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Adults' attitudes towards child cycling: a study of the impact of infrastructure

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Research on cycle infrastructure preferences generally suggests a preference for off-road cycle infrastructure and segregation from motor traffic, among both existing cyclists and non-cyclists. However, studies have so far not explored how the presence of children might shape adults' attitudes to cycle infrastructure. Similarly, studies on the determinants of child cycling have not as yet looked in depth at the impact of parental attitudes to specific infrastructure types. This paper reports on an online survey about how people's preferences might vary, depending on whether they were making a cycle journey alone, travelling with a child, or considering whether to let an older child travel alone. Respondents were also asked whether they thought each of ten infrastructure scenarios were suitable for 'most people'. The paper discusses findings from the online survey, identifying changes in preferences and investigating subgroup variation. The presence of children makes a major difference to people's willingness to cycle in the more challenging situations. There is substantial consensus across subgroups over the extent to which the various examples are suitable for cycling with children.

Keywords: *Britain, Children, Cycle Infrastructure, Cycling, Gender, Survey.*

1. Introduction

While cycling in the UK remains very low in a European context, some cities are investing more in cycling and seeking to develop better infrastructure standards (Butcher 2012, GLA 2013). However, as in other traditionally low-cycling countries, cities are struggling in the face of political obstacles and the persistence of inherited approaches now widely criticised. Britain's national cycle design guidance (known as LTN, Local Transport Note, 2/08) contains a general presumption against segregating cyclists from motor traffic, based partly on experience with often poor-quality 'segregated' designs (Aldred 2012).

Child cycling is often cited as a policy goal, with perceived benefits related to health, congestion reduction, and the promotion of lifelong sustainable travel habits. The Scottish Government's 2010 Cycling Action Plan stated (2010:4) that 'we want to increase [cycling to school] and to encourage those children to become cycling adults'; the current (2013) plan repeats this aspiration saying that 'Children and Young People are a core group of cyclists' (Annex G). England's nationally funded cycle training scheme ('Bikeability'), while available to adults, is largely aimed at getting children cycling through on-road training. However, increasing child cycling has proved particularly challenging. While some metropolitan areas in the UK have seen an uptake in adult commuting between 2001 and 2011 (Goodman 2013), rates of children cycling to school have barely shifted (DfT 2012).

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While not the only determinant of child cycling, one important factor is parental concern about children's safety in traffic situations. In low-cycling contexts this looms large, although many children want to ride to school (Lorenc et al 2008). Britain has seen a long-term increase in car dependency and concomitant decline in children's mobility, as parents increasingly escort children, often by car, for educational journeys (Shaw et al 2013). Only around 2-3% of UK children cycle to school (DfT 2012) compared to 49% of all Dutch primary school children (Fietsberaad 2009).

More research is needed on the issue, and this paper begins to address a dual gap. Firstly, the literature on the determinants of child cycling includes little on parental attitudes to specific types of infrastructure. Secondly, the literature on cycle infrastructure preferences does not as yet cover preferences related to the presence of children. In response this paper explores how the presence of children might affect people's attitudes towards cycling in different infrastructural contexts.

2. Literature review

2.1 Determinants of child cycling

As outlined above, this paper is positioned in relation to two sets of academic literature. The first relates to determinants of child cycling, an increasing area of interest to public health. Much work in the area treats child cycling and walking together with 'active commuting' the variable of interest (e.g. Kerr et al 2006, Carlson et al 2014). In low-cycling contexts, this has generated findings most relevant to walking; as levels of cycling within samples are often too small for independent analysis. For example, in Hume et al's (2009) Australian study of changes in levels of active commuting to school, only around one in eight 'active commutes' was by bicycle.

Focusing on cycling to school in Australia, Trapp et al (2011) found substantial suppressed demand, with parental traffic fears acting as a key barrier. While only 31.2% of boys and 14.6% of girls cycled to school once a week or more, 59.4% of boys and 36.7% of girls said it was their preferred school transport mode. Trapp et al (2011) comment on the limited understanding of determinants of cycling to school: 'Since few studies have specifically examined [it], most survey items were newly developed or modified from existing items regarding walking to school.' This meant for example using walkability measures rather than measures related to quality of cycling environment.

Also in Australia, Wati et al (2013) found significant associations between children's cycling for transport and a child's gender, the urban environment type, vehicle ownership and parental and child perceptions of safety. Similar themes have been found across the active commuting literature, as has distance. D'Haese et al (2011) found that household distance from school is an important correlate of children's transport mode to school, concluding that interventions should focus on shifting shorter trips to school still made by motorised modes.

Writing in the Flanders context (over 60% of children cycled to school at least some of the time) and focusing on those always or never cycling to school, Ducheyne et al (2012) concluded that 'the contribution of the physical environment […] within a criterion distance of 3.0 km' is limited. By contrast literature from lower-cycling contexts, where existing infrastructure is often poorer, tends to foreground infrastructural factors. Drawing conclusions from an English study that found both attitudinal and infrastructural correlates of child cycling, Panter et al (2010) argue that because of the difficulty in directly modifying attitudes, research should examine how different environments affect attitudes towards child cycling.

In sum, the literature on child cycling establishes a range of potential influencing factors, which vary by context, both nationally and within a country. A good quality cycling environment may be a necessary but not sufficient condition. Mäki-Opas et al (2014) conclude from their study of

young people from two ethnic minority groups in Amsterdam that 'when individuals from a non-cycling culture are exposed to a bicycle-friendly infrastructure or an enjoyable environment, these physical environments are not alone sufficient.' It is necessary to be cautious in interpreting findings in relation to (a) other contexts and (b) the impact any recommended interventions may have.

2.2 Infrastructural preferences

Another relevant body of work specifically focuses on cycle infrastructure preferences, and is more aligned to the transport literature. This has led to a broad academic consensus that most people prefer to cycle away from motor traffic, or in environments with low levels of motor traffic. Research involving a range of contexts and methods supports this, in relation both to current and potential cyclists (e.g. Björklund and Isacsson 2013, Broach et al 2012, Caulfield et al 2012, Pooley et al 2013, Steer Davies Gleave 2012, Wang et al 2012, Winters and Teschke 2010). Most studies that examine gender differences find women have stronger preferences for separation from motor traffic than men (e.g. Beecham and Wood 2014, Garrard et al. 2008, Heesch et al. 2012, Krizek et al. 2006, Steer Davies Gleave 2012, Twaddle et al. 2013 – although see Broach et al. 2012 for an exception).

Perceived motor traffic danger is cited as a major barrier to both adult and child cycling in countries such as Britain. This suggests that improvements in cycle infrastructure and cycle safety could be part of the solution to very low rates of child cycling. Yet there is little detailed research looking at what kinds of cycle infrastructure are perceived to be safe for child cycling, and how they compare to solo adult infrastructural preferences. In one of the few route choice studies to discuss the issue, Dill and Gliebe (2008:39) found that:

'Riding [...] with a child appears to influence route choice [...] avoiding streets with lots of traffic became significantly more important, averaging over 4 on a 1-5 scale. Minimizing distance was also important. Riding on a path or trail was also significantly more important if a child was on the trip than if not, as was avoiding hills.'

However there were only 87 trips with a child in Dill and Gliebe's dataset, made by 11 participants. This is part of a broader problem. In low-cycling countries, precisely where there is the greatest need to explore what infrastructural changes may contribute to increasing child cycling, the levels of child cycling are so low that the collection of data evidencing actual behaviour is difficult, as opposed to asking people about hypothetical preferences.

Writing from the higher-cycling Belgian context, Ghekiere et al (2014) focus on the impact of micro-cycling environments on child and adult views about cycling. They conducted innovative research (qualitative interviews using video recordings of participants' journeys), finding parental perceived safety a major concern affecting cycling among 10-12 year olds. Infrastructural types mattered: children and parents 'felt more comfortable when there are cycle facilities, separated from the road [...] Cycle lanes on the road were viewed less favorably than separated cycle tracks' (Gherkiere et al 2014: 4). The authors comment (2014: 1) that 'future studies should investigate whether hypothetical changes to such micro environmental features influence perceptions of safety'.

There remains relatively little research on the impact of different interventions (infrastructural or otherwise) on child cycling levels. Ducheyne et al (2014) examined child cycle training, finding it was (2014:60) 'effective in improving children's cycling skills [but without] increasing children's cycling to school levels.' They draw the conclusion that cycle training is useful but should not be seen as a means of increasing cycling. Panter et al argue that (2013: 10) 'interventions which focus on road safety may [...] be particularly efficacious', but note that few robust studies of high quality interventions have been conducted.

Interventions in a series of English towns and cities have been associated with an increase in cycling to work (Goodman et al 2013) although based upon successes in only some places.

Complex causation complicates measuring the impacts of changes: increased cycling may lead to increased policy interest and funding, which could then increase cycling. One attempt to explore this used complex system modelling in the New Zealand context, finding that small improvements had little impact on cycling levels: transformative change was needed for cycling levels to move sustainably upwards (Macmillan et al 2014).

Culture mediates the impacts of interventions (Aldred and Jungnickel 2014). Reviewing Dutch cycle infrastructure improvements, van Goeverden and Godefrooij (2011) did find increased cycling levels, but argued that the relatively high quality of pre-intervention infrastructure reduced these gains. Conversely in the UK, while existing infrastructure is poor, cultural factors militate against child cycling and may persist even given infrastructural improvements. Children are not expected to cycle to school, except in a few unusual local contexts (Aldred and Jungnickel 2012). Some schools even ban child cycling, seeing it as too dangerous (Walker 2009). Broader cultural disincentives to cycling include stigma and stereotyping (DfT 2010, Horton 2007). And even with substantial infrastructural improvements, for many journeys overall route quality would still remain patchy in the short term. Therefore, as preferences do not necessarily lead to changes in uptake, views about infrastructure must be interpreted in a broader cultural and policy context.

3. Methods

3.1 Aims and process

This study begins the process of establishing a benchmark for child-friendly cycle infrastructure, at least in the UK urban context. It involved an online questionnaire, with participants responding to 50 different combinations of situation (cycling environment/infrastructure type) and scenario (who would be cycling, e.g. adult carrying child). To ensure policy relevance and improve design, a process of piloting and stakeholder consultation was followed. London policy stakeholders advised on design and provided photographs, while the initial pilot stage involved feedback from researchers, practitioners, and cyclists from several different countries. The choice of photographs, survey flow and question wording was refined in response to their comments, although only the study lead is responsible for the final design.

As the study involves asking about hypothetical situations, it is inevitably limited and cannot predict the actual impact of infrastructural interventions. However, given the gap in the research, it is useful in exploring how we might expect people's infrastructural preferences to change (or not) if children are involved. By asking people about infrastructural preferences in relation to children or other people cycling, it contributes to ongoing debate about differences between the preferences of existing and potential cyclists (e.g. Pooley et al 2013). It further contributes to debates around diversity in cycling: recent research has found that where cycling is increasing in the UK, it is not becoming less gender unequal, while the under-representation of older people is growing (Aldred et al forthcoming). Lower rates of women cycling, and a drop-off among people cycling after their thirties, may both be related to views about child cycling (Emond 2009).

3.2 Design

The questionnaire was designed so that people could complete it in around ten minutes. In practice many took longer and we received extensive qualitative material in eleven comment boxes. The selection of only ten infrastructural situations limited the study. It was focused on urban rather than rural contexts, and apart from one question did not deal with junctions.

The study considered five possible scenarios for each situation, not limited to children's journeys seen in isolation. Children's journeys may be made independently or with adults; and adults might carry children on their bicycles, which might form part of a commute where there is a nursery at or near work. Different thresholds might apply in all these cases. This is important

from a planning perspective, complicating the 'view from the saddle' (Forsyth and Krizek 2011). If this 'view from the saddle' is assumed only to be that of a solo unaccompanied adult, planners are likely to design accordingly (Aldred 2012a).

There is debate over how best to present these kinds of situations to participants (Van Holle et al 2014). Options include describing the situations only verbally (for example asking people to compare 'a residential street' to 'a cycle track next to a main road'), providing engineering drawings (as in Steer Davies Gleave 2012) or using photographs. Sanders (2013) and Mertens et al (2014) use manipulated photographs, which in the former case allowed different types of main-road cycle lane to be compared, and in the latter case allowed different variants of Dutch-style cycle tracks to be compared. Manipulated photographs have the advantage of greater control over changes in micro-situations, for example cycle track smoothness.

In this case, non-manipulated photographs were used. The pilot found photographs were seen as useful in illustrating different examples; however, the situations were different enough that it was not possible to manipulate one or two images to encompass all of them. The photos sought not to gauge responses to a specific piece of infrastructure or micro-change but rather to illustrate a type of provision. There was a trade-off: while increasing participant understanding, visual aids mean unpredicted factors may shape responses (Van Holle et al 2014). In piloting, this did not seem limited to situations where visual aids were provided. For example, in the UK, cycle infrastructure is often poorly maintained, so regardless of what a photo showed (or even if no photo is provided, but only text or a diagram) some respondents are likely to factor this into their choice.

Even while stressing that photos were merely illustrative examples, the content did affect the responses received, a weakness to set against the greater comprehensibility of the photos over design drawings or text alone. The survey was also limited by the lack of high quality British infrastructural examples and using some Continental pictures was considered, but there was concern that this might bias the results. However, this did mean that the highest quality possible solutions cannot be shown, and this is likely to have affected participant responses.

After each situation participants were asked firstly whether they would choose to cycle there, if riding alone. The intention behind this question was to establish existing infrastructural choices, related to current options, and how these might change given the involvement of children. Around three-quarters were regular cyclists, with many relatively happy to ride in even quite challenging contexts. The second and third questions asked whether people would be willing to ride in the situation (a) while carrying a child and (b) if riding with an eight-year-old. The fourth and fifth questions asked whether the respondent believes the situation would be suitable (a) for a sensible twelve-year-old on his/her own and (b) for most people.

The rationale for the different ages was established through piloting. Respondents expressed a preference for specific ages for the third and fourth questions, and stakeholders suggested the ages used. UK cycle policy discourse has in recent years referred to '8-80 cycling'; the UK's National Cycle Network aims to be suitable for, among other users, a competent solo twelve-year-old (Scottish Government 2010). Some more challenging situations included sub-questions on the impact of 20mph limits on decisions about carrying a child or riding with an eight-year-old, and about the impact of on-road cycle training for the twelve-year-old. This provided further information about the possible contribution of these policies, both prominent in Britain.

In retrospect, it would have been worth stating that all examples were part of direct routes to a specific destination. In comments, many said in relation to more preferred examples, 'do you mean would I go a long way out of my way to cycle here?' There is an assumption in low-cycling countries that safety and directness will be traded off in this way, often carried through into research in a way not expected for other modes (e.g. Steer Davies Gleave 2012). Thus it is likely some options received a score penalty because respondents assumed (often on the basis of everyday experience) that such otherwise 'good' routes would be rare and require substantial

detours (or, as others mentioned, that they would soon degenerate into lower quality provision, another common UK problem).

Despite these limitations, the results are interesting and important for two reasons. Firstly, they contribute to the academic literature on cycling preferences by measuring how adults' attitudes to cycling change when children are involved. Secondly, they provide evidence for UK and other policy-makers to use in planning for inclusive cycling, which often entails the use of novel approaches and techniques that may encounter substantial opposition.

3.3 The Situations

The situations were selected in relation to UK urban cycling environments, and in discussion with stakeholders from London and the rest of the UK. Photos are included in the appendix. Because of the need to keep the survey short, the decision was taken to focus on links, even though junctions see a higher proportion of cycle casualties. Links provided simpler situations (e.g. no need to discuss signal phasing) and see a high proportion of near miss incidents such as 'close passes', which can put people off cycling (Joshi et al 2001). One junction example was included because of a hypothesis that it might be particularly problematic for children cycling on otherwise potentially suitable routes.

The situations are rooted within the UK urban context but also reflect design approaches used in other countries. For example, kerb segregation (on main roads) and modal filtering (on residential streets) are widely used within The Netherlands and are seen by many in the UK as representing a (perhaps unattainable) gold standard of provision. By contrast, painted cycle lanes and shared bus lanes are currently far more common in the UK, as are residential streets that also cater for substantial amounts of through motor traffic.

The situations were as follows, presented randomly. (Within the situations, it was decided to present the scenarios in the same order, as during pilot testing it seemed randomising both scenarios and situations could cause confusion, increase survey time and reduce response rates). Supplementary questions (related to the impact of 20mph or cycle training) were asked to those who 'disagreed' or 'strongly disagreed' that the situation in question was unsuitable for carrying a child, riding with an eight-year-old, or a sensible twelve-year old. While these sub-questions will not be discussed in detail here, it is worth pointing out that for all these questions, the percentage of people answering 'no' (that 20mph or training would not affect their decision) exceeded 50%.

The highest 'yes' level was 39.0% agreeing that a 20mph speed limit would make a difference to whether they thought an armadillo or 'semi' segregated lane was suitable for cycling with an eight-year-old. The lowest 'yes' level (17.7%) was found for two of the shared bus lane scenarios: whether a 20mph speed limit would make it more suitable for cycling with an eight year old, and whether on-road cycle training would make it more suitable for an unaccompanied twelve year old. This suggests that those measures, while they may be helpful, should be seen as secondary to infrastructural improvements and not a substitute for it.

One other limitation of the approach is that respondents would be less familiar with several of the examples, in particular, the use of armadillos to 'semi-segregate' cyclists. By contrast many will have had experience of riding in shared bus lanes, which along with painted lanes and shared pavements are the most common form of available cycling infrastructure in Britain. A shared pavement[2] was not included as an option because of broad consensus that it represents poor practice, especially in cities, whereas bus lanes and painted cycle lanes are still often considered good practice.

[2] In the UK context, shared pavements often mean that cyclists share narrow spaces with pedestrians and both must usually give way at side roads and driveways.

Table 1. Situations

Situation (& whether supplementary questions asked)	*Description provided*	*Rationale*
Armadillo Segregation Only (Y)	In this situation you would be cycling along a reasonably busy main road with a 30mph speed limit. There is a cycle lane painted on the road that is segregated from motor traffic using raised oblong humps.	A 'semi-segregated' approach increasingly promoted in London and other contexts, but under-researched in terms of impact on perceived safety.
Busy Road (Y)	This situation involves cycling along a relatively busy two lane road with no infrastructure for cycling. The speed limit is 30mph here.	Included as a 'worst case' scenario to gauge willingness of respondents to cycle in very hostile environments.
Cross Busy Road (Y)	In this situation you would be cycling along a quiet residential road (20mph speed limit) and come to give way lines, wanting to go straight ahead. The road you need to cross is a reasonably busy main road with a 30mph speed limit.	Perceived by the lead researcher as a possible 'hidden barrier' (by comparison with more obvious barriers such as unprotected major road junctions).
Filtered permeability (N)	This situation involves cycling along a street without through motor traffic. There will be people accessing their homes by car, and occasional deliveries, but drivers can't use the street as a cut through. The speed limit is 20mph.	Approach widely used in The Netherlands and other countries for residential roads – but under-researched in terms of impact on perceived safety.
Kerb Segregation (N)	In this situation you would be cycling along next to a reasonably busy main road with a 30mph speed limit. You would be riding on a cycle track that is separated by a kerb from the pavement as well as the road.	Used in The Netherlands and other countries on busier roads; other surveys indicate preferences for kerb separated infrastructure in the UK.
Mandatory Cycle Lane (Y)	In this situation you would be cycling along a reasonably busy main road with a 30mph speed limit. There is a cycle lane painted on the road (it is mandatory, meaning motor traffic isn't allowed to enter it) and there is no car parking permitted.	Paint separation is widely used in the UK; most such lanes are not mandatory (i.e. drivers can enter) so this example is a 'best case'.
Parking Segregated (N)	This situation involves cycling along a reasonably busy main road with a 20mph speed limit. There is a cycle lane painted on the road, which is also segregated from motor traffic by raised oblong humps and a row of car parking.	Segregation by car parking is widely used in other countries (including many new lanes in US cities) however in the UK, cycle lanes traditionally run outside car parking.
Residential Rat Run (Y)	This situation involves cycling along a residential road with a speed limit of 30mph. This road has parked cars on both sides, and is not a main road although at busy times it is used as a cut-through route for cars to avoid the main road.	Residential streets are often assumed to be suitable for all cyclists; yet anecdotally, rat running is seen as a problem and a justification for modal filtering in London boroughs.
Shared Bus and Cycle Lane (Y)	In this situation you would be cycling along a shared bus and cycle lane where the speed limit is 30mph. The bus lane is wide enough to allow you to pass the bus and it to pass you. Cars cannot park in the bus lane.	Shared bus and cycle lanes are a common form of provision in the UK. Most are not wide enough to allow passing within the lane so this represents a 'best case' scenario.
Shared Park Route (N)	This situation involves cycling along a park route. There is a shared-use path used by people on foot and on bikes. At peak commuter times, the route is busy with people walking, cycling and jogging.	Allowing cycling in parks (and other green spaces) is often controversial in the UK due to perceived conflict between cycles and pedestrians.

3.4 Sampling

The questionnaire survey was circulated using a range of online networks (most importantly, British Cycling and the CTC, two national cycling organisations) and offline (by handing out survey cards to people cycling on three busy commuter cycle routes, and on several organised rides, all in London). The survey was not restricted to British participants only, although nearly all respondents were based in Britain. It opened at the start of August 2014 and closed at the start of October 2014. Participants were told that the survey sought 'to find out your views about cycling in different situations, with and without children' and it was stressed that having children and/or cycling were not essential to complete the survey.

This method of recruiting participants provides a non-probability sample. Three-quarters of those who have answered the questionnaire are regular cyclists, who only represent around 2% of the British population. This can be seen in the 'solo cycling' attitudes expressed. Nearly two in three say that they would choose to cycle along a busy road with two lanes in either direction, whereas most people are unlikely to cycle in such contexts (Pooley et al 2013).

However, the findings shed light on the different decisions that even such committed and knowledgeable cyclists may make when considering whether to ride with children, or whether they will allow their children to ride independently. One can draw tentative conclusions about what conditions are needed for others to allow children to ride.

4. Results

4.1 About the participants

2,641 people started the survey and 1,958 people completed it. Tabulation and analysis for this paper has been conducted with the aid of SPSS survey software. 60.4% of participants said they were male, and 39.2% female, with the rest stating 'other' or that they preferred not to say. This is somewhat more gender-balanced than the population of cycle commuters, but less so than the UK population (ONS 2014). 61.0% had children, while 39.0% did not. However, 79.1% had cycled with children at least once, of whom 38.9% had done so often. The age group breakdown is as follows, and it can be seen that people aged 25-54 are over-represented, perhaps not surprising given the topic of cycling with children.

Table 1. Age groups

	Number of individuals	Percentage of Sample
Under 25	50	2.6
25-34	423	21.6
35-44	668	34.2
45-54	491	25.1
55-64	216	11.0
Over 65	107	5.5
Total	1955	100.0

Only 3.4% of participants were from outside the UK, with many of these ex-patriates or former UK residents. The largest single group lived in London, forming 34.6% of the sample. Another 12.9% lived in the South-East of England, with the next largest groups from Yorkshire and the Humber (9.0%) and Scotland (7.8%). Wales and Northern Ireland had relatively small proportions of respondents (1.7% and 0.5% respectively), so the sample is mostly from England and Scotland with London and South-East England over-represented within that.

Three-quarters of participants cycle three times a week or more. Those who completed the survey therefore would seem to fit into the category of 'committed cyclists'. This is unsurprising: those most likely to respond to detailed questions about cycling infrastructure are more likely to be

regular cyclists. However, it is an additional reason for caution. These are people who already feel cycling is to some extent acceptably safe for them and many already cycle with children at least some of the time. The sub-category analysis conducted below seeks to explore the extent to which the nature of the sample has shaped the results.

4.2 Scores for the situation/scenario combinations

The research generated results for 50 combinations of situation and scenario. These were analysed in two forms; firstly as ordinal data coded to the original Likert scale (-2 = 'Strongly Disagree' to +2 = 'Strongly Agree') and secondly as binary data, collapsing categories to 0 (Strongly Disagree/Disagree/ Neither Agree nor Disagree) or 1 (Strongly Agree/Agree). This latter was done to facilitate comparisons; the table below shows the percentage agreeing that each proposed combination was acceptable.

Table 2. Preferences by situation and scenario

	On Own	*Carrying Child*	*With 8 Year Old*	*By 12 Year Old*	*Most People*	*Average (final four scenarios)*
Busy Road	66%	19%	6%	8%	11%	11%
Residential Rat Run	76%	42%	21%	25%	29%	29%
Shared bus lane	86%	50%	26%	30%	39%	36%
Cross busy road	85%	55%	28%	29%	37%	37%
Painted cycle lane	88%	57%	33%	42%	46%	45%
Armadillo segregation	90%	76%	61%	69%	71%	69%
Kerb segregation	86%	85%	80%	83%	81%	82%
Car Parking Segregation	92%	86%	79%	81%	83%	82%
Shared Park Route	70%	91%	93%	93%	83%	90%
Filtered Street	96%	92%	89%	89%	91%	90%

NB this table and the figure below is ordered low-high by the sixth column, representing the average score across categories involving others (this is in fact identical to the ordering by the average score across all). The filtered street comes out particularly highly at an average of 90%, followed by the park route at 90%, with segregation by kerb or car parking segregation both on 82%.

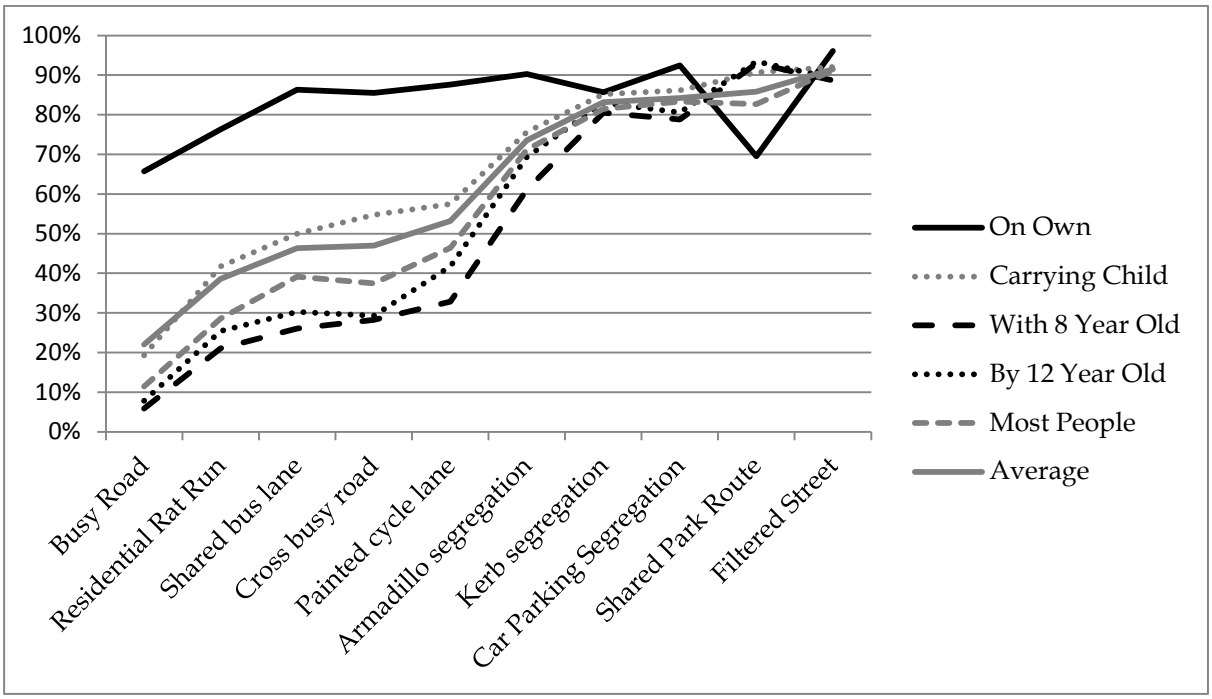

Figure 1. Preferences by situation and scenario

Statistical tests were run on both the original Likert-scale variables (Friedman test) and on the recoded binary variables (Cochran's Q) to establish whether differences were statistically significant. For each set of variables, this involves (a) testing each set of five scenarios, per situation and (b) testing each set of ten situations, per scenarios. For example, (a) asked whether attitudes towards a busy road differed depending on who was cycling, and (b) asked whether attitudes towards the situations differed, when carrying a child. All tests were significant at the 0.01 level; however, this does not indicate whether an individual comparison is significant.

The next stage of the testing covered paired comparisons within each situation; so for example, does someone's attitude towards a busy road differ specifically when carrying a child, compared to riding on their own. These tests were carried out using the Wilcoxon Signed Ranks test (Likert scaled variables) or McNemar's test (binary variables).

Likert variables: 79 out of the 90 comparisons were significant to the 0.01 level; the exceptions and their significance levels are listed below (in ascending order).

0.012 – Cross busy road carrying a child vs. Painted lane carrying a child

0.019 – Shared park route, most people vs. Car parking segregation, most people

0.021 – Car parking segregation, most people vs. Kerb segregation, most people

0.028 – Cross busy road on own vs. Shared bus lane on own

0.036 - Shared park route on own vs. Residential rat run on own

0.080 – Car parking segregation carrying child vs. Kerb segregation carrying child

0.200 – Car parking segregation, 12 year old vs. Kerb segregation, 12 year old

0.258 – Car parking segregation, with 8 year old vs. Kerb segregation, with 8 year old

0.330 – Painted lane on own vs. Kerb segregation on own

0.737 – Cross busy road, most people vs. Shared bus lane, most people

0.900 – Cross busy road, 12 year old vs. Shared bus lane, 12 year old

Binary variables: slightly more, 16 out of 90 variable pairs failed to meet the 0.01 significance threshold. As with the Likert variables, these fell into two categories; those seen as similarly problematic (e.g. crossing a busy road versus using a shared bus lane, accompanied by an eight year old) and those seen as good (e.g. car parking segregation versus kerb segregation, for most people).

4.3 Comparison of scenarios

The ordering of situations is fairly similar across the five scenarios (for example, filtered permeability scores highly – first and second - for both, while busy two-lane roads and residential rat runs score poorly – ninth and tenth, and eighth and tenth, for both). However, the gradient is much shallower for the solo adult than the other scenarios, indicating that the perceived quality of the infrastructure matters much more when children are involved. While all situations scored at least 66% agreement for solo adults, half of the situations failed to reach 50% agreement for all of the five scenarios.

4.4 Differences by cycling experience

Three-quarters of respondents were frequent cyclists; therefore it is important to ask to what extent this is likely to have affected the results. The table below shows the different levels of agreement by regularity of cycling. There is relatively little difference in attitudes to the most popular forms of infrastructure, with the 'top four' situations getting very similar ratings in almost all scenarios. There is strongest consensus between regular and non-regular cyclists for twelve-year olds, with no significant differences. Close behind was the consensus on cycling with eight-year olds and 'most people', with eight out of ten of each demonstrating no statistically significant difference at the 0.01 level. This suggests that although regular cyclists may have greater tolerance of the less popular forms of infrastructure, there is substantial consensus about what is needed to cycle with children or to encourage cycling by 'most people'.

Table 3. Preferences by experience

	On Own		*Carrying Child*		*With 8 Year Old*		*By 12 Year Old*		*Most People*		***Average exc. solo riding***	
	Reg	Non-reg	Reg	Non-reg	Reg	Non-reg	Reg	Non-reg	Reg	Non-reg	**Reg**	**Non-reg**
Busy Road	*69.2%*	*54.2%*	*21.4%*	*14.0%*	6.5%	3.6%	7.9%	7.4%	11.9%	9.6%	**12%**	**9%**
Residential Rat Run	*78.8%*	*69.5%*	*45.3%*	*31.0%*	*22.5%*	*16.1%*	25.4%	23.3%	29.6%	24.7%	**31%**	**24%**
Shared bus lane	*88.5%*	*80.3%*	*52.3%*	*43.7%*	*27.5%*	*20.8%*	31.2%	27.7%	*39.7%*	*35.2%*	**38%**	**32%**
Cross busy road	*87.3%*	*80.0%*	*57.5%*	*46.6%*	29.2%	24.3%	28.9%	29.0%	37.4%	35.9%	**38%**	**34%**
Painted cycle lane	88.4%	86.8%	59.2%	53.8%	33.4%	31.2%	40.7%	45.4%	46.1%	49.5%	**45%**	**45%**
Armadillo segregation	*89.7%*	*93.7%*	77.1%	72.4%	62.4%	58.4%	69.4%	69.8%	70.5%	74.1%	**70%**	**69%**
Car Parking Segregation	91.9%	95.0%	86.6%	85.1%	78.7%	80.7%	79.7%	84.0%	82.8%	85.5%	**82%**	**84%**
Kerb segregation	*84.1%*	*93.1%*	85.6%	85.3%	80.4%	82.7%	82.7%	85.5%	*80.3%*	*86.2%*	**82%**	**85%**
Filtered Street	96.3%	97.5%	93.3%	89.9%	89.2%	88.1%	89.9%	89.1%	91.1%	91.8%	**91%**	**90%**
Shared Park Route	*67.5%*	*78.2%*	90.2%	92.7%	93.1%	93.1%	93.3%	94.1%	81.6%	86.4%	**90%**	**92%**

Italics = difference significant to 0.01

4.5 Differences by London, gender, and experience of cycling with children

Differences by London were explored because of the over-representation of London in the sample, and the different methods of recruitment (in London, direct leafleting of commuters and of event participants was used alongside online recruitment). There were relatively few (7/50) differences in preferences significant to the 0.01 level, however. Most related to residential rat runs (Londoners were more tolerant than non-Londoners) or shared bus lanes (where Londoners were less tolerant than non-Londoners):

1. Busy roads carrying a child; 3.7% of Londoners against 6.9% of non-Londoners
2. Residential rat runs carrying a child; 48.3% of Londoners against 38.0% of non-Londoners
3. Residential rat runs by twelve year olds; 30.2 of Londoners against 22.4% of non-Londoners
4. Residential rat runs, most people; 34.9% of Londoners against 25.2% of non-Londoners
5. Shared bus lanes carrying a child; 45.6% of Londoners against 52.4% of non-Londoners
6. Shared bus lanes with an 8 year old; 21.1% of Londoners against 28.2% of non-Londoners
7. Painted cycle lanes, 12 year olds; 37.7% of Londoners against 44.5% of non-Londoners

Differences by gender were explored because these have historically been found in relation to solo adult preferences, and because women are more likely to make escort trips. As with Londoners and non-Londoners, the majority (43/50 again) of comparisons were non-significant; however some differences were found. In general, where there are differences, women are as expected indicating greater support for segregation than men; however, there was consensus on all questions related to eight- and twelve-year olds. One slightly anomalous result is the residential street with rat running, where more women than men agree that it is suitable for most people (although still clearly a minority, but one in three rather than one in four):

1. Busy roads on own; 68.1% of men against 61.8% of women
2. Residential rat runs, for most people; 25.4% of men against 32.7% of women
3. Shared park routes on own; 65.6% of men against 77.0% of women
4. Shared park routes, for most people; 80.7% of men against 85.8% of women
5. Filtered street, carrying a child; 91.2% of men against 94.8% of women
6. Armadillo segregation, on own; 88.8% of men against 94.0% of women
7. Kerb segregation, on own; 82.9% of men against 91.9% of women

Finally in this section, it is useful to consider differences related to whether people have specific experience of cycling with children. Of our sample, 38.8% said they often cycled with children; 25.3% occasionally; 15.1% had but only once or twice and 20.1% had never done so. Differences tended to reflect the fact that cycling often with children implies the use of more challenging infrastructure; so for example, 27.6% of those who often cycled with children agreed that they would carry a child on a busy road, against an average of 19.6%. 8.4% would cycle with an eight-year old on a busy road, compared to an average of 5.8%.

Results for carrying children or cycling with 8-year olds along residential rat runs, crossing a busy road, shared bus lanes, painted cycle lanes and armadillo segregation were also higher for those who had often cycled with children. Results where differences were not significant related to twelve-year olds (where there was consensus over suitability for all situations) or the more popular situations (e.g. car parking segregation).

5. Discussion

While the sample is not random, the results show substantial consensus across gender, location (London or non-London), cycling experience and frequency of cycling with children. There is most consensus over suitable cycling environments for twelve year olds, followed by cycling with eight year olds and cycling by 'most people'.

Considering all scenarios, the four most popular situations, which cluster together at the top of almost all scenario scales, were segregation by kerb, segregation by car parking, shared park routes, and filtered streets. All four provide substantial degrees of separation from motor traffic; in the case of filtered streets there is interaction but motor traffic volumes would be very low, and generally either accessing or leaving properties in the street. Lagging somewhat behind is segregation by armadillo, which offers a lower level of separation from motor traffic on main roads than does kerb or car parking segregation (more permeable by motors). All the other, less segregated, situations, scored 33% or less for at least one of the five scenarios.

Among these less segregated situations, the data indicate that the UK's traditional approaches to cycle infrastructure are problematic for cycling with children. Residential rat runs, unlike quiet filtered streets, are unpopular. As respondents noted in comments, a combination of through motor traffic and parked cars restricting visibility and manoeuvring may prove hostile for children, in residential streets. Often it is assumed that residential roads are more pleasant than main roads, and suitable for cycling by people with diverse ages and abilities[3]. However, the results here indicate that this may not be the case if motor traffic is unrestrained.

The situations with shared bus lanes and mandatory (paint-based) cycle lanes were only seen as safe for cycling with an eight-year-old by a quarter and a third of respondents, respectively. Crossings of busy roads may also mean that an otherwise safe route becomes unsuitable for

[3] For example, in TfL's (2014) Accessibility scoring tool, which implies that any road that is not a main road is by default suitable for mass cycling.

children, in the eyes of adults at least. While 85% of respondents said they would be happy crossing over a busier road as part of a cycle route (similar to the figures for cycling in bus lanes), under 30% said that they thought the crossing would be suitable for a solo twelve-year-old or an accompanied 8-year-old.

For shared use park routes, respondents generally felt these were highly suitable for children and 'most people' but not ideal for themselves. To an extent, this response was 'primed' by highlighting potential conflict with non-motorised users, just as the 'residential rat run' situation primed responses by referring to motor traffic cutting through. In fact, our respondents overall rated the 'residential rat run' situation somewhat more favourably for themselves than they did the park route, although this still left it third from bottom. However, the park situation was more popular with solo women and less frequent cyclists.

This suggests that to widen the cycling demographic, ambitious improvements need to be made. When building for 8-80 cycling, policy-makers need first to consider interventions that substantially separate people cycling from motor traffic, such as Greenway routes, filtered permeability, and segregation on busier roads by kerbs or car parking. All such routes must be high quality and avoid or minimise problems noted by respondents on inferior quality routes, such as obstructive barriers, poor quality surfacing, lack of route continuity and priority. Armadillo segregation, which scored in between the fuller segregation and the less popular options, needs further investigation to explore its acceptability for different age groups.

Less ambitious interventions, such as shared bus and cycle lanes, or mandatory cycle lanes, may encourage an adult minority to try cycling, yet not have similar impacts on cycling with and by children. Arguably this approach has been tried in contexts such as Inner London, with an increase in bus lane provision, seen as substantially inferior by users to full segregation (Steer Davies Gleave 2012). Inner London cycle to work rates have increased dramatically, but without a similar change in cycle to school rates (for example, although adult commuting rates in Hackney rose from 6% to 15% in ten years, cycling to school remained below 2%: DfT 2011) and without improvement in existing age and gender imbalances (author reference deleted).

There is substantial (although not universal) consensus on characterising good cycling environments for inclusive, all-ability cycling. Respondents, largely confident and experienced adult cyclists, are clear that policy needs to provide something other than the environments to which they have become accustomed. As one respondent put it:

> 'I wish the facilities were better so that everyone could enjoy the freedom and exercise that cycling offers without having to be road warriors.'

Given other barriers, even the infrastructural scenarios rated relatively highly here for riding with children may not always succeed in attracting a broader demographic of parents. However the study forms a useful starting point to establish criteria for child-friendly cycle routes in countries such as Britain, which are only just beginning to think about inclusive cycling. Policy-makers and planners need to consider what proportion of planned cycle networks are, and should be, cycle-able by children and adults cycling with children. It should not be difficult to identify and mitigate barriers to child cycling along key routes to schools and other trip attractors.

One final thought relates to the need for more research. This study only begins to address an issue crucial for cities and countries seeking to grow cycling from a low base. More in-depth research could explore the qualitative side of parental decision-making processes, focusing on contexts where cycling has been growing among adults (and hence interest in child-friendly cycling environments is relatively high). Additional surveys could focus on junction design, largely overlooked here, and consider using video material to better convey junction timings and situations. However, one obstacle here would be the lack of good cycling infrastructure at UK

junctions (even more so than on link sections). Finally, cross-cultural comparisons would be interesting, although developing comparable surveys will be a challenge.

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Appendix: photographs used

Figure Apx.1. Armadillo Segregation Only

Figure Apx.2. Busy Road

Figure Apx.3. Cross Busy Road

Figure Apx.4. Filtered street

Figure Apx.5. Kerb Segregation

Figure Apx.6. Mandatory Cycle Lane

Figure Apx.7. Parking Segregated

Figure Apx.8. Residential Rat Run

Figure Apx.9. Shared Bus and Cycle Lane

Figure Apx.10. *Shared Park Route*