studies necessarily only reveal the behaviour of those who have already chosen to cycle, and women and older people who do cycle might be relatively unrepresentative of their broader demographics (Broach et al 2012).

A second point is that cycling environments on a local level often show little variability, so choice is limited. In the UK, there is often little separated infrastructure for cycling, and where this exists it is often in the form of recreational routes which may not link utility trip origins and destinations (Latham and Wood 2015). Hence a cyclist using a busy road may not be actively 'choosing' that infrastructure type over a separated cycle route, but using the only option that will get her to her destination.

A simpler variant of a route choice study is to use counts to compare usage of different route types. While lacking the geographical coverage and sophistication of a full route choice study, this has the advantage that in theory all cyclists riding in a local area can be included, rather than just those who

[1] Women are statistically more likely than men in central London to be killed or seriously injured by an HGV while cycling (Woodcock et al 2014) but are not generally at greater risk than men across the UK while cycling.

choose to participate in a route choice study[2], who may not be representative of all cyclists. (Where cycling levels are low, it is hard to sample cyclists using anything other than a convenience sample, but this brings with it potential selection biases).

Two such studies have recently been conducted: one, in Ireland (Seymour and O'Mahoney 2014) compared cyclists using on-road (painted) cycle lanes on the South side of Dublin's Grand Canal, to those using a segregated cycle track on the North side. The former provided a faster journey mixed with motor traffic, and the latter a slower but more comfortable journey. Seymour and O'Mahoney found that women were more likely to use the track than men.

This preference was not unique to women; when looking at different groups divided by age and gender, all but one showed a similar preference (the exception being men aged 20-40, who were slightly more likely to use the lane). However, women's preferences for a more comfortable cycling environment seemed stronger. Seymour and O'Mahoney also found that those they categorised as 'commuters' ('characterized by high-visibility clothing, cyclist looks likely to change their clothing/shower in work, generally wearing helmets, cycling speeds are usually between 15-20 mph') were more likely to use the lane than those categorised as 'general utility riders' ('cyclist is characterized by their everyday clothing, body position is generally more upright and relaxed, bike may contain basket, generally cycle at a leisurely pace of 10-15 mph') (Seymour and O'Mahoney 2014: 3). They conclude that 'If there is an appetite to change the male (MAMIL) dominated cycling culture it is essential that the segregated infrastructure that is favoured by those that are not cycling currently is provided.' (Seymour and O'Mahoney 2014:8).

The other recent study using this method is by Goodman et al (2014). This compares London Bicycle Sharing System (LBSS) users to private bicycle users, and finds LBSS riders less likely to wear helmets, high-visibility or sporty clothing. Goodman et al (2014) did not focus on comparing infrastructure types. However, one of their selected sites was within Hyde Park, a large park with off-road cycle routes. Goodman et al (2014) observed large numbers of LBSS bicycles during a Sunday afternoon session, and almost half the LBSS users in the park setting were women, compared to 22-27% for both LBSS and personal-bicycle cycling elsewhere. The authors conclude that the LBSS scheme could help normalise cycling in London through two pathways: firstly, through broadening the image of cyclists, and secondly, through possibly exposing new cyclists to leisure cycling in a park, which might then lead on to utility cycling.

This paper complements the work done by Seymour and O'Mahoney (2014) and Goodman et al (2014). Focusing on infrastructure type it covers both demographic diversity and clothing worn to cycle. It uses data collected for a study commissioned by the London Borough of Camden, including cycle counts and user views gathered through an intercept survey. The study compares 'light segregation' cycle tracks (in practice, this segregation is usually quite substantial, for example here routing cyclists on the inside of parked cars) to parallel busy roads where cyclists share space with motor traffic. While a limited and hence exploratory study in a small area, it is to our knowledge the first published academic paper to use this method in a UK context focusing on differences by infrastructure type.

# 2. Case study

## 2.1 Location

London has seen strong growth in cycling in recent years albeit from a low base: cycling now carries as many people as do the city's Docklands Light Railway and taxis combined (TfL 2015). In recent years there has been a substantial uplift in investment (GLA 2013) although lagging well behind investment in public transport modes. While cycling mode share is currently 2% for London overall, on busy corridors in Central and Inner London high flows are recorded at peak times (TfL 2013), including on roads in Camden which covers both Inner and Central London (see Figure 1). In 2011, 7.1% of Camden resident commuters cycled to work, the same as the average for Inner London boroughs[3].

[2] Beecham and Wood (2014) is unusual in being able to use GPS data on origins and destinations of all London cycle hire journeys. It should however be noted that actual routes were estimated from this.

[3] Figures from the Census 2011, which reports on main mode of travel to work.

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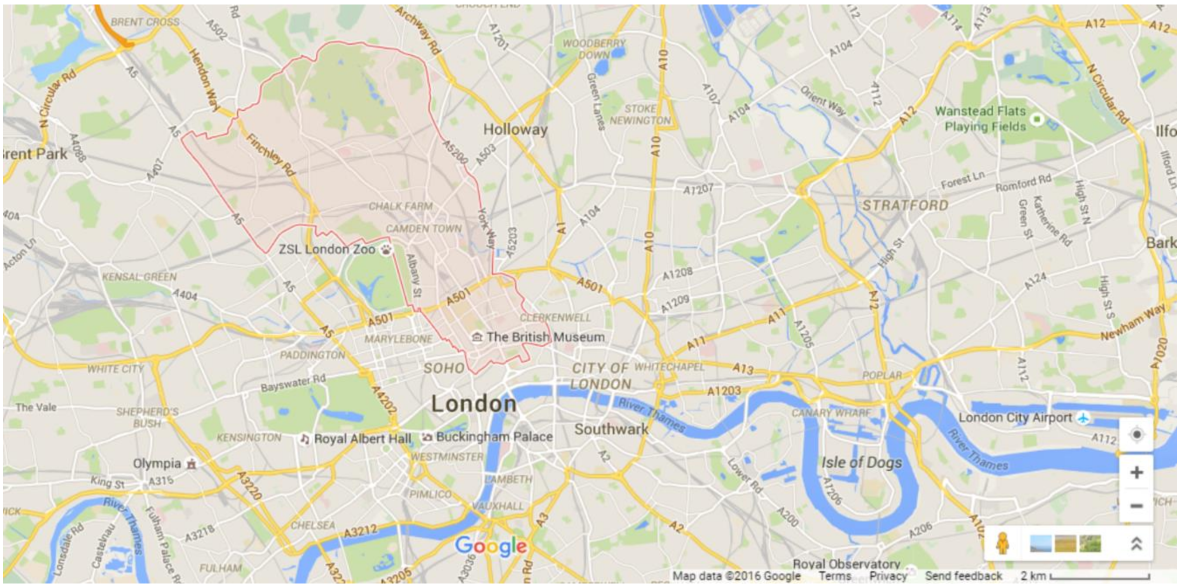
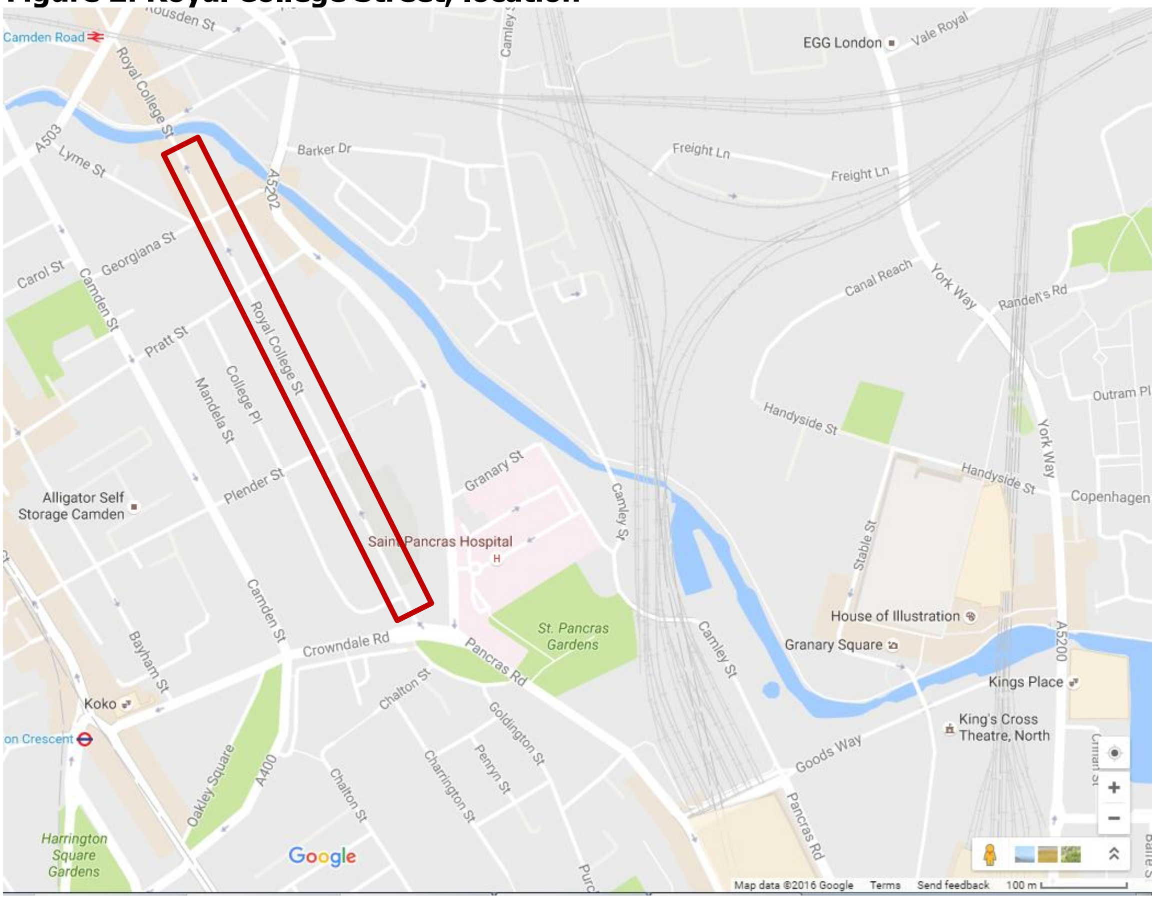
**Figure 1: London Borough of Camden, location**




In August 2013, the London Borough of Camden completed Phase 1 of the Royal College Street cycling project, the first in the UK to use 'light-segregation' to protect cyclists from motor traffic[4]. The section of Royal College Street (RCS) upgraded runs between Crowndale Road to the south and Baynes Street to the north. The street is part of the Camden Town one-way system, and motor traffic runs one-way northbound.

**Figure 2: Royal College Street, location**

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[4] More information on the scheme and its reception by local cyclists can be found here: http://camdencyclists.org.uk/2013/09/royal-college-street-cycle-track/

The red box indicates the study area, which is approximately 550m long.

What impact is this route section likely to have on user behaviour? Among Camden-based cycle commuters with a fixed UK workplace, 46.2% had a commute between 2 and 5km – so Royal College Street makes up between 10-25% of their total journey. 15.3% had a commute of 2km or less, meaning Royal College Street would make up at least 25% of their total journey[5]. The impact of the segregated track will also depend on the rest of the person's journey. So it seems reasonable to suggest that the track would not affect the behaviour of all users, but for some (e.g. where the track is a substantial proportion of the journey and the rest of the route reasonably quiet), it might do.

'Light segregation' used for the Royal College Street tracks consists of a combination of 'armadillos' (in this case 'Zicla Zebra' separators, made from recycled PVC) and higher-profile planters. The contra-flow track on the east side of the street is also protected from moving motor traffic by a line of parked vehicles (with a 0.5m buffer zone). When the tracks were introduced (replacing an existing, narrow bi-directional track with a poor safety record) other improvements were made including extending and widening the cycle track and changing/introducing new crossings. Initial assessments of the scheme highlighted positive results, including an increase in the number of people cycling, and a decrease in motor traffic speeds. After a year, the Council commissioned further assessments, reported in Urban Movement (2015), data from which have been used in writing this article.

**Figure 3: Royal College Street northbound track, separated by planters and 'armadillos', approaching one of the two bus stops**

**Figure 4: Royal College Street southbound track, with separation from the carriageway by 'armadillos', a planter, and parked cars.**

[5] Figures from the 2011 English Census.


## 2.2 User Views

Camden Council's community researchers conducted street-based interviews on the part of Royal College Street between Baynes Street and Crowndale Road in the period from 9th to 23rd December 2014. This included interviews with 202 cyclists, using a short survey form developed in discussion with local stakeholders. Two questions asked of the cyclists within the user views survey are relevant here in illustrating the quality of the route and how it compares to other parts of the London network used by interviewees. Cyclists were asked to comment on how safe they felt cycling along this section of Royal College Street. 80% answered that they felt 'very' or 'fairly' safe:

**Table 1: User views: perceived safety on Royal College Street**

| | |
|---|---|
| Very safe | 30% |
| Fairly safe | 50% |
| Neither safe nor unsafe | 9% |
| Quite unsafe | 5% |
| Very unsafe | 4% |
| Don't know/not answered | 1% |

Cyclists were also asked how cycling on Royal College Street compared with the rest of their route. This provides a benchmark for assessing the quality of cycling infrastructure in London, from the perspective of people generally supportive of the segregation available on Royal College Street.

**Table 2: User views: perceived safety on Royal College Street compared to rest of route**

| | |
|---|---|
| Much worse | 2% |
| Worse | 6% |
| No different | 15% |
| Better | 40% |
| Much better | 31% |
| Don't know/not answered | 6% |

Hence it is suggested that while Royal College Street is a relatively preferred type of infrastructure (this sample did only include people choosing to follow the route; but other research, e.g. Aldred 2015,

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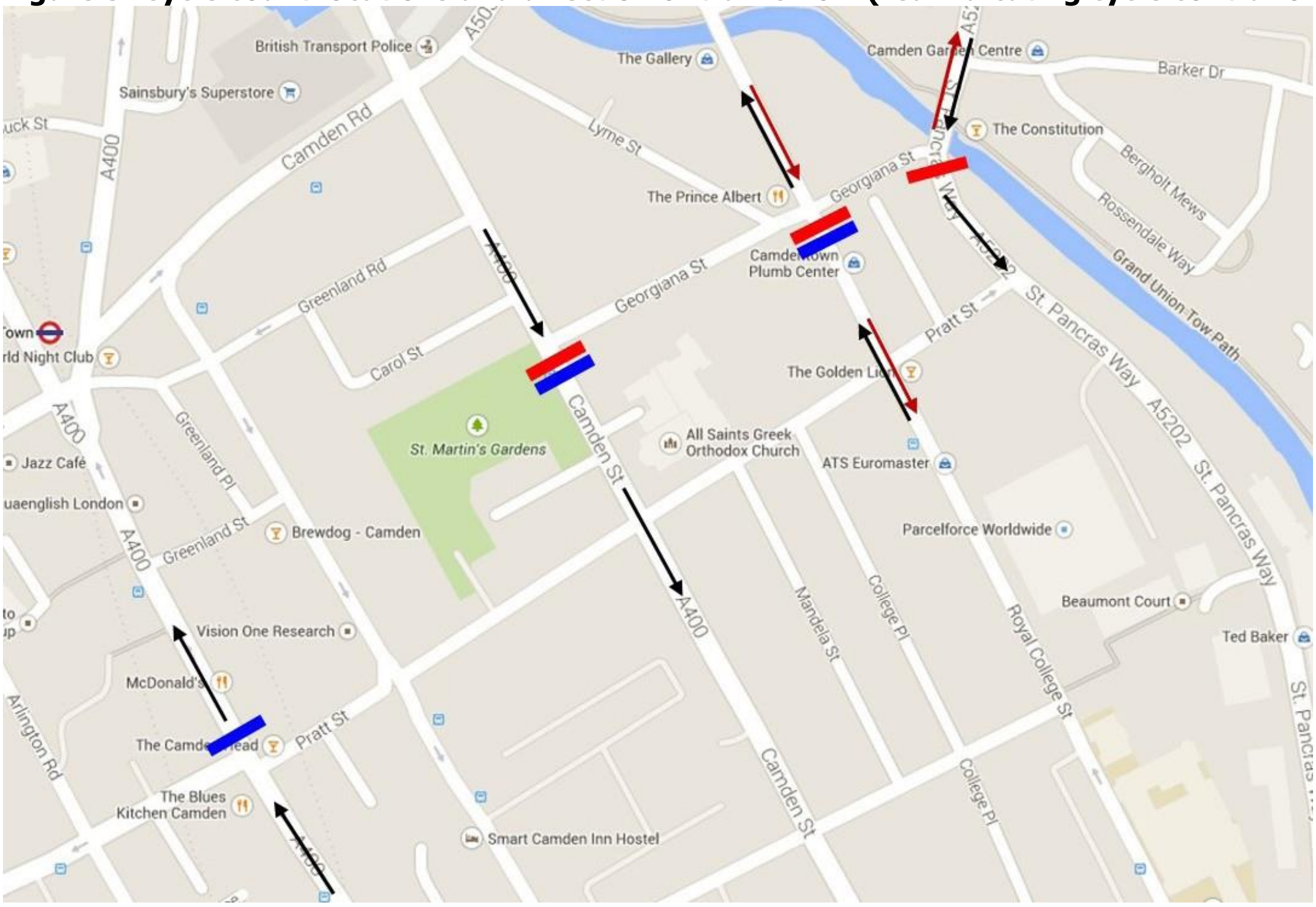
suggests that these views may reflect broader infrastructural preferences), much other London cycling infrastructure is experienced as less good. 71% of those interviewed characterised Royal College Street as better than, or much better than the rest of their route, indicating a failure to find a comparable quality direct route throughout. Given for instance stronger preferences among women than men for separated cycle infrastructure (Aldred et al 2016), this is likely particularly to suppress women's cycling along Royal College Street, if subsequent or preceding infrastructure does not need their needs.

# 3. Methods

### 3.1 Count locations

Visual surveys of people cycling were undertaken from 8am-10am and 4pm-6pm on Friday 3rd and Thursday 23rd October, 2014. Counts were conducted by employees of Urban Movement.

**Figure 5: Cycle count locations and direction of traffic flow (red indicating cycle contraflow)**




Red lines show the morning survey cordons and blue the evening.

Cycling in Inner and Central London remains relatively skewed towards commuting trips (TfL 2015). Thus during morning and evening peaks much cycling is likely to be for commuting purposes, primarily into Central London workplaces. The images below illustrate commuting rates in the 2011 Census likely to pass through the area in question: cycling levels are relatively high just North of this area and there are strong desire lines that could map to Royal College Street or nearby parallel routes.

**Figure 6: Cycling to work, 2011 Census data, via pct.bike (study area location highlighted)**

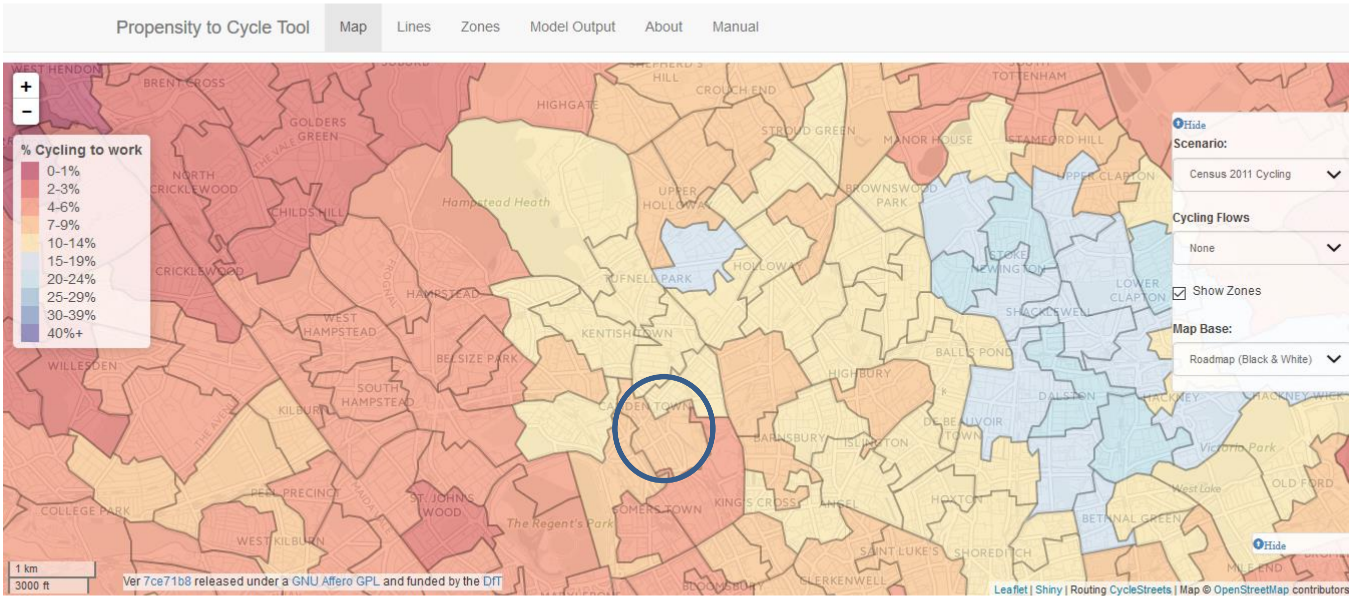
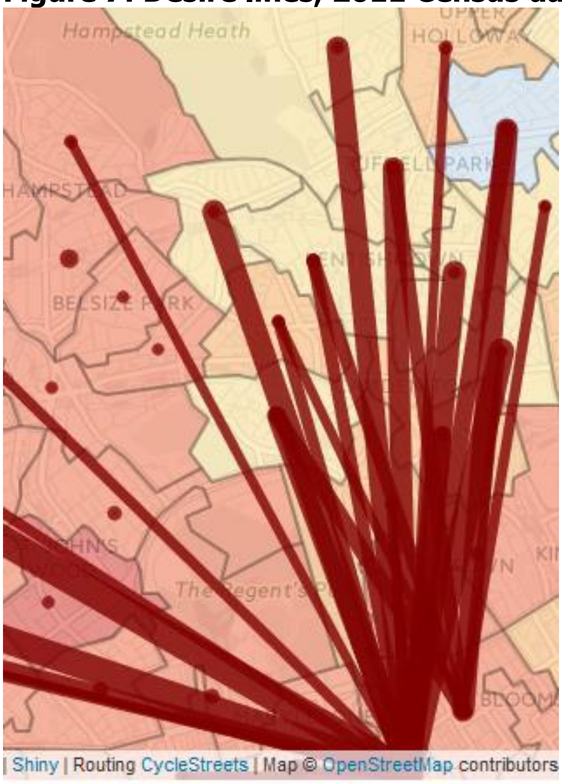



**Figure 7: Desire lines, 2011 Census data, via pct.bike, study area**




Given the strength of the North-South commuting desire lines, the comparator sites chosen were the closest parallel routes likely to form plausible alternatives to Royal College Street for people travelling into or out of Central London from the North of the borough. This would help guard against capturing people with completely different (possibly longer) journeys. Flows into and out of Central London (both cycle and motor traffic) are concentrated at peak times. The TfL Cycle Census (2013) surveyed a range of sites between 6am-10pm and found that 36% of cycle traffic and 26% of all traffic was counted between 7-10am.

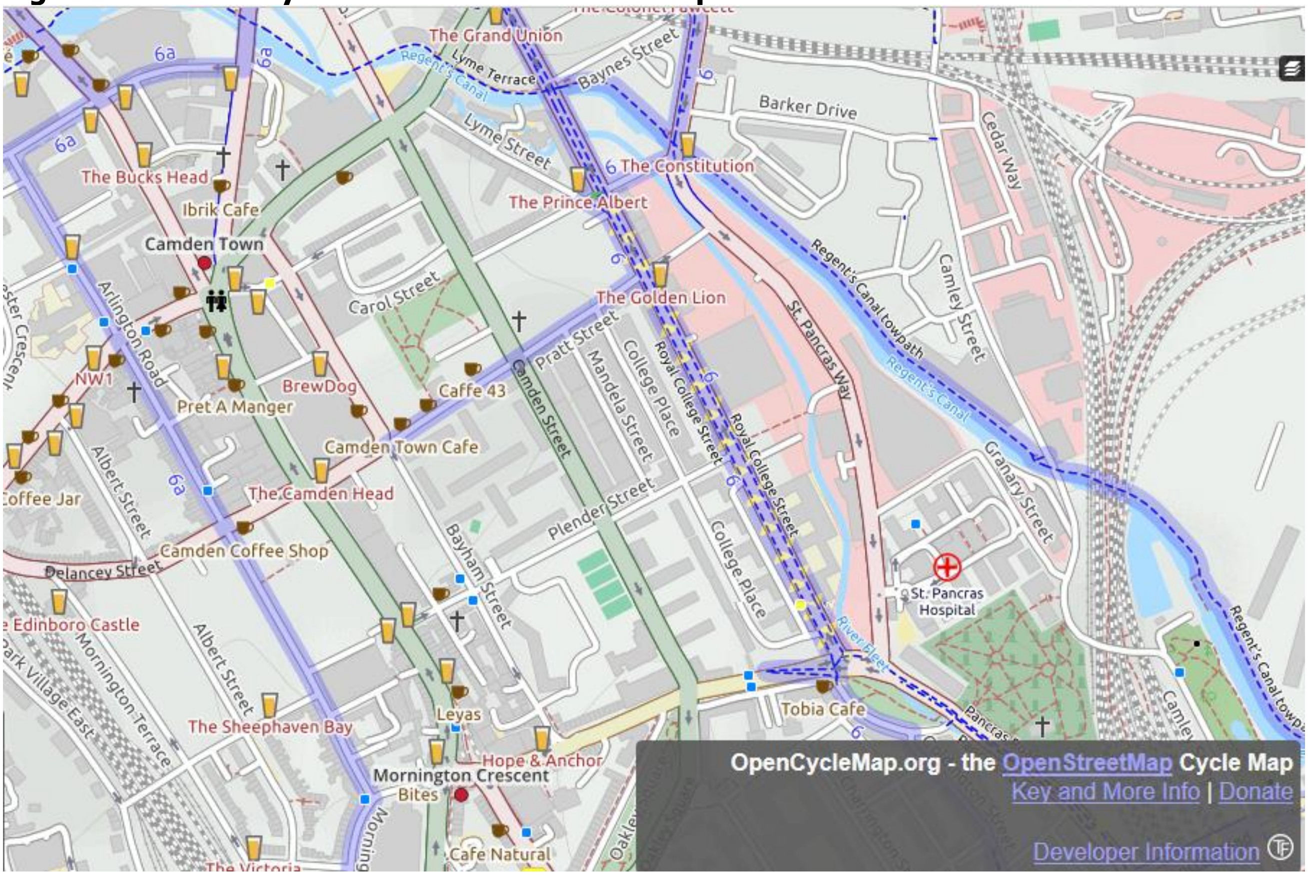
The layout of the area is such that alternatives are limited. To the East, the Regent's Canal (and then the rail lines into Kings Cross) forms a natural barrier, meaning that routes further East do not represent alternatives to the Royal College Street alignment. While the Canal itself does permit cycling, at peak times on a sunny October day, the towpath width and pedestrian flow is such as to make cycling difficult. It also curves off East (off the edge of Figure 5) so would serve different desire lines.

Hence for Southbound cycle traffic, Camden Street and St Pancras Way were selected as being the nearest alternatives, one to the West of Royal College Street and one to the East. Camden Street was

believed to represent a more likely alternative than (also busy) Bayham Street, one road further away. The St Pancras Way count point is a close alternative for people on similar routes: further up St Pancras Way is a narrow bi-directional cycle path, also forming part of the London Cycle Network. Upon reaching Georgiana Street (just North of the count point) those riding Southbound would have the option to turn right on Georgiana Street and left down Royal College Street (along the track) or to continue along the busier St Pancras Way, where an advisory, paint-based lane[6] is present.

Figure 6 below highlights the London Cycle Network in the area covered.

**Figure 8: London Cycle Network in the area in question**




Northbound cyclists have fewer options. Camden High Street (the A400) was chosen as the nearest Northbound route parallel to Royal College Street. As mentioned above, the canal (to the East) is relatively unsuitable for peak hour cycling and did not seem to serve similar routes. Arlington Road is another LCN route (albeit a reasonably busy road without much cycle infrastructure) but is 0.5km West of Royal College Street so probably does not represent a clear alternative for trips with similar origins and destinations.

Images below illustrate cycling environments on the three alternative routes at the time the study was conducted:

**Figure 9: Camden Street**

[6] In the UK advisory cycle lanes, signalled by a broken white line, can also be driven in and – usually – parked in.

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**Figure 10: St Pancras Way**


**Figure 11: Camden High Street**

### 3.2 The Observations

For each time period, observations were made at three locations selected to ensure comparability and to exclude double-counting. Observations were made between 8-10am at Royal College Street, Camden Street, and St Pancras Way. Between 4-6pm, observations were made at Royal College Street, Camden Street, and Camden High Street.

In the morning peak, the Southbound flows are busy while in the evening peak, it is the Northern flows that are the busiest. We term these here the 'peak direction' and the opposite direction flows (Northbound am, and Southbound pm), the 'counter-peak direction'. This may be important because most people travelling with the peak flow are likely to be commuters[7], while those travelling in the other direction might have more diverse journey purposes. Arguably, journey purpose might have an independent influence on journey characteristics and on the likelihood of wearing specialist clothing (Goodman et al 2014, Seymour and O'Mahoney 2014).

JD provided instructions for observers to record numbers and characteristics of cyclists using the two sites. These were developed during piloting and disseminated during briefings. The observers recorded apparent gender of cyclists along with apparent age group on a paper form. The latter here have been combined due to difficulty experienced in accurately judging the age of adults. Categories retained here were children (aged under 18), those aged 60 or over, and all other adults; under the assumption that this would provide a reasonably accurate estimate of children and older cyclists using the routes.

Observers also recorded type of clothing worn by cyclists. This comprised: whether or not a helmet was worn, whether high-visibility clothing (typically a vest) was worn, and whether sporty clothing was worn. Clearly there is some subjectivity involved, as in Goodman et al's paper which similarly sought to identify 'sporty clothing'. However, on the days when the counts took place, weather was warm and pleasantly autumnal, making it easier to define and identify sporty clothing.

As with gender and age, when the count method was piloted checks were conducted to ensure that observers were applying the same criteria. For instance, many cycle panniers (bags) include (more or less subtle) reflective strips as part of the design, but this would not be counted as wearing high-visibility clothing. In practice, while the categories are subjective, a shared understanding of these existed. For this analysis, a new category of 'No Special Clothing' was created, meaning that a cyclist was recorded as wearing neither helmets, nor high-visibility clothing, nor sporty clothing.

The images below demonstrate how individuals would be categorised, with all images courtesy of Cyclestreets.net image bank.

**Figure 9: Helmet, no hi-vis, no sporty clothing**

[7] Cycling in London is skewed towards commuter trips, unlike in some other countries. For example, the London Borough of Hackney has a commute mode share for cycling of 15% but for all trips of only 5-6%.

The woman pictured above is wearing a helmet, but has no high-visibility items and is not dressed in sporty cycling gear.

**Figure 10: Helmet, hi-vis, no sporty clothing**

Common attire among UK commuters: the man pictured above is wearing a helmet and a high-visibility jacket (safety clothing), but not sporty cycling gear. Were he to remove his coat and helmet, he would be wearing 'normal' clothing.

**Figure 11: Helmet, sporty clothing**

By contrast the image above shows attire more associated with sports riding, which one would expect to be changed before a day at work.

The count data had been analysed in aggregate by Urban Movement for a report for the London Borough of Camden. To allow more detailed analysis for this paper, the data was entered line by line into Microsoft Excel and then analysed using Excel and SPSS.

# 4. Findings

## 4.1 Summary

Table 3 below summarises all findings, outlined in the following section. Firstly, we decided to separate 'peak' and 'counter-peak' travellers to ensure that we are comparing like with like. It is possible, as explained above, that a relatively high proportion of counter-peak travellers (i.e. those travelling Southbound in the evening peak, or Northbound in the morning peak) are travelling for non-commute purposes. This might affect what they wear, either directly (e.g. those on a leisure ride might be more likely to wear sporty clothes, compared to people heading into an office) or indirectly (e.g. if commute trips are relatively long, commuters might be more likely to wear specialist clothing).

The potential for peak versus counter-peak differences to shape results was confirmed by analysis. For example, 57% of those cycling counter-peak were wearing a helmet compared to 67% of those cycling at peak, while there is a higher percentage of females cycling in the peak direction (but not of those aged over 60). In general, results were however similar when considering peak or all travellers; counter-peak trends for two variables seemed different but due to low numbers this was not generally statistically significant.

Secondly, we compared the characteristics of people cycling in the protected lane to people cycling at control sites, for demographic and clothing-related variables. We have chosen to highlight characteristics where a higher percentage suggests more 'normalisation' – i.e. female, under 18, sixty plus, no helmet, no high-visibility clothing, normal (i.e. non-sporty clothing) and a final variable, 'no specialist clothing' indicating that the rider was wearing neither a helmet, nor high-visibility gear, nor sporty clothing.

Underlined results indicate the difference between protected and unprotected lane riders was significant to p<0.01 and **bold results** to p<0.05.

**Table 3: Summary of results**

| | | Female | Under 18 | 60+ | No helmet | No high-visibility clothing | Normal (i.e. non-sporty) clothing | No specialist clothing |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Counter-peak | Control sites | 67 | 0 | 16 | 138 | **253** | 216 | 107 |
| | | 21.7% | 0.0% | 5.2% | 44.7% | **81.9%** | 69.9% | 34.6% |
| | Protected cycle lane | 56 | 7 | 7 | 91 | **164** | 179 | 72 |
| | | 25.1% | 3.1% | 3.1% | 40.8% | **73.5%** | 80.3% | 32.3% |
| | Total | 123 | 7 | 23 | 229 | 417 | 395 | 179 |
| | | 23.1% | 1.3% | 4.3% | 43.0% | 78.4% | 74.2% | 33.6% |
| Peak | Control sites | 604 | 1 | 48 | 734 | 1811 | 1358 | 555 |
| | | 25.0% | 0.0% | 2.3% | 31.1% | 74.9% | 56.2% | 23.1% |
| | Protected cycle lane | 494 | 11 | 92 | 511 | 1000 | 1024 | 382 |
| | | 35.0% | 0.8% | 6.5% | 36.2% | 70.9% | 72.6% | 27.1% |
| | Total | 1098 | 12 | 140 | 1245 | 2811 | 2382 | 937 |
| | | 28.7% | 0.3% | 4.0% | 33.0% | 73.4% | 62.2% | 24.6% |
| Total | Control sites | 671 | 1 | 64 | 872 | 2064 | 1574 | **662** |
| | | 24.6% | 0.0% | 2.6% | 32.7% | 75.7% | 57.7% | **24.4%** |
| | Protected cycle lane | 550 | 18 | 99 | 602 | 1164 | 1203 | **454** |
| | | 33.7% | 1.1% | 6.1% | 36.8% | 71.2% | 73.6% | **27.8%** |
| | Total | 1221 | 19 | 163 | 1474 | 3228 | 2777 | 1116 |
| | | 28.0% | 0.5% | 4.0% | 34.3% | 74.0% | 63.7% | 25.7% |

## 4.2 Key findings

Most cyclists were male (72.0%) and very few were either under 18 or over 60. For the locations with protected cycle lanes, i.e. Royal College Street, females made up a higher proportion than males, a difference which was statistically significant ($p<0.01$). They were however still under-represented: 34% rather than 25%.

Numbers of people aged under 18 were very low throughout. 18 were cycling on the protected cycle lanes, and 1 cycling on the other roads. This was statistically significant ($p<0.01$). Only 163 (4.0% of all those whose age categories were recorded) cyclists aged over 60 were counted. Again there was a statistically significant ($p>0.01$) difference between numbers cycling on the protected and unprotected roads: 99 (6.1%) vs. 64 (2.6%).

Considering specialist cycling clothing, only 25.7% (1116) of users wore no specialist clothing (i.e. no helmet, no 'Lycra', and no high-visibility clothing). This is similar to the 30% recorded by Goodman et al (2014). 65.7% (2827) wore helmets, 26.0% (1,133) some form of high-visibility clothing, and 35.7% (1,559) sporty cycle clothing. Note that these are not mutually exclusive, so it is possible for example for someone to wear sporty clothing and a helmet, but no high-visibility items.

There were statistically significant ($p<0.01$) differences again between Royal College Street and the other routes related to clothing. These were in different directions, however, for different types of specialist clothing: although overall users of the protected lanes were slightly less likely to wear any specialist clothing than others ($p<0.05$).

Considering only those cyclists travelling in the peak direction, similar differences were found for percentage female (35.0% in the protected lane vs. 25.0% on other routes, $p<0.01$) and for percentage under 18 or over 60 ($p<0.01$, although numbers were small). For specialist clothing, differences found were similar and in the same direction to those found for all cyclists.

Considering cyclists travelling in the counter-peak direction, where differences reached statistical significance the trends found for all cyclists and peak direction cyclists also held. In the case of cyclists over 60 and those wearing no specialist clothing, the differences were in the other directions – but these did not reach $p=0.05$.

## 4.3 Additional findings

While not the focus of this article, we also explored how wearing specialist clothing varied by age and by gender. Women were more likely than men to wear helmets ($p<0.01$) and to wear high-visibility clothing ($p<0.05$), but less likely to wear sporty clothing ($p<0.01$). None of the under 18s observed wore sporty

clothing. Those aged sixty plus were relatively unlikely to wear sporty clothing, but more likely to wear high-visibility clothing ($p>0.01$). The biggest sized differences were for the wearing or not of sporty clothing, rather than for the safety items. For example, 27% of women were wearing sports clothing, compared to 39.1% of men; while helmets were worn by 64.1% of men compared to 69.9% of women.

# 5. Discussion

## 5.1 Limitations

This is a small-scale study with inherent limitations. Clearly, people do not choose a route only because of one bit of infrastructure. A whole route may consist of a range of infrastructure types. If using a high-quality piece of infrastructure negatively impacts other parts of someone's route (e.g. if it leads to a difficult junction), the high-quality infrastructure may not be used. In contexts without a coherent high-quality cycling network, people who currently cycle may expect poor quality environments and so prioritise direct routes.

Further, as planning for walking and cycling has historically lagged behind planning for motorised modes, where high-quality infrastructure is sparse it may simply not serve the routes that people want to use. Finally, where cycling is demographically skewed, cultural assumptions about 'who cycles' may initially persist, even where infrastructure is improved. All these are reasons why a strong stated preference for protected infrastructure (Misra et al 2015) is likely to be much weaker in actual usage data – and why these results should be viewed as exploratory.

One way of overcoming these limitations would be to use this kind of framework to examine changes before and after separated infrastructure is introduced. This would control for differences that may have existed here between control and intervention sites.

## 5.2 Summary of findings

On the protected cycle lanes, there was greater gender and age balance (although still noticeably skewed). People using those lanes (as a whole, or just at peak) were less likely to wear any specialist clothing, helmets, or sports clothing; but were however more likely to wear high-visibility clothing. Across all sites women and older people were more likely than men and under 60s to wear high-visibility clothing; while women were more likely than men to wear helmets. However, women and over 60s, and under 18s were all less likely to wear sporty clothing.

## 5.3 Detailed findings

### *5.3.1 Age, gender and cycle specific clothing*

Our analysis found that women and older people were both more likely than men or younger people to wear high-visibility clothing, with women also more likely than men to wear helmets. This finding supports suggestions in the literature than women and older people are more sensitive to perceived cycling risk (Griffin and Haworth 2015), given that use of such items is associated with perceived cycling danger (Aldred and Woodcock 2015). Why might men make more use of sporty clothing? Perhaps because they are likely to cycle further and faster than women; or alternatively, because the 'sporty' image of cycling prevalent where mixing with motor traffic is common is more easily assimilated into male identities (Steinbach et al 2011). Getting more women cycling might, like the successful introduction of cycle hire, help to normalise cycling through creating a less sporty image (c.f. Goodman et al 2014).

### *5.3.2 Protected space, age and gender*

Women, over 60s and those aged under 18 were more likely to be riding on protected lanes than on parallel roads. This supports the finding in a recent systematic review (Aldred et al in press) that women and older people tend to express stronger stated preferences for cycling away from motor traffic. We suggest building high-quality protected lanes is a necessary part of diversifying cycling in London and other low-cycling contexts.

It should be noted that women remain under-represented, and that numbers of young and old people cycling are very low in all cases. One reason for this might be the peak hour counting times: women are

more likely than men to work part time, or to be making non-commute trips, while older people tend to make more journeys during the interpeak period. Another reason might be that men tend to make longer trips than women, which could mean men appear over-represented if count data is taken as a proxy for mode share of trips.

However, these factors on their own will not account for the low representation of women and older people. There are a range of barriers to cycling which tend to reinforce each other. While, as suggested by the user views survey, cycling in London remains often very problematic, many cyclists will need to detour to avoid unpleasant busy roads. This is likely to lower rates of cycling by women and older people: analysis of NTS data carried out for the Propensity to Cycle Tool project[8] has suggested that where distances are lengthened, drop-off in cycling will be greater among women and older people. Similarly, older people seemed particularly unlikely to wear sporty clothing: if cycling is perceived as a sporty activity, this cultural stereotype may continue to negatively affect older people's cycling participation.

The very low levels of child cycling suggest that London has some way to go before on-road cycling by children becomes normalised. Research suggests that for children to (be allowed to) cycle, cycling environments have to be particularly high quality (Aldred 2015). While solo adults may put up with relatively poor quality route segments, such problems may be an absolute barrier to child cycling, particularly in a context where child utility cycling is unusual and even negatively viewed.

### *5.3.3 Age, gender and cycle specific clothing*

Users of the protected tracks were slightly less likely than those on the parallel roads to wear any kind of specialist clothing; suggesting that protected lanes can help to normalise the image of cycling. In particular, users were less likely to wear helmets or sporty clothing. (Although women are generally more likely to wear helmets, and more women used the protected lanes, overall the rate of helmet wearing was lower on the protected lanes than on the other routes).

Users of the protected lanes were however more likely than those on the parallel roads to wear high-visibility clothing. This would often mean a fluorescent vest over someone's normal clothes. Why might there be higher use of this kind of clothing on the protected lanes, given there is lower use of helmets and sporty clothing? London is a context where use of specialist clothing is overall very high; three-quarters of all observed cyclists wearing such clothing. So it is possible that the use of a high-visibility vest could represent a step down from sporty clothing, in that people are choosing not to wear 'cycling kit' but still feel obliged to add a safety item on top of their ordinary work clothing.

# 6. Conclusion

This small-scale study suggests protected cycle infrastructure can contribute to improving the gender balance of cycling, where this is poor. Findings for age are statistically significant but relate to very small numbers, so this is more provisional. Protected cycle infrastructure may, like cycle hire schemes, help to 'normalise' the image of cycling by helping to reduce the amount of safety and specialist clothing worn by users – particularly in terms of sporty clothing. Given these and other findings, provision of high-quality cycle infrastructure should be an important part of a co-ordinated strategy to increase, diversify and normalise cycling.

[8] See the manual online at www.pct.bike

# 7. Bibliography

Aldred, R. 2015 Adults' attitudes towards child cycling: a study of the impact of infrastructure, European Journal of Transport and Infrastructure Research 15 (2), 92-115

Aldred, R. and Crosweller, S. 2015 Investigating the rates and impacts of near misses and related incidents among UK cyclists, Journal of Transport & Health 2 (3), 379-393

Aldred, R. and Woodcock, J. 2015 Reframing safety: an analysis of perceptions of cycle safety clothing, Transport Policy 42, 103-112

Aldred, R., Woodcock, J. and Goodman, A. 2016 Does More Cycling Mean More Diversity in Cycling? Transport Reviews, 36(1), 28-44

Aldred, R., Elliott, B., Woodcock, J. and Goodman, A. In press. Cycling provision separated from motor traffic: a systematic review exploring whether stated preferences vary by gender and age. Transport Reviews.

Beecham, R. and Wood, J. 2014 Exploring gendered cycling behaviours within a large-scale behavioural data-set, Transportation Planning and Technology 37(1), 83-97

Bernhoft, I.M., Carstensen, G., 2008. Preferences and behaviour of pedestrians and cyclists by age and gender. Transportation Research Part F: Traffic Psychology and Behaviour 11, 83–95. doi:10.1016/j.trf.2007.08.00

Broach, J., Dill, J. and Gliebe, J. 2012. Where do cyclists ride? A route choice model developed with revealed preference GPS data, Transportation Research Part A: Policy and Practice 46(10), 1730–1740

Daley, M., Rissel, C., Lloyd, B., 2007. All dressed up and nowhere to go? A qualitative research study of the barriers and enablers to cycling in inner Sydney. Road and Transport Research 16, 42–52.

GLA 2013 *The Mayor's Vision for Cycling in London: An Olympic Legacy for All Londoners*. London: TfL, https://www.london.gov.uk/sites/default/files/cycling_vision_gla_template_final.pdf

Goodman, A., Green, J. and Woodcock, J. 2014. The role of bicycle sharing systems in normalising the image of cycling: An observational study of London cyclists, Journal of Transport & Health 1, 5–8

Griffin, W. and Haworth, N. 2015. Male and Female, Cyclist and Driver Perceptions of Crash Risk, Transportation Research Board Annual Meeting 2015 Paper #15-3879

Krizek, K.J., Johnson, P.J., Tilahun, N., 2005. Gender Differences in Bicycling Behavior and Facility Preferences, in: Transportation Research Board Conference Proceedings. Transportation Research Board, pp. 31–40.

Latham, A. and Wood, P. 2015. Inhabiting Infrastructure: Exploring the Interactional Spaces of Urban Cycling, Environment and Planning A 47(2), 300-319

Misra, A., Watkins, K., Le Dantec A, C., 2015. Socio-demographic Influence on Rider Type Self Classification with respect to Bicycling. 94th Annual Meeting of the Transportation Research Board TRB, http://trid.trb.org/view.aspx?id=1339455

Public Health England/Local Government Association 2013. Healthy people, healthy places briefing Obesity and the environment: increasing physical activity and active travel. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/256796/Briefing_Obesity_and_active_travel_final.pdf

Pucher, J. and Buehler, R. 2008. Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany Transport Reviews 28(4), 495-528

Seymour, J. and O'Mahoney, E. 2014. Widening the Participation in Cycling-A Case Study of the Grand Canal Cycle Route, available at

http://www.itrn.ie/uploads/Widening%20the%20Participation%20in%20Cycling-A%20Case%20Study%20of%20the%20Grand%20Canal%20Cycle%20Route.pdf

Steinbach, R., Green, J., Datta, J. and Edwards, P. 2011 Cycling and the city: a case study of how gendered, ethnic and class identities can shape healthy transport choices, Social Science and Medicine, 72 (7) 1123–1130

Transport for London 2010. Analysis of Cycling Potential. London: TfL, available at http://content.tfl.gov.uk/analysis-of-cycling-potential.pdf

Transport for London 2013 Cycle Census: technical note. Transport for London Research report, available at http://content.tfl.gov.uk/cycle-census-technical-note.pdf

Transport for London 2015. Travel in London 8. London: TfL, available at http://content.tfl.gov.uk/travel-in-london-report-8.pdf

Urban Movement 2015. Royal College Street Phase 1 Post Implementation Report. Currently unpublished report produced for the London Borough of Camden.

Woodcock, J., Tainio, M., Cheshire, J., O'Brien, O. and Goodman, A. 2014 Health effects of the London bicycle sharing system: health impact modelling study, BMJ 2014;348:g425

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