BICYCLE INFRASTRUCTURE PREFERENCES – A CASE STUDY OF DUBLIN

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Abstract

This paper examines infrastructure preferences for cyclists in Dublin. The culture for cycling in the city has grown substantially over the past decade and much debate exists as to what type of infrastructure individuals require. The Irish National Cycle Policy Framework acknowledges that investment in cycling infrastructure type and quality in Ireland has been 'in many cases, inadequate' and has, generally, not led to an overall increase in cycling numbers. In order to ensure future investment is targeted where it is likely to be most effective in achieving adopted mode share targets for cycling, the following research has been undertaken to determine the factors which most influence cycling route choice. In particular, the research aims to determine the factors, which have greatest influence on cycle route infrastructure preference the correlation between the level of cycling confidence and preferred types of infrastructure and route characteristics.

A stated preference survey, undertaken by almost 2,000 cyclists and non-cyclists, was used to gauge preferences for a range of infrastructure types and route characteristics. Results from the survey were compared against individual characteristics, such as age, gender and level of cycling confidence. This comparison provides the authors with a robust data set to determine infrastructure types, which are most likely to influence a mode shift to cycling.

INTRODUCTION AND BACKGROUND

Smarter Travel, Ireland's National Sustainable Transport Policy marks a significant departure from previous national policies for transport. This plan has a greater focus to strengthening Irelands road and public transport networks (*1*). The strategy highlights the implications of future growth projections on the Irish transport network: increasing car ownership and annual vehicle kilometres travelled, declining average speeds in commuting periods and increasing congestion amidst a decline in walking and cycling modal share. In light of these forecasts, the strategy sets out bold travel targets supported by a 48 actions for implementation, ranging from infrastructure to policy and education measures. The overall target is to reduce work related commuting by car from a current modal share of 65% to 45%. In addition, it is envisaged that total vehicle kilometres travelled by car will not increase substantially from a 2009 baseline (*1*).

These targets are challenging and highlight the need for a robust response in terms of policy and investment. The Strategy therefore sets out separate objectives and targets for walking, cycling and public transport. In relation to cycling, the Strategy aims to secure a *'strong culture of cycling in Ireland and ensure that all cities, towns, villages and rural areas will be cycle-friendly'* (*1*). The strategy envisages that by 2020, 10% of all our trips will be by bike. In relation to commuting, the Strategy envisages that by 2020 cycle trips to work will have increased to 160,000 from a 2006 baseline of 35,000. To encourage delivery of the

Smarter Travel vision, the National Cycle Policy Framework was adopted in 2009 (*2*). The Framework is clear on the challenges, which lie ahead by acknowledging that investment in cycling infrastructure has been inadequate and has not led to an overall increase in cycling. The Framework presents a robust package of measures classified into the following categories: Planning, Infrastructure, Communication and Education. With regards infrastructure design, the National Cycle Policy Framework also reiterates the need for transportation infrastructure design to be 'cycle friendly'. 'Cycle friendly' routes are defined as those that are deemed to be: safe, direct, coherent, attractive and comfortable. These five criteria frequently form the basis of cycling infrastructure policies internationally and are also identified in the National Cycle Manual (*3*) as being the five 'basic needs' of cyclists which should be understood by designers if 'cycle friendly' environments are to be created (*3*).

To design 'cycle friendly' routes, the guidelines state that infrastructure design for cycle routes should be influenced by the Principles of Sustainable Safety. These principles also form the basis of infrastructure planning in the Netherlands where cycling is the preferred mode of transport for almost 30% of trips. The principles are as follows:

- Functionality: The designer should have an awareness of place and movement related functions within a space,
- Homogeneity: By reducing the relative speed, mass and directional differences of different road users sharing the same space, the designer can increase safety for all road users,
- Legibility: Road environments, which are legible to all road users, are likely to be safer,
- Forgivingness (Passive Safety): Infrastructure design should consider the safety risks to vulnerable road users. For example, are there physical hazards impacting on cyclists, is lighting in the area appropriate for cyclists, and
- Self-awareness: The principle of self-awareness is that where road users are aware of their own abilities and limitations to negotiate a road environment, the environment is safer.

A parallel decision to be made in the planning and design process is whether cycling facilities should be integrated with vehicular traffic or mixed. This decision is one, which critically shapes our cycle network and, arguably, divides opinions about the most appropriate form of infrastructure among cyclists as well as non-cyclists.

While the guidelines provide an excellent resource for cycle network planning and design, it is apparent that preference for type of cycling facility can vary widely depending on age, gender and cycling confidence among other factors. The perceptions of cyclists and non-cyclists about the interpretation of 'cycle friendly' varies. Even among cyclists, there is little consistency with regards a 'preferred' infrastructure type (*4*). Providing cycling infrastructure to attract a maximum amount of existing and new users therefore becomes much more challenging than initially perceived. This challenge is one, which requires further investigation to ensure that current and future investment in cycling infrastructure will effectively contribute to the creation of 'cycle-friendly' urban areas and targets for cycling mode share can be met.

In recognition of the challenges identified in planning and designing infrastructure for cyclists, the following research aims to establish the factors, which influence cycle route choice and how these factors vary between individuals. The research will conclude on how the identified route choice preferences could impact on cycle route infrastructure design and in turn, a modal shift to cycling.

METHODOLOGY

Stated Preference Model

The stated preference experiments used in this paper consisted of a route choice model. In this route choice model 5 attributes where examined. Table 1 outlines the different attributes and attribute levels examined. These determinants were proposed on the basis of local knowledge of the local transport network as well as outputs from the literature review.

TABLE 1 Attributes and attribute levels examined through the route choice model

Attribute	**Attribute level**
Adjacent traffic speed	30 km per-hour
	50 km per-hour
	80 km per-hour
Type of infrastructure	No facilities
	Off road cycle lane
	On road cycle lane
	Shared cycle/bus lane
	Greenway
Travel time	10 minutes
	20 minutes
	30 minutes
Number of junctions on route	Less than 2 junctions
	2 – 5 junctions
	More than 5 junctions
Cycle traffic on route	Light traffic
	Heavy traffic

The infrastructure options presented are highlighted in Figure 2. These options were based on the five most common cycle route infrastructure types in the Greater Dublin area.

A fractional factorial was designed which included two routes each which had the same attributes but differed on the attribute levels. A fractional factorial was designed using the method described in Hensher et al (*5*). The fractional factorial design produced 64 scenarios to be evaluated. These scenarios were randomly distributed to 11 versions of the survey, with 10 versions of the survey containing 6 scenarios to evaluate and 1 with 4 scenarios.

As the respondents may not be familiar with the variants of cycle lane presented in the scenarios, it was decided to make these scenarios as visual as possible. An example of one of the scenarios is shown in Figure 3. The following text was used to set up the scenarios presented to the respondents.

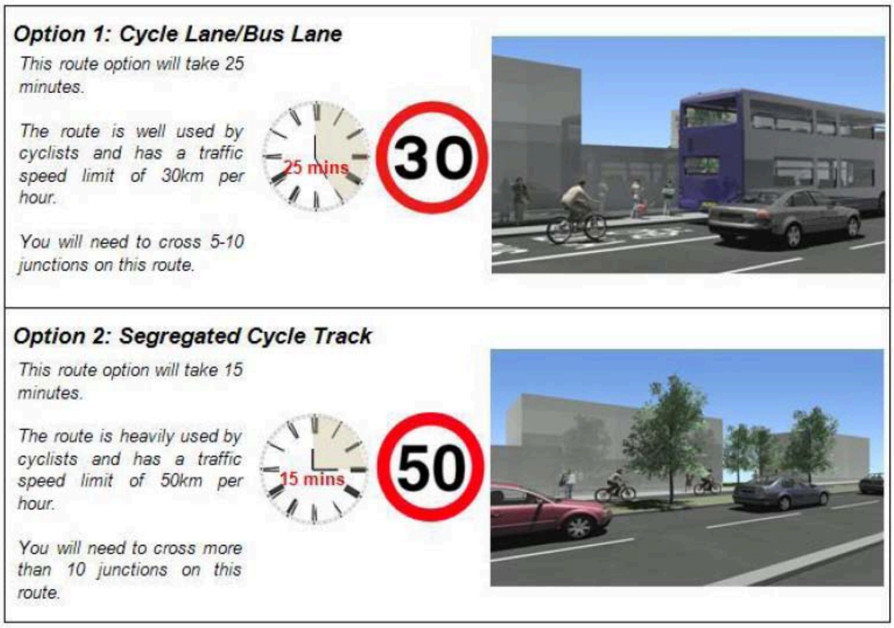
"You have started a new job, which is located close to your home. Cycling to work has now become a possibility. Whether you currently cycle to work or not, please consider the following route choices for your trip to work and choose the most preferable route for your journey to work in each instance".

FIGURE 2 Cycling infrastructure choices used within the route choice model

No Facilities[1]	
Bus/Cycle Lane	
Off Road Cycle Track	
Parks/Quiet Residential Streets	
On road cycle lane	

[1] Note: The highlighted route includes road markings to highlight the presence of cyclists in a mixed use environment as recently supported in the National Cycle Manual.

FIGURE 3 Cycle route options as presented to survey respondents



A multinomial logit model was used to estimate the impact of each of the attributes presented in Table 1. The model takes the following functional form:

$$U_{in} = \beta X_{in} + \varepsilon_{in} \qquad (1)$$

where *n* represents the route choice option and *i* represents the individual. X_{in} represents the set of explanatory variables specific to route option *n* and by individual *i.* U_{in} is the utility obtained by individual *i* and ε_{in} is a random error term, which is assumed to be identically and independently distributed using the Gumbel distribution method (*6*).
The probability that individual *i* chooses route *n* can be expressed as follows:

$$\text{Prob}(U_{in} > U_{jn}) = \frac{e^{\beta X_{in}}}{(e^{\beta X_{in}} + e^{\beta X_{in}})} \qquad (2)$$

The above equation states that the individual will choose route *n* over the other route (*j*) providing the utility that's derived from this route is greater than the alternative route. The models estimated using a maximum likelihood estimation approach (see *5, 6, or 7* for more details on this approach). Several models are presented in the next section, some of the models have been segmented by various attributes such as gender, age etc. The models were segmented to provide an indication as to how various characteristics of the respondents' impact upon their route choice selection.

Data collection

The survey was undertaken by 1,941 people employed in businesses participating in the Smarter Travel Workplaces initiative, currently being managed by the Irish National Transport Authority. The businesses are all located within an 8km (5 miles) radius of the city centre.

RESULTS

Descriptive results

Table 2 presents descriptive results of the sample collected. The gender balance of respondents was relatively balanced, 51.8% male and 48.2% female. 45.7% of respondents were in the 25-34 age group and 26.1% in the 35-44 age group. 51.8% of the sample was shown to have one car and 31.2% had two cars in their household. The results for mode of transport used to travel to work showed that just under 30% of the sample drove alone on a regular basis to work. 14.9% indicated they walked and 18.1% said they cycled to work on a regular basis. The final result presented in Table 2 details the distance travelled to work. 9% travelled less that 2km (1.2 miles) and 21.8% travelled 3-5km (1.8-3.1miles).

TABLE 2 Descriptive results

Gender	N	%
Male	1006	51.8
Female	935	48.2
Total	1941	100
Age		
18-24	203	10.5
25-34	888	45.7
35-44	507	26.1
45-54	252	13.0
55-64	87	4.5
65+	4	.2
Total	1941	100.0
Number of cars per household		
No car available	244	12.6
1	1006	51.8
2	605	31.2
2+	86	4.4
Total	1941	100.0
Mode of transport used to travel to work		
Walk	289	14.9
Cycle	351	18.1
Bus	265	13.7
Rail	358	18.4
Car - driver	569	29.3
Car - passenger	74	3.8
Motorcycle	33	1.7
Work from home	2	.1
Total	1941	100.0
Distance travelled to work		
0-2km (0 – 1.2 miles)	175	9.0
3-5km (1.8-3.1 miles)	423	21.8
6-9km (3.7 – 5.6 miles)	462	23.8
10-15km (6.2 – 9.3 miles)	444	22.9
16km+ (10 miles +)	437	22.5
Total	1941	100.0

In the survey respondents were asked to indicate what factors would encourage the respondents to begin cycling. The results from this question can are presented in Table 3. 74.1% of respondents said more off road cycle tracks and 56.4% said that more connected on-road cycle lanes would encourage them to begin to cycle to work. The results for better facilities at work, better signage, improved information and increased bike parking were found to be unlikely to encourage individuals to cycle to work. Interestingly 69.1% of respondents said less traffic was unlikely to encourage them to cycle on a regular basis.

TABLE 3 Which of the following measures would encourage you to begin cycling or to cycle more?

	Yes	No
More dedicated, off road cycle tracks (for example, through parks or beside main roads)	1439 (74.1%)	502 (25.9%)
More connected on-road cycle lanes	1094 (56.4%)	847 (43.6%)
Better facilities at work (lockers and showers for example)	812 (41.8%)	1129 (58.2%)
Better signage	122 (6.3%)	1819 (93.7%)
Increased and secure bike parking	757 (39%)	1184 (61%)
Better information about local cycling routes	438 (22.6%)	1503 (77.4%)
Less traffic	600 (30.9%)	1341 (69.1%)

Route choice models

This section of the paper presents the results from the route choice models. The first model presented in Table 4 contains the results of the base model, which includes all of the respondents in the sample. The first set of coefficients examines the impact adjacent traffic speed has upon route choice. The findings show that respondents had a greater preference for lower adjacent traffic speeds as the 30KM per-hour (19 miles per-hour) coefficient has the highest positive value. The second set of coefficients measure the impact that the cycle route type has upon route choice. The results show that both the 'cycle/bus lane' and the 'no-lane' options both had significant negative coefficients indicating that respondents are unlikely to select a route option if it has this type of route infrastructure. The 'off road cycle lane' option was found to have the highest positive coefficient followed by the 'greenway' option, this result indicates that respondents are more likely to choose a route that has one of these infrastructures.

The results for the travel time coefficients show, as one would expect, that respondents had a greater preference for lower travel times, with the coefficient related to a 10-minute travel time having the highest positive coefficient. The number of junctions that the respondent would encounter while cycling along the route was examined to determine if this would significantly impact upon respondents' utility. The findings show that respondents are more likely to choose a route that has fewer junctions with the 'less than 2 junctions' coefficient having the highest positive value. The final set of coefficients presented in Table 4 relates the amount of cycle traffic along the route. The findings show that respondents have a slight preference for light traffic while cycling along the route.

Segmented Route Choice Results

In this section of the paper the dataset is split by several individual specific characteristics. The first set of results presented in Table 4 is segmented by gender. The results for the adjacent traffic speed coefficients show that females were shown to have a higher preference for lower speeds compared to males. The findings for the cycle route type show that females have a greater preference for 'greenways' and 'off road cycle lanes'. The preferences for cycle route choice overall show very little difference when comparing the estimated male and female coefficients. A comparison between the travel time coefficients demonstrates that females have a greater preference for shorter trip times. Females were also shown to have a greater preference for fewer junctions along the routes chosen. The final comparison shows that males had a greater preference for light cycle traffic along the route compared to females.

TABLE 4 Base model and results segmented by gender

	Base model	Male	Female
Intercept	-1.388**	-1.260**	-1.549**
Adjacent Traffic Speed			
30KM per-hour (19 miles per-hour)	.788**	.635**	.921**
50KM per-hour (31 miles per-hour)	.535**	.436*	.611**
80KM per-hour (49 miles per-hour)	Ref	Ref	Ref
Cycle Route Type			
Cycle/bus lane	-.792**	-.844**	-.736*
Greenway	.202*	.146*	.346**
No – lane	-1.116**	-1.060**	-1.167**
Off road cycle lane	.449**	.340**	.597**
On-road cycle lane	Ref	Ref	Ref
Travel Time			
10 minutes	1.353**	.923**	1.150**
20 minutes	.240*	.306**	.230**
30 minutes	Ref	Ref	Ref
Number of Junctions			
Less than 2 junctions	1.050**	.923**	1.150**
2 to 5 junctions	.419**	.306**	.230**
More than 5 junctions	Ref	Ref	Ref
Cycle Route Traffic			
Light traffic	.083**	.149**	.044**
Heavy traffic	Ref	Ref	Ref
Number of cases	11,692	5742	5298
R-squared	.262	.270	.262
Log likelihood	983.34	786.43	456.09

****** Significant at 1%, * Significant at 5%

SUMMARY OF FINDINGS

As outlined at the outset of this paper, the National Cycle Manual guidelines provide robust advise to practitioners in the planning and design of cycle networks. The purpose of this research was to add further clarity in relation to individual preference regarding infrastructure and the measures, which are most likely to achieve modal shift. In this regard, findings from the current study provide an interesting insight to the variations, and similarities, in preferences among existing cyclists and non-cyclists.

A summary of the findings is as follows:

- Direct routes with short journey times are the most important variable for existing cyclists and non-cyclists in determining route choice. This is followed by infrastructure type, the number of junctions along the route, traffic speed and cyclist volumes,
- In terms if infrastructure, regardless of the level of cycling confidence, routes which have 'no facilities' or 'bus/cycle lanes' are the least favoured cycle route types,
- There appears to be no direct correlation between cycling confidence and route choice preference with confident cyclists demonstrating a similar preference for the presented infrastructure types as respondents with no cycling confidence,
- There are, however, a small proportion of very confident cyclists who place high importance on short journey times and direct facilities with low cyclist volumes. For these cyclists, type of infrastructure and traffic speeds are of less relevance,
- Respondents who currently drive or use public transport to travel to work have a poor perception of cycling and demonstrate a greater need for segregation and lower vehicular speeds,
- Regardless of cycling confidence, there is a similar preference for fewer junctions along cycle routes,
- Respondents who walk/cycle to work have the greatest value of time for the journey to work, and
- Cyclists with little or no experience have a greater preference for routes with a high volume of cyclists.

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