Does UK cycling infrastructure guidance limit rates of cycling

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Submission date: 02-Sep-2019 12:10PM (UTC+0100)

Submission ID: 110446164

File name: 115579_Douglas_Tremellen_Does_UK_cycling_infrastructure_guidance_limit_rates_of_cycling_1064857_744102885.docx (39.86M)

Word count: 14375

Character count: 78412

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Does UK cycling infrastructure guidance limit rates of cycling?

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Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MSc Transport and City Planning at University College London: I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

Douglas Tremellen

1 September 2019

Word count: 10,824

Acknowledgements

The author is grateful to Gualtiero Bonvino for their supervision in the preparation of this dissertation.

The author is an employee at Surrey County Council. Colleagues Sumaya Sharif Ali and James Northfield assisted the author with observation studies, allowing data to be collected for unbroken 7.30am to 6.30pm periods. The author would like to thank them for their help, and to thank Surrey County Council for offering their time. Nick Grudgings, a former Research Engineer at Surrey County Council, is also to be thanked for kindly supplying a copy of their doctoral thesis, which looked at cycling in Surrey and which is fully referenced in the text of this work. In all other respects, this work is the author's own. Accordingly, views expressed within it or conclusions drawn may or may not reflect the position of Surrey County Council.

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Abstract

There has been growing recognition in the UK of the benefits of bicycle travel to both individuals and society, and accordingly there has been renewed interest in and support for the creation of new cycle routes. Despite investment however, UK cycling rates have remained low outside of a few notable cities. This paper builds on recent studies (Seymour and O'Mahoney, 2012; Aldred and Dales, 2017) that have begun measuring the success of 'link' cycle infrastructure in terms of its ability to diversify and normalise cycling, and finds tensions between UK national guidance and a growing body of academic literature, particularly research in relation to the spread and growth of new behaviours such as cycling in a society. From this, and in contrast with the guidance, it is proposed that some types of link cycle infrastructure are better able to encourage growth in cycling rates than others. Existing theory and research is synthesised to construct a prospective hierarchy for types of infrastructure with regards to growing rates of cycling. A comparison study of routes with contrasting link infrastructure types was undertaken in Surrey, UK, which found evidence in support of the hypothesis that some types of link cycle infrastructure are better able to grow rates of cycling. The study also tested the validity of some elements of the proposed infrastructure hierarchy. From this, conclusions are drawn, with a discussion of the implications for future research and practice.

Introduction

The bicycle is a practical and healthy transport mode with environmental and societal advantages over the motor car.

For the traveller, it offers affordable, flexible transport and an opportunity to improve physical and mental wellbeing as a by-product of a necessary journey.

For society collectively, the benefits of increasing the mode share of cycling relative to motor cars include cleaner air, quieter streets and fewer greenhouse gas emissions; reduced traffic congestion and more efficient use of land (reducing requirement for car parking and wide carriageways); reduced transport-induced inequality (from severance effects and the higher financial cost of motor transport); and greater prosperity at a neighbourhood-level (Garrard, 2003; Lawlor, 2014). Further, the cost to society of lack of exercise 'is second only to smoking' (Shannon et al., 2006), and the societal benefits of cycling outweigh the health risks from accidents and exposure to air pollution seven-fold (van Bekkum, Williams and Morris, 2011). Reducing motor traffic dominance by increasing cycling mode share has the potential to naturally raise walking rates too (Transport for London, 2017), extending these benefits.

Growing cycle mode share will mean these benefits can be felt more widely and deeply by communities and individuals. Doing this will require existing cyclists to cycle more, non-cyclists to begin cycling or a combination of the two. Partly because individuals make a finite number of trips and partly because health benefits to an individual have diminishing returns the more they cycle (Shannon et al., 2006), encouraging more people to cycle offers the greatest benefits.

It has previously been found that cycling rates can be increased through investment in cycle route infrastructure, end-of-trip facilities, transit integration, promotional programmes, bicycle access and regulation (Handy, van Wee and Kroesen, 2014; Lovelace et al., 2017). This research examines the role of cycle route infrastructure, and in particular whether varying the type of 'link' cycle infrastructure affects growth in bicycle use. 'Link' cycle infrastructure is taken to be an engineered intervention between two points in space which can be meaningfully travelled between – either an unbroken path or an affiliated series of measures – in contrast with a singular nodal network feature such as a junction improvement.

The role of cycle infrastructure is of particular relevance to Local Highway Authorities as the area they can most easily influence through their capital spending. Given that available funds are reducing (Bulman, 2018), and the challenges that cycling can solve that are faced by Local Highway Authorities (e.g. traffic congestion) are mounting, there is a need to identify and focus on the most effective interventions. Further, Gatersleben and Appleton (2007) identify a lack of suitable infrastructure as the most commonly cited reason occasional cyclists do not cycle more routinely.

Research and policy context

UK cycling infrastructure guidance

The UK's principle guidance on cycle infrastructure is Local Transport Note 2/08: *Cycle Infrastructure Design* (Department for Transport, 2008), which prioritises on-road cycling, discourages infrastructure measures and advocates for site-specific solutions targeted at specific user groups.

The guidance offers some discussion on contrasting approaches to link infrastructure, advocating a 'hierarchy of provision' that advises approaches be considered in the following order (ibid., p10), from first to last:

1. traffic volume reductions;
2. traffic speed reductions;
3. junction and hazard site treatments;
4. reallocation of carriageway space;
5. cycle tracks; and
6. shared use pavements and footpaths (shared by pedestrians and cyclists).

Whilst the latter two items on this hierarchy correspond directly to types of link infrastructure, the guidance avoids an infrastructure lens on the first four items on the preferred four approaches, which are framed as approaches to treatment of existing roads rather than as types of link infrastructure. This is consistent with the guidance's underlying philosophy, which maintains that keeping cyclists on-road by adapting traffic movements and carriageways is preferable to considering infrastructure interventions. As a result, the guidance does not contain a discussion of link infrastructure types beyond generic on-road, on-pavement or cycle-only track options, instead progressing from this higher-level discussion of approaches directly into chapters dedicated to detailed design guidance for components common to multiple infrastructure types, such as facility widths and acceptable margins of error in kerb flushness.

The other substantial contribution of the guidance is to recommend a combination of route-led design ('planning and designing high-quality infrastructure involves developing site-specific solutions' – Department for Transport, 2008, p.9) and user-led design ('the design … needs to take account of the type(s) of cyclists expected to use it' – ibid., p.11). This is consistent with a design philosophy for cycle infrastructure that has historically prevailed in much of academic thinking and practice: 'what intervention strategy is best for this group, in this particular place' (Handy, van Wee and Kroesen, 2014). This philosophy may have arisen in part to the relatively low usage of experimental centrally-planned cycle facilities in the past, such as those installed in the 1960s in Stevenage, UK, however Reid (2017) notes that subsequent changes in socio-cultural context and increased motor traffic volumes may have weakened the validity of these lessons.

Since the guidance was released, rates of cycling have not changed. The number of bicycle trips per person per year (t/p/y) across England has remained steady: 17 t/p/y in 2008, the year the guidance was published, identical to the 17 t/p/y rate in 2018 (Department for Transport, 2019b), although the average miles cycled per person per year (m/p/y) has increased from 44 m/p/y 58 m/p/y over the same period (ibid.) implying that those that are cycling are undertaking longer trips.

A review of contemporary academic research suggests that the approaches recommended by the guidance may not be conducive to growing the rate of cycling. The practice of user-led design may be perfecting facilities for too narrow a group of users which limits the potential of a cycle route. Some issues arise from the application of user- and route-led design principles: the way in which users have historically been categorised and prioritised is found to be problematic, as is the focus route-led design and a preference for adapting roads has placed on certain types of targeted measures.

User-led design

User-led design has promoted scrutiny of the characteristics of different types of cycle trip and the requirements of the users who make them. However, high rates of cycling will require trip-type and user diversity over a single section of route – arguably perfecting route design for one particular group may not be as helpful in terms of growing cycling rates as creating a design that is reasonably acceptable to a range of users and trip types, as Furth (2012) notes Dutch practice has done to great success. Whilst it may be a ‘mistake’ to attempt to cater for everybody (Damant-Sirois and El-Geneidy, 2015), paying too much attention to the particular needs of a narrow range of users will limit the efficacy of the cycle facility for others, and stunt mode share growth.

User-led design also requires user typologies to be developed. Historically these have been derived from trip, ability and demographic characteristics. The typology proposed by the Department for Transport (2008, p.12) guidance has five categories: ‘fast commuter’; ‘utility cyclist’; ‘inexperienced and/or leisure cyclist’; ‘child’; and ‘user of specialised equipment’. In practice, a typology similar to that of the Institution of Highways and Transportation et al. (1996, p.12) is often used, which groups users by speed and trip length: ‘sports adults’; ‘commuter adults’; and ‘vulnerable children, inexperienced adults, elderly people and those with some form of disability’. However these typologies are not exhaustive, mutually-exclusive or derived from a single classificatory principle, as Rogers (2003) notes category sets should be, and, as Boyer (2018) argues, create distinctions that cyclists themselves wouldn’t recognise.

These typologies are also backwards-looking, based on an analysis of existing cycle users and as a result may over-emphasise ‘vehicular cycling’ – fast, confident, on-road cycling (Schoner and Levinson, 2014). Further, typologies like these assume that the relative importance of current groupings of cyclist would hold true in future growth scenarios – however some types of cycling may have greater prospect for growth than others, and some demographic groups are under-represented in current cycling. Falling bicycle sales in the UK could be symptomatic of a situation where the ‘cyclists of the heart’ (Jensen, quoted in Gatersleben and Haddad, 2010) common today – sports adults and commuter adults – are saturated markets with limited further growth potential: Reid (quoted in Eley, 2019) attributes the bicycle sales issue to ‘the industry … selling to the same people’ rather than identifying mainstream markets. The preference for prioritising on-road cycling has been led by the desire to design for sports adults and commuter adults (Daley and Rissel, 2011) which typologies of current cycling often give prominence to, but which may have limited potential for cycle rate growth.

Conversely, Furth (2012) notes that ‘traffic-intolerance’ is a ‘mainstream’ position across all society. Buehler and Dill (2015) show that whilst there is a preference amongst existing cyclists for on-road cycling, amongst potential future cyclists there is strong traffic-intolerance.

User typologies based on currently cyclists also over-account for the preferences of men, who make up the majority of current cyclists. Women have been found to be four times more traffic-intolerant than men (Davies et al., 2001). They are typically more positive towards the benefits of cycling (Matthies, Kuhn and Klöckner, 2002) and in areas with high rates of cycling such as Denmark, the Netherlands and even Cambridge, UK, cycle as much, and sometimes more, than men (Garrard, 2003; Grudgings, 2018). Women represent a demographic that has high propensity for cycle rate growth, but user-led design based on current categories defined around predominantly male cycling habits reinforces the status quo by over-emphasising fast, confident, on-road cycling that women generally are put off by – limiting growth potential and creating an equity issue.

On-road cycling may also have been over-emphasised by data availability. Data on commuter trip-types is readily available from the UK national census and other sources, giving rise to a greater degree of study than other types of cycling (Handy, van Wee and Kroesen, 2014). However, Transport for London (2017) estimate that commuting only represents 21% of potentially cyclable trips. Further, measures of user preference such as Reid and Guthrie's (2004) study that concluded that bus lanes were a suitable facility for cyclists and cited by the Department for Transport (2008) guidance, have been limited to the behaviour of existing cyclists. User-led design has therefore mostly resulted in cycle facilities designs that are well-suited to existing cyclists, but that maintain current rates of cycling rather than grow them.

A final difficulty with designing for trip purpose is that across all the travel that they do, a typical cyclist, or potential cyclist, will make all types of trips – and by creating infrastructure that only supports a single trip-type the bicycle remains an impractical mode choice for other types of trip. As a result, habits are less easily formed and ready access to other forms of transport (e.g. owning a car, buying a season ticket for the bus) is still required such that a bicycle trip is made deliberatively rather than by default. Further it fails to account for changes in an individual's principle bike-trip purpose over time. With typically shorter distances, time-pressures and other responsibilities, trips for personal business trips or leisure will often require a lower-level of commitment than commuting trips, and as such offer a lower barrier-to-entry for novice cyclists. As habit develops and confidence grows, however, an individual may look to broaden the range in types of trips they undertake.

Route-led design

Route-led design, in combination with the preference for cycling to remain on-road, places an emphasis on working around existing highway infrastructure and surgically adapting roads with targeted improvements, most commonly to address specific safety problem points or to identify opportunities to give priority to cyclists over other vehicles. This surgical approach is popular with local authorities as it is typically lower-cost and politically easier.

However, priority over other vehicles may only be of interest to vehicular cyclists, as only vehicular cyclists frame their journey in relation to other vehicles on the road. Vehicular cyclists can commonly be found on unmodified roads too, suggesting that such measures may be welcome but not a determinant of whether they choose to cycle.

Further, Gatersleben and Haddad (2010) review several studies to find that while safety measures may be a pre-condition for wider cycling uptake, they do not contribute to cycling growth on their own. A distinction may therefore need to be made between measures that promote cycling growth from road safety schemes, with the latter in future being justified on the grounds of accident prevention rather than cycling growth.

As a result of the principle of adapting existing routes engendered by route-led design, the Department for Transport (2008) guidance to choose to avoid discussion of the inherent merits of types of link cycle infrastructure, or even the discernment of what different types of link infrastructure exist. The guidance instead suggested Cycling England, a semi-public body, would separately review the merits of types of cycling facility (ibid., p.9), but this organisation was disbanded before it reported on the issue (Department for Transport, 2011).

Aldred et al. (2017) argue that greater understanding of and discrimination between types of infrastructure is now needed. It may be that some types of link infrastructure are better able to encourage cycling growth than others. If so, the principle of route-led design needs to be very carefully applied such that it does not limit the installation of the infrastructure that would best support growth, on the occasions where this involves the comprehensive reworking of the exiting route.

A link-by-link approach is also at risk of creating an inconsistent and fragmented network of varying facility types that fails to cater for any individual cyclist's journey (Transport for London, 2017) or support growth (Schoner and Levinson, 2014). Further, route-led design may also encourage planners to narrowly concentrate on a single route, however, if some link infrastructure is better at supporting growth than others, a better outcome may be arrived at by considering the corridor on which a route sits, and identifying the routing within that corridor which would support a cycling facility most able to foster growth.

Philosophical origins

The Department for Transport (2008) guidance is substantially a formalisation of *Cycle-Friendly Infrastructure: Guidelines for Planning and Design* (Institution of Highways and Transportation et al., 1996), which it cites. The origins of the philosophies employed by the Department for Transport guidance - prioritising on-road cycling, discouraging infrastructure measures and advocating for site-specific solutions targeted at specific user groups – can be traced back to these previous guidelines.

The Institution of Highways and Transportation et al.'s (1996) guidelines were developed as a collaborative between government, civil engineers, the bicycle trade and cycle users. However, whilst this collaborative group contained a range of voices, it lacked outsider views. Cycle users were represented by the Cyclists' Touring Club, a membership organisation for hobby cyclists that typically practice vehicular cycling. Similarly, the Bicycle Association, representing the bicycle trade, and Institution of Highways and Transport, representing civil engineers, may have had little appetite for disrupting their existing business models (centred around premium-product hobbyists) and technical practice (developed around road engineering practice) respectively. The particular make up of this group is arguably reflected in the philosophy the Institution of Highways and Transportation et al. (1996) adopt, and in turn the philosophy of the Department for Transport (2008) guidance.

In producing their guidelines, the Institution of Highways and Transport et al. (1996) reviewed guidance by the Dutch cycle infrastructure design authority CROW. Dutch guidance was thought to be relevant as rates of cycling in The Netherlands was, and still is, substantial – for example, 2018 research found that 'more than a quarter of all trips made by Dutch residents are travelled by bicycle' (Harms and Kansen, 2018).

The Institution of Highways and Transport et al. (1996) guidelines, however, recommended that the UK did not follow the Dutch model. The guidelines concluded that Dutch guidance wasn't compatible with vehicular cycling, and the authors were minded that cyclists 'fare better' (Forester, 1983, in Furth, 2012) when on the road amongst, and acting consistently with, other vehicles including motor vehicles. The guidelines considered off-road cycle facilities wasteful, as both off-road and on-road facilities might be built along the same route, and felt that comprehensive off-road facilities had little prospect of being delivered. The guidelines expressed concern too that off-road cycle facilities would encourage less experienced cyclists to travel by bike, who some of the guideline's key authors noted, in research contemporary to the publication of the guidelines, would lack the 'traffic sense' to cycle safely when on the parts of their journey where they inevitably came into contact with roads (McClintock and Cleary, 1996).

As a result, a comparison between Dutch guidance (as documented in Furth, 2012) and UK guidance (Department for Transport, 2008) shows Dutch guidance recommending more substantial infrastructure interventions on roads with lower speeds and less traffic.

Arguably, there are difficulties with the positions taken by the Institution of Highways and Transport et al. The role of guidelines, and the way that guidelines will be read, is as a tool for making decisions about what measures are best. To pre-suppose within the guidelines the outcomes of those decisions – that comprehensive off-road facilities will always prove too difficult – prevents such measures from being introduced where they are feasible and appropriate. Concerns over dual networks of on- and off-road facilities alongside one another are arguably misplaced – would it ever be necessary to modify the carriageway if there was an off-road option, when vehicular cyclists are still able to use the carriageway with other vehicles when they choose to? Further, revealed preference surveys have found that even vehicular cyclists typically choose to switch to a slower, off-road option where they are available (Schoner and Levinson, 2014).

The principle difficulty with the Institution of Highways and Transport et al.'s (1996) guidelines, however, is that the fear of encouraging new people to cycle, who may initially lack 'traffic sense' (as McClintock and Cleary, 1996, put it) and be at particular risk of injury, has led to a deliberate prescription of avoiding implementing cycle measures that encourage more people to cycle. Given this, it is perhaps not surprising that rates of cycling in the UK are static. It employs, perhaps, a flawed logic too – whereas new and inexperienced cyclists, who as established are known to prefer off-road facilities, would be exposed to traffic sometimes if off-road cycle facilities were introduced, they are always exposed to traffic where they remain on-road.

The Department for Transport (2008) guidelines, then, can trace the philosophy of its approach back to a small group of cycling insiders that chose to promote one approach to cycling – vehicular cycling – over others, which resulted in a weak application of international best practice, a preference for on-road cycling and the avoidance of discussion around the merits of different types of dedicated cycling infrastructure.

Philosophies re-evaluated

If aiming to grow rates of cycling, it may be necessary to re-evaluate the types of cyclist that measures are designed for, and to open discussions on what types of link cycle infrastructure are preferred by these groups.

As established, if user typologies are primarily based on trip type, it becomes difficult to cater for mass cycling. An alternative approach to creating user typologies that is better suited to facilitating growth might be to backcast user categories from future scenarios where rates of cycling are high, and to prioritise measures that are desirable in common across the range of user categories with the best prospects for growth, moving away from understanding users in terms of trip type and instead considering their 'adopter category'. Rogers (2003) *Diffusion of Innovations*, originally published in 1962, devised a standardised model to describe how new practices spread through a population. Rogers found that ideas typically diffuse through a society according to a normal distribution, and identified 'adopter categories' that sort a given population by their propensity to take up a new habit.

Rogers used the term 'innovator' for the first 2.5% of a population to adopt a new practice. Innovators are content to adopt a new practice without that practice being well-supported, widely understood or coveted. With only 3.2% of the English population travelling by bike three times a week or more (Department for Transport, 2019b), many regular cyclists would be categorised within this 'innovator' population. If a new practice is to spread, however, it needs to be adopted outside of this innovator group, by 'early adopters' as Rogers defined them.

Whilst early adopters may not currently cycle regularly, it is not necessarily the case that they do not cycle – they may be 'toe-dipper' occasional cyclists (Davies et al., 2001).

Geels and Schot (2007) conceptualise the transition from one dominant social practice to another through a 'multi-level perspective' of established regime – practices that dominate now – and niches –practices that are currently atypical, but that could become dominant in the future. In this model, it prior to something becoming mainstream, it is possible to observe characteristics of future practice on a small scale in 'niches'.

Whilst Dickinson et al. (2003) find that few non-cyclists are close to starting cycling, there are people who cycle already but that exist outside of the innovator regime who may be potential indicators of early adopters, and the niche activities that have the potential to become mainstream. According to Rogers' (2003) innovation-decision process and the Transtheoretical Stages of Change model (Nehme et al., 2016), activity outside of the regime is likely to be lower commitment, more irregular and less likely to be sustained.

Ajzen's (1991) Theory of Planned Behaviour conceptualises the adoption of new behaviours in terms of how an individual appraises a behaviour ('attitude'), the extent to which they believe others would view their acting in that way as unremarkable ('social norm'), and how easy they believe the behaviour would be for them to practice ('perceived behavioural control').

Rogers' early adopter group make 'judicious innovation-decisions' (Rogers, 2003, p.283) – they require a new practice to be simple and supported in a way that innovators do not. Early adopters begin the process of social diffusion, where ideas spread as people know of or observe people similar to themselves successfully undertaking a new practice.

It is arguably critical, then, that toe-dipper, niche cyclists encounter facilities that make it easy to cycle and that give them a good impression of cycling as a mode choice when they do decide to cycle. These cyclists, as early adopters, are acutely aware of how they are perceived by others (Rogers, 2003; Heinen, Maat and Van Wee, 2011) and will not be attracted to facilities which put them in conflict with others, or that they do not readily, confidently understand how to use, or that are quirky. Aldred, Woodcock and Goodman (2016) argue that 'creating a mass cycling culture may require deliberately targeting infrastructure and policies towards currently under-represented [niche] groups'. These individuals are critical to social diffusion – Garrard (2003) notes that as it is extremely difficult to persuade people of the benefits of a new activity, its spread relies upon people that try it for themselves.

Gatersleben and Appleton (2007) observe that there is a widely held opinion by people who are not cyclists that cycling is for ‘someone else’, and Steinbach et al. (2011) note that describing someone as ‘a cyclist’ carries personality connotations, rather than simply being an account of their typical mode of transport. This creates a barrier to further diffusion: ‘the seduction of inclusion into a small “cycling club” are, however, offset by the public availability of that identity to others’ (ibid.). These are indications that cycling remains a pursuit of an innovator ‘clique’ (Rogers, 2003, p.282) and is not being widely practiced by the early adopter group that are closer to the social networks of the majority of the population. Nehme et al. (2016) note the importance of ‘perceived compatibility’ when an individual makes a decision to try cycling – that cycling needs to be seen as practical and in line with their self-identity, and to do this they need to observe others cycling easily and effectively. Instead, Gatersleben and Haddad (2010) find that whilst most people view cycling as green and healthy, only current cyclists view it as an effective mode of transport, and Aldred and Dales (2017) note that cycle wear such as lycra and helmets present an impression of danger and exertion that detract from the perception of an everyday choice of travel.

If instead niche, early adopter cyclists, who are more representative of the population as a whole than the current cycling regime, can be observed cycling more frequently, more comfortably and in greater numbers, attitudes, social norms and perceived behavioural controls will shift favourably in the wider population in a way that opens the door to cycling growth. William Gibson’s aphorism ‘the future is here, it’s just not evenly distributed’ applies (Gibson, quoted in Rosenberg, 1992) – it may be that cyclists in niches outside the current regime offer clues as to the composition of a future, more inclusive regime and how it might be reached.

It seems reasonable to look at niche cycling practices outsider of the innovator ‘MAMIL’ culture as potential indicators of practices preferred by early adopters. Previous studies (Seymour, J., O’Mahoney, 2012; Aldred and Dales, 2017) have looked at cycle user age, gender and clothing choice as indicators of whether someone cycling is part of ‘MAMIL’ cycling culture. Whilst being middle aged or male will not always place someone as a regime member (or innovator), *not* having those attributes suggests that someone is more likely to be an early adopter. Not wearing cycling-specific clothing is also a good indication that someone exists outside the regime, as are trip characteristics such as shorter trips and more spontaneous and irregular trips.

As a result, to understand what levels of support early adopters will want from infrastructure, it is necessary to look at the preferences of women, older and younger cyclists, those not wearing specialist clothing, and those undertaking shorter and less regular trips. This will lean towards being a more supportive environment than currently exists (Aldred et al., 2017), which research shows are valued equally by men and women (Grudgings, 2018) – it is simply that innovator cyclists are happy to cycle without this support in place.

Research gap

UK cycle guidance has promoted on-road cycling on the recommendation of insider voices, and encouraged cycle facility design focus on adaptations to roads that typically cater to existing cyclists. As a result, research and debate into any inherent value different cycle facilities have in terms of their propensity to encourage growth in cycling numbers has been limited. A review of academic literature has shown however that there may be benefit to understanding the relative merits of different types of cycle infrastructure in terms of attracting and catering to the needs of early adopter cyclists, who can begin a process of social diffusion – the method by which rates of cycling will increase. This can be achieved through studies of characteristics of cyclists on existing cycle links, to identify relative proportions of users who show signs of being early adopters. There is evidence to show that infrastructure is preferred by early adopters to on-road cycling, and a call for greater distinctions of and investigations into different types of infrastructure – beyond on-road, on-pavement and cycle-only – if infrastructure that is to have the greatest impact on growing rates of cycling is to be invested in.

Research aims

The principle aims of this research are to

(a) establish whether cycle facility type influences the degree of success new cycle infrastructure has on encouraging more people to cycle;
(b) investigate which cycle facility types are preferred by 'early adopter' cyclists, and whether this supports the infrastructure hierarchy model proposed in this paper;
(c) establish the extent to which cyclists, and in particular 'early adopter' cyclists, will go out of their way to use varying cycle facility types; and
(d) from these, assess whether UK guidance has limited rates of cycling.

Methodology

Site selection

The study has adapted the observation study methodologies of Seymour and O'Mahoney (2012) and Aldred and Dales (2017). Strong corridors of cycling demand are identified, and two proximate, parallel cycle link infrastructure routing options within the corridor are compared by observing and surveying cyclists that pass a set cordon point along each link. Comparing routing options within a corridor helps to control for background social, demographic and environmental factors that may affect rates of cycling across wider areas. The previous studies used the comparator street methodology in city contexts (London and Dublin respectively), where streets are densely packed and grid alignments reasonably common. As a low-density, polycentric region of towns and villages, instances of parallel streets were found to be relatively rare in Surrey which constrained the selection of survey sites.

Nevertheless, an initial review of cycling facilities in Surrey, using a combination of Surrey County Council's records of the county's cycling infrastructure (Surrey County Council, 2019a) and crowdsourced OpenCycleMap mapping (OpenCycleMap.org, 2019), identified nine sites within the county and three further sites close to the county border where cycling infrastructure totalling 500m length or greater ran parallel to and in close proximity with a comparator route. The requirement to be of at least 500m in length was so that the facility would form a significant proportion of a cycle trip of between 1km and 5km (i.e. a distance that is easy to cycle).

The twelve potential sites were subsequently analysed using the Propensity to Cycle Tool (PCT, 2019), and those sites where there was not a significant and dominant demand for cycling in the same direction as the cycle facility were disregarded. The tool can only identify demand for work and school journeys, and as discussed the relative availability of data on commuter trips may be skewing studies towards an overemphasis on such routes. However, the sites eventually selected also had a number of other types of destination proximate as both were near town centre and leisure locations, which should minimise this effect.

Finally, where two prospective sites offered a comparison between identical types of cycle facility (for example, between a cycle lane and a quietway), the site with the facilities deemed most representative of the model facility described within the typology outlined earlier was selected.

As a result, two sites were initially selected for assessment based upon this desktop study:

- Corridor one: Redhill to Reigate: 'Community Route' quietway vs Reigate Road cycle lanes
- Corridor two: Kingston to Surbiton: Portsmouth Road cycle track vs route 32/75 quietway vs Penrhyn Road (no specific cycle facility)

An initial field investigation was undertaken to identify optimum locations along these routes to act as cordons for observation studies and surveys. During this initial site visit it was found that Penrhyn Road on corridor two would be undergoing substantial roadworks for the duration of the study period, so this corridor was not surveyed.

Data collection

Observation studies were conducted at the roadside. It was a condition that the cyclist was riding the bike, and children accompanied by an adult on foot were not counted. It was possible for an individual cyclist to cross the line more than once and be counted each time, for instance a cyclist making a return trip later in the day.

For each cyclist observed, the following data was collected:

- gender (male or female),
- age bracket (under 30, 30 to 60, or over 60 years old), and
- clothing (everyday, augmented, or bespoke)

The data was recorded according to the judgement of the observer, per Aldred and Dales' (2017) method, on the basis that it would not be practical to confirm this information with every passing cyclist and that an observer was likely to judge these faculties reasonably accurately. Observers spent time together at the beginning of the day jointly recording observation data to develop a consistency between different observers' judgements. Variation between observers' judgements were very low following this initial joint monitoring period.

Observed clothing categories were defined as:

- everyday (no clothing associated with cycling as an activity),
- augmented (high-visibility clothing and helmets warn over other clothing), and
- bespoke (clothing which would ordinarily be changed out of immediately after the cycling activity was complete).

These categories are similar to those of Aldred and Dales' (2017) study.

The observation studies took place on two consecutive summer weekdays (Wednesday 31 July 2019 for quietway site; Thursday 1 August 2019 for cycle lane site) between 7.30am and 6.30pm, with no breaks in observation, capturing both commuters and daytime trips. As these survey days were during the traditional summer holiday period the cycling observed may not be typical of cycling for the full year. The fine weather may have increased rates of cycling overall, and the holiday period may have seen an increase in leisure-time trips; conversely, the holiday period may have suppressed commuting trips and the choice of a weekday has meant that weekend leisure-time trips were missed. These effects in combination may have acted to cancel each other out to a degree however, and moreover the two study sites experienced the same conditions which allows relative comparisons to be made between the sites. The decision to undertake an unbroken, all-day study rather than just studying commuter hours (as is more common) arose from a desire to avoid the aforementioned overemphasising of importance of commuter cycling based on data availability.

Whilst conducting these observation studies, a short questionnaire was undertaken with cyclists that were willing to stop. Both survey locations featured safe areas for cyclists to stop, away from traffic. The questionnaire asked:

- where a cyclist began and ended their journey (to a level of precision that the cyclist was happy to volunteer – typically the name of a road – and never a full address);
- why the cyclist chose to take the route that they did;

- whether they agreed with the statements 'I'm cycling to get somewhere' and 'I'm cycling because I enjoy it as an activity'; and
- age bracket, gender and clothing type (all according to the categories used in the observation study, above).

Those surveyed were not pressed to answer any questions that they did not want to. The data collected did not enable the identification of an individual and is presented in this paper in an anonymised, aggregate form.

Risk assessments in both UCL (Appendix 1) and Surrey County Council's prescribed formats were undertaken prior to commencing the study and immediately prior to data collection respectively and appropriate mitigations were put in place.

Significance testing

To confirm the significance of results, a two-tailed *t*-test was employed to analyse to what extent the variation in results between two routes could be explained by natural variations in the observed data. The *t*-test was deemed appropriate as it was anticipated that sample sizes would be low. The methodology for this (below) was informed by Boddy and Smith (2009).

$$\text{Test value} = \frac{|\bar{x} - \mu| \sqrt{n}}{s}$$

Where:

$\bar{x}$ *is the mean result for the cycle facility that it is hypothesised is superior (the sample facility)*

μ *is the mean result for the comparator cycle facility*

n *is the number of data points from the sample facility*

s *is the standard deviation of sample facility data*

The test values were then compared with reference Table A.2 in Boddy and Smith (2009, p.218). Results are noted against either the 5% confidence interval or 1% confidence interval, and where presented at the former the results were not significant at the higher degree of confidence.

GIS analysis

Survey respondents were asked to provide approximate origin and destination locations, typically a road or landmark.

These origins and destinations were plotted in QGIS software (version 3.6.1) for analysis. Where a road name was given for an origin or destination, the midpoint along the road was used. Reigate and Redhill town centres were common responses: the junction of High Street, Bell Street and Church Street was taken as a representative central point in Reigate and the junction of High Street, London Road and Station Road was taken as the equivalent for Redhill. The use of approximate locations introduced a margin of error into the results, but as this would potentially allow a respondent to be identified, precise locations were not used. Surrey County Council's geospatial record of the county's roads and paths (Surrey County Council, 2019b) was used to represent the route options. The QNEAT3 shortest path algorithm (Raffler, 2019) was run to identify the shortest network path between origin and destination, and the length of this path. Where the shortest path was not the route taken, the shortest path between the origin and survey site and then survey site and destination were also calculated.

Using a shortest path algorithm to identify the path taken by a cyclist between origin and destination provides a likely but also conservative estimation of their total trip length, as well as showing what route options they had.

Proposed infrastructure hierarchy

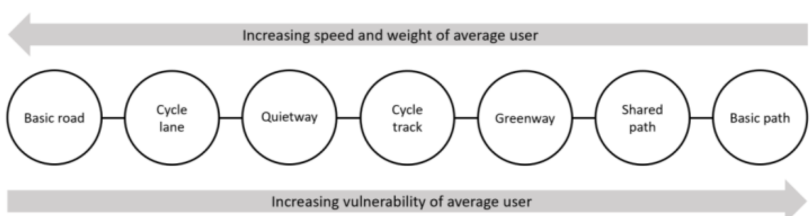
A new cycle facility typology has been developed for this study. It attempts to offer a greater level of resolution of cycle facility types than current guidance. It presents this in a hierarchy framed around cycling growth, a hierarchy that assumes an inherent value to growing cycling arising from the characteristics of a facility type, which can be applied to a corridor-led approach to implementation that seeks opportunities within a corridor to offer the best possible facility for that corridor rather than the best possible facility for a route. The typology will be used to identify which types of cycling facility best attract cyclists with early adopter characteristics, and the hierarchy used as a hypothesis against which to test different facilities in relation to one another.

The basis for the hierarchy is taken as Caulfield, Brick and McCarthy's (2012) study into preferences for different types of facility, which found that – other than for a small minority of vehicular cyclists – stated facility preference was in the following order, from most preferable to least preferable: off-road track, quiet street, cycle lane, bus lane and no facility. Further, Broach, Dill and Gliebe (2012) found cycle tracks preferred over cycle lanes in a revealed preference study.

It is observed that a speed-vulnerability differential appears to form the backbone of this preference, with infrastructure types that reduce exposure to faster, more fortified modes of transport (i.e. motor vehicles) faring better. This is likely to be as a result of relative feelings of physical comfort and safety, but may also result from the degree to which a cyclist feels like an outsider in the environment. The differences in speed and vulnerability between motor traffic and cycles makes a cyclist, to a car driver, both frustratingly slow and a relatively more burdensome responsibility. Where potential cyclists feel they will be unfavourably judged or made to feel like a nuisance or threat, they are unlikely to take up cycling. Early adopters have a particular sensitivity to how they are perceived by others in comparison to innovators (Rogers, 2003), and Steinbach et al. (2011) find that unconfident cyclists are particularly self-conscious of their cycling behaviour and wary of being socially deviant.

For this reason, it is hypothesised that the hierarchy may extend beyond the relationship between cyclists and motorists to additionally cover the relationship between cyclists and pedestrians. Here, roles are reversed – whilst motorists are four times faster and more fortified than cyclists, cyclist are four times faster and more fortified than pedestrians (Daley and Rissel, 2011). Cycling on pavements is viewed as unusual (Buehler and Dill, 2015) and has contributed to a poor public perception of cycling (McClintock and Cleary, 1996). It is hypothesised that the inconvenience and social outsidering that results from mixing with slower, more vulnerable pedestrians is also off-putting to early adopters. The proposed hierarchy model therefore takes on a mirror-image state, with cycle tracks in the centre and increasing exposure to motorists and pedestrians on either side. Whilst the pedestrian side of the hierarchy is presented below based upon theory, it was not possible to test as part of this study as no suitable survey sites were found within Surrey.

Fig. 1. Speed-vulnerability continuum



By developing a typology based upon this single speed-vulnerability continuum (fig. 1), cycle facilities can be matched to the model facility that they are most close to on the spectrum, and any cycle facilities not here identified can be placed within the typology. This creates an exhaustive typological method. A description of the classes of cycling facilities that have been identified in a more detailed typology are presented in Table 1, and are adapted from Caulfield, Brick and McCarthy (2012).

The concept facility hierarchy is shown in fig. 2. It has some similarities with the Department for Transport's (2008) hierarchy in that both suggest quiet routes are preferable to cycle lanes, and both suggest shared pavements are less preferable than cycle tracks. However, it differs in suggesting that cycle infrastructure is preferable to on-road facilities, and that some types of infrastructure are more beneficial than others in terms of growing rates of cycling.

Fig 2. Concept facility hierarchy

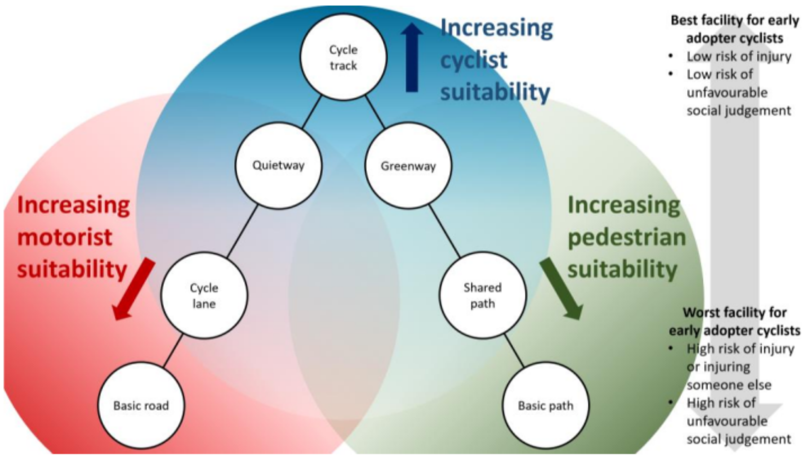


Table 1: Detailed cycle facility typology

Facility type	**Defining characteristics**
Basic road  Fig. 3. Basic road. Camberley, Surrey. Source: author.	All vehicles (cyclists and motor traffic) share one carriageway. Bicycles are a form of vehicle in UK law and are permitted to use any UK road, with the exception of motorways. Basic roads are the default cycle network.

<table>
<tr><th>Facility type</th><th>Defining characteristics</th></tr>
<tr><td>Bus and cycle lane


Fig. 4. Bus and cycle lane. Crystal Palace, London. Source: author</td><td>Cyclists share a traffic lane with buses (and limited other types of vehicle where designated). This reduces the quantity of vehicles cyclists share a lane with, although the stop-start nature of bus movements creates a need to continually pull out into a regular traffic lane to overtake buses at bus stops.</td></tr>
<tr><td>Advisory cycle lane

Fig. 5. Advisory cycle lane. Reigate, Surrey. Source: author.</td><td>A marked lane for cyclists within the carriageway. Dashed lines denote the lane as advisory, allowing motor traffic to use the lane space when regular traffic lanes are obstructed or narrowed. The lane can be used for vehicle parking unless separate traffic restrictions are applied – as with combined bus and cycle lanes above, this creates a need to pull out into a regular traffic lane to overtake.</td></tr>
<tr><td>Mandatory cycle lane

Fig. 6. Mandatory cycle lane. Knaphill, Surrey. Source: author.</td><td>A marked lane within the carriageway that is exclusively for the use of cyclists. An unbroken white line separates cyclists from motor traffic. Cyclists remain in close proximity to motor traffic, and mandatory lanes are, in practice, subject to occasional incursions from motor traffic.</td></tr>
</table>

Facility type	Defining characteristics
Quietway  Fig. 7. A quietway, created through traffic calming and management of through-traffic. Walthamstow, London. Source: author.	A route where motor traffic speeds and volumes are both sufficiently low as to be similar to the speeds and volumes of cycle users, which all but eliminates interactions between motor traffic and cyclists. Cyclists remain on-carriageway. Quietways may or may not feature cycle lane markings: in UK practice quieter roads typically do not have cycle lane markings, conversely in Dutch practice cycle lane markings are only ever used on roads that have quietway characteristics (Furth, 2012).
Cycle track  Fig. 8. Cycle track. Leyton, London. Source: author.	A carriageway dedicated to bicycles – typically narrower and designed only for lighter-weight traffic in comparison with a regular road's 'heavy' carriageway. There is a material separation from both this heavy carriageway and footways through the use of verge-type features or a height differential to reserve the space. Cycle tracks may be uni- or bi-directional.
Greenways and urban greenways  Fig. 9. Urban greenway. Kingston, London. Source: author.	A path shared by pedestrians and cyclists, typically with sufficient width for travellers to pass and overtake comfortably. The path is away from buildings, which results in less conflict because there are fewer pedestrians and milling behaviour is minimal. Whilst typically employed as a term for rural routes, which often follow canals and railway trackbeds, it also accurately describes wide urban paths away from roads, such as the one pictured and termed here 'urban greenways'. Also includes routes through parks.

Facility type	**Defining characteristics**
Segregated shared pavement  Fig. 10. Segregated shared pavement. Woking, Surrey. Source: author.	A pavement alongside a road, with a solid divider line to separate the facility into two such that pedestrians and cyclist each have their own side of the path. As these facilities tend to be converted from existing pedestrian facilities, they are often relatively narrow which creates conflict (and can also bring cyclists in a proximity to motor traffic similar to that of a cycle lane). Where volumes of movements by one mode dominate over the other, or where there is very low traffic of either mode, observation of the distinction between the two sides is thought to be low, however the divison offers some reasurance to self-conscious cyclists as well as pedestrians with mobility, sight or hearing difficulties.
Shared pavement  Fig. 11. Shared pavement. Camberley, Surrey. Source: author.	A pavement alongside a road where cycling is explicitly permitted, similar in many respects to a segregated shared pavement (above) but without a dividing line. It too can place cyclists in close proximity to traffic such that the facility has a similar feel to a cycle lane.
Pavement  Fig. 12. A cyclist riding on a pavement. Crystal Palace, London. Source: author.	A pavement alongisde a road: a refuge for pedestrians from faster moving and more fortified vehicle traffic. It is not legal for adults to cycle on pavements; likewise it is often considered socially unacceptable. It is used by a facility, however, by some cyclists that do not wish to travel in the road, and by those accompanying children. In built up areas with buildings, pedestrian milling behaviour and driveways create particular conflict (as they do for shared pavements and segregated shared pavements, above).

Case context

Cycling in Surrey

Surrey is a relatively affluent county to the immediate southwest of London, UK. Where the county borders London, settlements are reasonably (and increasingly) contiguous and urban. Further away from London, the county adopts a rural character of villages and medium-sized towns.

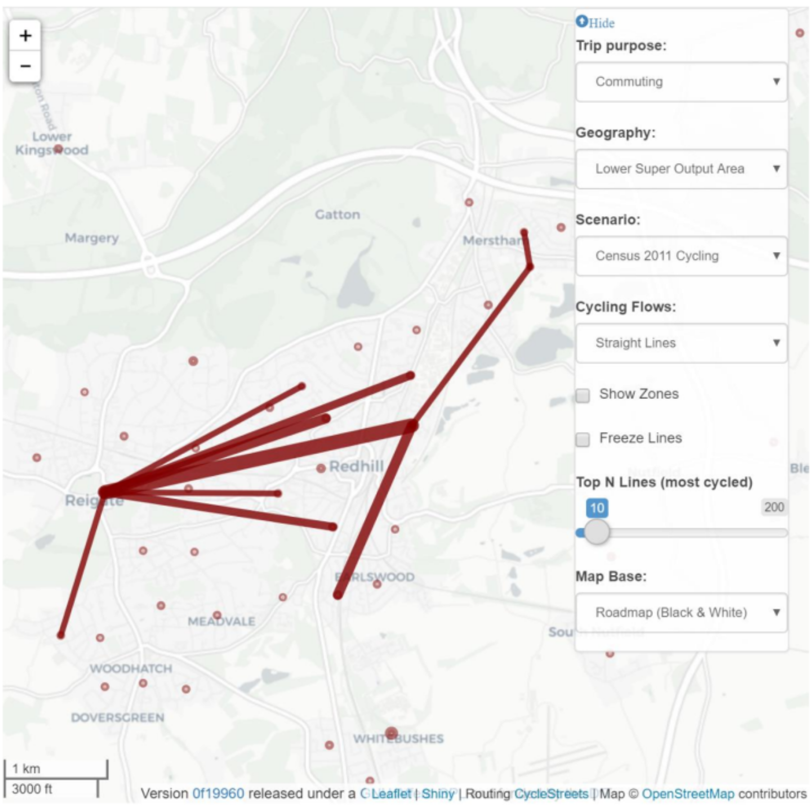
Cycle rates in Surrey are low, as is typical for a polycentric non-city region (Department for Transport, 2019a). Department for Transport statistics (ibid.) estimate that 3% of Surrey residents use a bicycle as a means of transport at least three times per week, which is slightly below the south east regional average (3.6%) and the English national average (3.2%). However, the proportion of people who use a bicycle once per month for any purpose (19.4%) is higher than the regional and national averages (18.2% and 16.1% respectively, ibid.). This suggests that there is considerable opportunity to grow rates of cycling, as there are many occasional cyclists who have the skills, equipment and inclination to cycle but who are not routinely cycling shorter journeys in place of travelling by car. Whilst parts of Surrey have a rural character, there are still many short distance journeys that could be cycled – for instance Grudgings (2018, p.93) identifies 173,000 commuter journeys in Surrey are between 2km and 5km in length – compared to an estimated total resident population of 1.2 million people (Surrey County Council, 2019c).

Surrey County Council, like many local authorities, has invested in link cycling infrastructure to encourage growth in cycling rates however cycling rates have remained relatively low. Grudgings (2018), writing as a Research Engineer employed by Surrey County Council, concluded a doctoral thesis that the county's cycling infrastructure needed to be accommodating of a wider diversity of user needs (specifically using women cyclists' needs as an exemplar under-represented group) if it was to be effective at increasing rates of cycling – a conclusion which has informed the topic of this study.

Survey corridor

Reigate and Redhill are two adjacent Surrey towns that form a contiguous built-up area. The two urban centres are separated by around 3km, and as such it is practical for the most part to make a cycle trip between any two points in either town. A visualisation created by the Propensity to Cycle Tool (PCT, 2019) shows that current commuter cycle flows in the area are dominated by demand to travel on the corridor between the two towns (fig. 13). Data is not available for off-peak trips, but is assumed to be similar given the strong travel demand anchors of the two town centres at either end of the corridor.

Fig. 13. Current cycle flows in Reigate and Redhill, Surrey (Propensity to Cycle Tool visualisation).

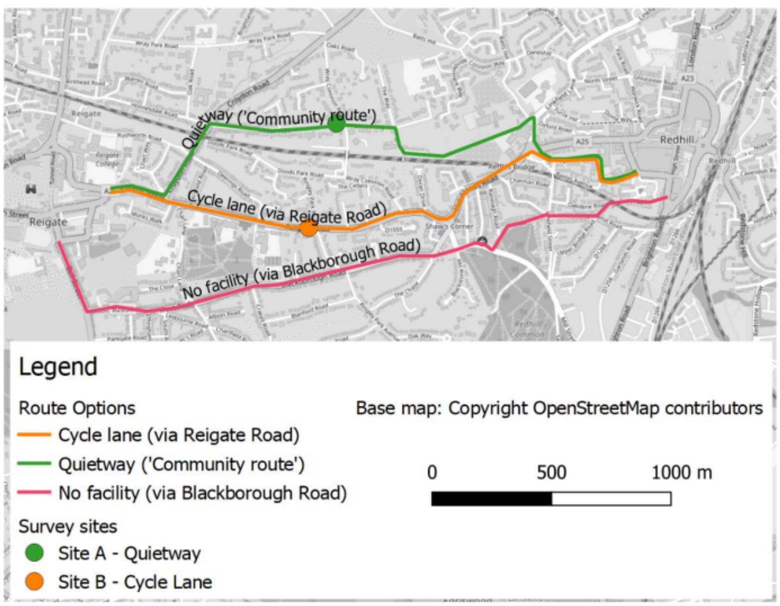


The corridor between the two towns is taken as corridor one for this study. Surrey County Council promote three linear routes of similar distance along this corridor for walking and cycling in publicity that has been distributed locally and which is available online (Surrey County Council, n.d.). The Reigate Road route has a cycle lane facility (fig. 14), and a second route running along Doods Road and Madeira Walk has been designated a quietway (fig. 15), with commensurate infrastructure improvements along the route. These two facilities were chosen for comparison on this corridor. A survey cordon was set up midway between the towns on both routes. The routes and cordon locations are shown in fig. 16.

Fig. 14. Reigate Road survey site.
Source: author

Fig. 15. Quietway survey site.
Source: author

Fig. 16. Routes between Reigate and Redhill. Adapted from Surrey County Council (n.d.)



Findings and analysis

Observation study

The observation studies found very similar numbers of cyclists used the quietway route (84 users) and the cycle lane (83 users) during the survey period, but that there were some differences between who was using the facilities, based upon the observed characteristics.

For two of the three measures –age and clothing – the results supported the hypothesis that the quietway would attract a greater proportion of users that did not conform to MAMIL cycling culture.

Whilst 86% of cycle lane users were observed as being between 30 and 60 years old, the proportion was much reduced on the quietway where 52% of cyclists were aged between 30 and 60. There was a larger proportion of younger people using the quietway route – 42% of cyclists, compared with 8% for the cycle lane – a result found to be significant at the 99% confidence interval.

$$\frac{|\ 0.42 - 0.08\ |\ \sqrt{84}}{0.495967676} = 6.28$$

$$p < 0.01$$

The proportion of persons observed as being aged over 60 was consistent for both facilities.

There was a strong trend for those using the quietway to not wear specialist cycling clothing, whereas this was the most common clothing option for those on the cycle lane.

95% of quietway users did not wear bespoke clothing, compared to 64% on the cycle lane. This result was found to be significant at the 99% confidence interval level.

$$\frac{|\,0.95 - 0.64\,|\,\sqrt{84}}{0.214237899} = 13.26$$

$$p < 0.01$$

Similarly, 52% of quietway users were without helmets or other removable cycle clothing accessories, compared to 33% on the cycle lane, and this result was also significant at a 99% level of confidence.

$$\frac{|\,0.52 - 0.33\,|\,\sqrt{84}}{0.502432408} = 3.47$$

$$p < 0.01$$

This suggests that people who are newer to cycling, or not part of the MAMIL culture, prefer the quietway facility.

For the final observed characteristic, gender, It was expected that the preference observed in women for low levels of traffic interaction in previous studies would lead to a preference for the quietway, but a higher proportion of women were observed using the cycle lane (19%) than the quietway (12%). A two-tailed *t*-test found that this result may have been the result of random sampling fluctuations, however, so the result for variations in observed gender by facility were inconclusive.

$$\frac{|\,0.12 - 0.19\,|\,\sqrt{84}}{0.325789566} = 1.97$$

$$p > 0.05$$

The results are summarised in Table 2.

Survey

Twenty-three of the cyclists observed on the quietway (27%) and 16 cyclists on the cycle lane route (19%) agreed to stop for to answer survey questions.

One question asked respondents to describe why they chose to cycle the route that they did, in their own words. Responses were analysed to identify common influencing factors, presented in table 3. Some respondents noted multiple factors, and some factors (such as low traffic and safe/pleasant) overlap.

Table 2. Results – observation study.

	Quietway	Cycle Lane
Observed gender		
Male	74 *(88%)*	67 *(81%)*
Female	10 *(12%)*	16 *(19%)*
Observed age		
Under 30 years	35 *(42%)*	7 *(8%)*
30 – 60 years	44 *(52%)*	71 *(86%)*
Over 60 years	5 *(6%)*	5 *(6%)*
Clothes		
Everyday	44 *(52%)*	27 *(33%)*
Augmented	36 *(43%)*	26 *(31%)*
Cycling	4 *(5%)*	30 *(36%)*
Sample size	**84**	**83**

Table 3. Factors that positively influenced route choice

Factor	Quietway	Cycle lane
Quickest or most direct	17 *(74%)*	11 *(69%)*
Low traffic	10 *(43%)*	0 *(0%)*
Safe/pleasant	7 *(30%)*	0 *(0%)*
Prefers vehicular cycling	0 *(0%)*	2 *(13%)*
Regular training circuit	0 *(0%)*	2 *(13%)*
No alternative known	0 *(0%)*	1 *(6%)*
Gradient	0 *(0%)*	1 *(6%)*
Errands en-route	1 *(4%)*	0 *(0%)*

Two questions sought to ascertain, between them, whether there is any overlap between the generic trip purposes supposed by traditional user typologies. Respondents were asked whether or not they agreed with each of the following statements: 'I am cycling to get somewhere' and 'I am cycling because I enjoy it as an activity'. The results are presented in table 4.

Table 4. Cyclist motivations

Statement agreed with	Quietway	Cycle lane	Total
Cycling to get somewhere (only)	3 *(13%)*	3 *(19%)*	6 *(15%)*
Cycling to enjoy it (only)	0 *(0%)*	2 *(13%)*	2 *(5%)*
Both	20 *(87%)*	10 *(63%)*	30 *(77%)*
Neither	0 *(0%)*	1 *(6%)*	1 *(3%)*

The results show that most cyclists on both types of facility do not recognise the distinction between these two cycling purposes, and supports Boyer's (2018) comment that most cyclists wouldn't recognise the artificial distinctions drawn between transportation and leisure cycling.

GIS route analysis

Figures 17 and 18 show the shortest path routes between origin and destination that passed the cyclist's survey site for the quietway and cycle lane routes respectively at the same scale, based on origin, destination and shortest path analysis. Figure 19 shows the cycle lane paths at a smaller scale, as some of these journeys were substantially longer. Three journeys that passed the cycle lane could not be plotted according to this study's methodology as they were circular (joyride) routes that started and ended at the same point.

Journeys that used the cycle lane had a greater range of calculated trip lengths (based on shortest paths between origins, destinations and survey point), but were also typically longer. Figure 20 plots a comparison between the trip length distributions of both sites. The three circular journeys that could not be analysed through the shortest path method will also have been longer journeys, meaning the cycle lane results are likely to be on the conservative side.

Fig. 17 – Map of journeys passing through quietway survey site

Fig. 18 – Map of journeys passing through cycle lane survey site

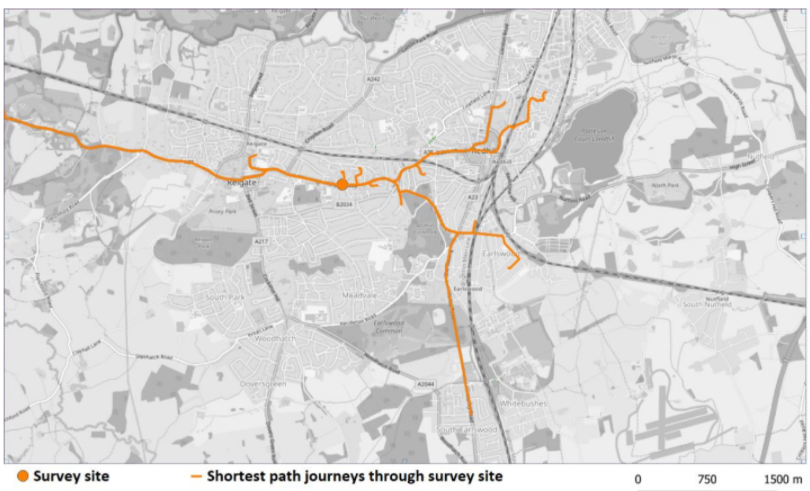


Fig. 19 – Map of journeys passing through cycle lane survey site – reduced scale

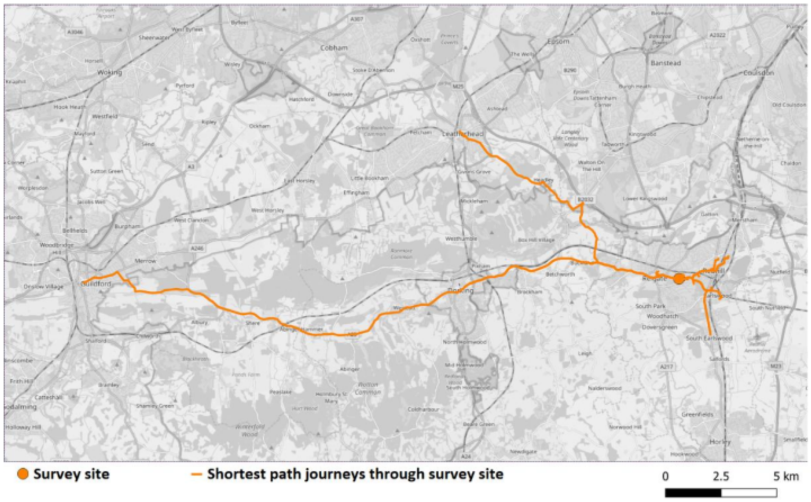
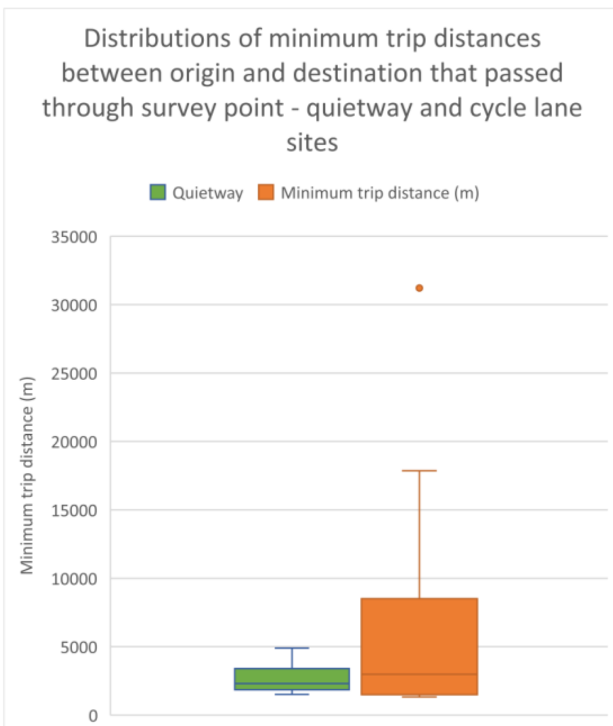


Fig. 20 – Trip length distributions at survey sites



For the longer distance journeys, the exitance of the cycle lane facility on the Reigate Road is relatively insubstantial – the great majority of the journey will be on roads with no cycle facility at all. Many of the journeys catered for by the cycle lane are beyond the means or interests of an occasional or novice early adopter cycler – the quietway appears to attract journeys more of this nature, in terms of trip length. The mean calculated trip length for quietway trips was 2.6km; for the cycle lane 4.6km (excluding outlier value and the three trips with no data).

The GIS shortest path analysis was also able to identify where a cyclist was not using the most direct route, and how much they had deviated from the most direct route to use the facility. It is proposed that the further and more often facilities attract cyclists off their most direct path, the greater value cyclists place in the existence of the facility.

It was found that the quietway attracted four cyclists off their most direct path, away from the Reigate Road cycle lane facility and an unadapted route to the north of the quietway along Croydon Road and Batts Hill; the cycle lane attracted one cyclist away from an unadapted route to the south along Cockshot Hill and Woodhatch Road, but did not attract any cyclists away from the quietway.

For the survey respondents who did not take the most direct route, their answers to survey questions on gender, age and clothing choice were used to create a 'MAMIL' score that ranged between 0 and 3, where the following responses each contributed 1 to their overall MAMIL score: male; aged 30-60; wearing bespoke cycling clothing. Lower MAMIL scores indicate the respondent is more likely to be an 'early adopter'. There was a preference amongst those with lower MAMIL scores to use the quietway instead of the cycle lanes, but there were only two such data points.

The deviations are presented in table 5. This methodology assumes that the cyclist had knowledge of the route that they were avoiding. Deviations of less than 1% additional distance were ignored.

Table 5 – Deviations from shortest route

Distance, route taken (m)	Distance, shorter route (m)	Additional distance, as % of shorter journey length	Route avoided (and facility type)	MAMIL score
		--- Quietway ---		
2366	2252	5%	Croydon Road etc. (basic road)	2
4897	4688	4%	Reigate Road (cycle lane)	1
2101	1818	16%	Reigate Road (cycle lane)	1
2475	2200	13%	Croydon Road etc. (basic road)	2
		--- Cycle lane ---		
18330	17228	6%	Cockshot Hill etc. (basic road)	2

Discussion and conclusions

These findings allow some conclusions related to the studies principle research aims to be drawn.

With regards establishing whether cycle facility type influences the degree of success new cycle infrastructure has on encouraging more people to cycle, it is found that whilst both facilities a very similar number of cyclists (84 cyclists on the quietway; 83 on the cycle lane), there were significant differences between the key measured characteristics of cyclists that used the facility suggesting that the two facilities differ in their ability to encourage more people to cycle.

Secondly, with regards investigating which cycle facility types are preferred by 'early adopter' cyclists, and whether this supports the infrastructure hierarchy model proposed in this paper, it is found that the quietway facility is preferred by such cyclists and this supports the placement of a quietway as a superior facility on the proposed cycling growth facility hierarchy. The evidence for this is that significantly more cyclists were observed on the quietway facility who were aged under 30 and/or wearing everyday clothes, the facility was attractive to cyclists who prefer low-traffic environments and those cyclists undertaking shorter, more manageable trips.

Finally, it has been found that cyclists, including potential early adopters, will go out of their way to use the quietway facility, preferring it over unaltered roads and the cycle lane.

A review of academic literature raised questions on whether the UK's principle guidance on cycle infrastructure (Department for Transport, 2008) is correct in prioritising on-road cycling, discouraging infrastructure measures and advocating for site-specific solutions targeted at specific user groups (where these user groups are identified by trip characteristics) if the objective of cycle measures is to grow rates of cycling. This is principally because growth in rates of cycling is likely to arise from identifying and catering to the needs of occasional cyclists and those outside of the dominant 'MAMIL' vehicular cycling culture. Conversely, the guidance has overemphasised the importance of the latter culture, it is thought partly because the guidance's underlying philosophy was inherited from previous guidance developed by a group that lacked 'outsider' voices, and partly as a matter of convenience – data is more readily available on vehicular cycling, and infrastructure measures are more costly and disruptive than on-road cycling.

Whilst there is a role for user-led design as advocated by the guidance, the classification of users needs to move away from trip motivations and characteristics which this study finds evidence to suggest creates false distinctions between cycling for transport and pleasure. Instead, user classifications should be based upon adopter categories, if measures that have the greatest effect on increasing rates of cycling are to be prioritised.

This study has found that users that display characteristics that indicate that they may belong to a category of early adopters – the social group that cycling needs to be built to appeal to and accommodate to increase cycling beyond current levels – significantly preferred quietway infrastructure to on-road cycle lanes, choosing it because it was low-traffic, more pleasant and more direct and choosing to go out of their way to use the facility in place of cycle lanes or other on-road alternatives. The quietway appears to be better matched with cycle journey distances that have the greatest potential for growth, too. Whilst a preference for low-traffic cycling is consistent with UK guidelines in that these currently place lowering traffic speeds and volumes at the top of the intervention hierarchy, but inconsistent in that the guidance avoids considering this as an infrastructure intervention and setting out the characteristics that distinguish a quietway from (for example) a roads where a speed limit is reduced. The same philosophy has caused the guidance not to develop a standardised typology of cycle infrastructure, however where this has meant cycle measures are delivered inconsistently there will be a suppression effect on rates of cycling as social norms are not established, individual pieces of infrastructure are notably quirky and as toe-dipping cyclists may initially be confounded in how to optimally use of them.

The scope of this study only afforded the opportunity for one relationship within the hierarchy to be tested. Other facility types within the typology and hierarchy now need subjecting to similar studies. Such studies could improve on this one with longer survey periods that yield greater sample sizes, and that capture data for weekends and throughout the year. Despite it being harder to identify suitable survey sites, this study has shown that the comparative observation study method pioneered in Dublin and London can be operationalised in non-city regions too.

It is concluded that UK cycle guidance has limited rates of cycling growth, by not identifying what measures would be most effective at growing rates of cycling, promoting measures that reinforce an existing cycling clique and the perceptions that arise from it that cycling is difficult and for 'someone else' and encouraging a piecemeal, route-based approach.

It is recommended that UK guidance use adopter categories to ensure cycle measures are targeted at opportunities to grow rates of cycling, which is likely to see a shift away from on-road cycling based upon the results of this study and others. It is further recommended that UK guidance recognises the importance of consistent cycling infrastructure design in the social norming of cycling, and as such should develop a facility typology. A typology is proposed in this study, based upon a speed-vulnerability continuum. Finally, guidance should recognise that different types of cycling infrastructure have varying degrees of effectiveness at encouraging new and occasional cyclists to switch to the bicycle for trips where this is practical – which might involve further research int and development of the hierarchy proposed in this study. As a consequence, guidance should recommend that infrastructure is planned on a corridor basis, where the route which is best able to accommodate a cycle facility of the highest type on an infrastructure hierarchy is selected and modified, rather than a route-led approach.

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Appendix 1

UCL risk assessment

RISK ASSESSMENT FORM

FIELD / LOCATION WORK

The Approved Code of Practice - Management of Fieldwork should be referred to when completing this form

http://www.ucl.ac.uk/estates/safetynet/guidance/fieldwork/acop.pdf

DEPARTMENT/SECTION BARTLETT SCHOOL OF PLANNING

LOCATION(S) ROAD SIDE LOCATIONS IN SURREY (VARIOUS, PUBLIC)

PERSONS COVERED BY THE RISK ASSESSMENT Douglas Tremellen (student)

BRIEF DESCRIPTION OF FIELDWORK

Consider, in turn, each hazard (white on black). If **NO** hazard exists select **NO** and move to next hazard section.

If a hazard does exist select **YES** and assess the risks that could arise from that hazard in the risk assessment box.

Where risks are identified that are not adequately controlled they must be brought to the attention of your Departmental Management who should put temporary control measures in place or stop the work. Detail such risks in the final section.

ENVIRONMENT	The environment always represents a safety hazard. Use space below to identify and assess any risks associated with this hazard
e.g. location, climate, terrain, neighbourhood, in outside organizations, pollution, animals.	Examples of risk: adverse weather, illness, hypothermia, assault, getting lost. Is the risk high / medium / low ? NO environment related risk

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk

☐	work abroad incorporates Foreign Office advice
☐	participants have been trained and given all necessary information
☐	only accredited centres are used for rural field work
☐	participants will wear appropriate clothing and footwear for the specified environment
☐	trained leaders accompany the trip
☐	refuge is available
☐	work in outside organisations is subject to their having satisfactory H&S procedures in place
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

EMERGENCIES	Where emergencies may arise use space below to identify and assess any risks
e.g. fire, accidents	Examples of risk: loss of property, loss of life

Low risk of witnessing or becoming involved in a road accident, low risk of creating a distraction to road uses and cyclists.

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk

☐	participants have registered with LOCATE at http://www.fco.gov.uk/en/travel-and-living-abroad/
☐	fire fighting equipment is carried on the trip and participants know how to use it
☐	contact numbers for emergency services are known to all participants
☐	participants have means of contacting emergency services
☐	participants have been trained and given all necessary information
☐	a plan for rescue has been formulated, all parties understand the procedure
☐	the plan for rescue /emergency has a reciprocal element
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

The research will be conducted in public places, the researcher has means of contacting emergency services, efforts will be made to avoid creating a distraction for drivers beyond activity that could typically and reasonably expected to occur at a roadside.

EQUIPMENT	Is equipment used?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. clothing, outboard motors.	Examples of risk: inappropriate, failure, insufficient training to use or repair, injury. Is the risk high / medium / low ?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for equipment is followed
☐	participants have been provided with any necessary equipment appropriate for the work
☐	all equipment has been inspected, before issue, by a competent person
☐	all users have been advised of correct use
☐	special equipment is only issued to persons trained in its use by a competent person
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

LONE WORKING	Is lone working a possibility?	YES	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. alone or in isolation *lone interviews.*	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

Low risk. Surveys will be conducted in public, well frequented places in daylight.

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for lone/out of hours working for field work is followed
☐	lone or isolated working is not allowed
☐	location, route and expected time of return of lone workers is logged daily before work commences
☐	all workers have the means of raising an alarm in the event of an emergency, e.g. phone, flare, whistle
yes	all workers are fully familiar with emergency procedures
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

ILL HEALTH	**The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.**
e.g. accident, illness, *personal attack, special personal considerations or vulnerabilities.*	Examples of risk: injury, asthma, allergies. Is the risk high / medium / low? low
CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**

☐	an appropriate number of trained first-aiders and first aid kits are present on the field trip
yes	all participants have had the necessary inoculations/ carry appropriate prophylactics
☐	participants have been advised of the physical demands of the trip and are deemed to be physically suited
☐	participants have been adequate advice on harmful plants, animals and substances they may encounter
☐	participants who require medication have advised the leader of this and carry sufficient medication for their needs
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

The research will be suspended in instances of ill health.

TRANSPORT	**Will transport be required**	**NO**		**Move to next hazard**
		YES	**YES**	**Use space below to identify and assess any risks**
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low? low			
CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**			

yes	only public transport will be used
☐	the vehicle will be hired from a reputable supplier
☐	transport must be properly maintained in compliance with relevant national regulations
☐	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php
☐	drivers have been trained and hold the appropriate licence
☐	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
☐	sufficient spare parts carried to meet foreseeable emergencies
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	Will people be dealing with public	YES	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low? Low risk of personal attack, causing offence, being misinterpreted.		
CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**		

☐	all participants are trained in interviewing techniques
☐	interviews are contracted out to a third party
☐	advice and support from local groups has been sought
yes	participants do not wear clothes that might cause offence or attract unwanted attention
yes	interviews are conducted at neutral locations or where neither party could be at risk
yes	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

Researcher will be clear about the purpose of the study, information will not be sought from those who are unwilling to give it, interactions to occur in a well-frequented public place.

WORKING ON OR NEAR WATER	Will people work on or near water?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		
CONTROL MEASURES	**Indicate which procedures are in place to control the identified risk**		

☐	lone working on or near water will not be allowed
☐	coastguard information is understood; all work takes place outside those times when tides could prove a threat
☐	all participants are competent swimmers
☐	participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
☐	boat is operated by a competent person
☐	all boats are equipped with an alternative means of propulsion e.g. oars
☐	participants have received any appropriate inoculations
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for MH is followed
☐	the supervisor has attended a MH risk assessment course
☐	all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
☐	all persons performing MH tasks are adequately trained
☐	equipment components will be assembled on site
☐	any MH task outside the competence of staff will be done by contractors
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	Will participants work with substances	NO	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangements for dealing with hazardous substances and waste are followed
☐	all participants are given information, training and protective equipment for hazardous substances they may encounter
☐	participants who have allergies have advised the leader of this and carry sufficient medication for their needs
☐	waste is disposed of in a responsible manner
☐	suitable containers are provided for hazardous waste
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	**Have you identified any other hazards?**	**NO**	**If 'No' move to next section** **If 'Yes' use space below to identify and assess any risks**
i.e. any other hazards must be noted and assessed here.	Hazard: Risk: is the risk		

CONTROL MEASURES	**Give details of control measures in place to control the identified risks**

Have you identified any risks that are not adequately controlled?	**NO**	**NO** ☐	**Move to Declaration**
	~~**YES**~~	☐	**Use space below to identify the risk and what action was taken**

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research?	no

If yes, please state your Project ID Number

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION	The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

- ☐ I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
- ☐ I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR

**** SUPERVISOR APPROVAL TO BE CONFIRMED VIA E-MAIL ****