Everyday cycling in urban environments: Understanding behaviours and constraints in space-time

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1. Introduction

Motorised transport contributes to greenhouse gas emissions which also impact on climate change. But, cycling as a means of transport has the potential to ameliorate this situation; hence, understanding cycling as means of transport is paramount. This research is partly a response to calls from UK National Institute for Health and Clinical Excellence 2012 recommendations as well as urban transport literature for further research to incorporate the investigation and discovery of cyclists' perception and experiences (Forsyth and Krizek, 2011; NICE, 2012; Skinner and Rose, 2007); to support urban designers as well as cycling policy interventions and transportation engineers and thereby increase cycling uptake to ensure sustainable means of transport with low impact on environment. The ultimate realisations of cycling benefits by cities – such as cities in North East England – are hampered by lack of appropriate data to inform policy strategies to improve cycling uptake as well as data processing methodologies. Moreover, several efforts are being made to enhance data availability to inform policy strategies and cycling uptake for which this research aim to contribute.

The purpose of this research is to provide evidence on the use of the area's cycling infrastructure by experienced commuter cyclists. This research has for the first time facilitated the collection and analysis of detailed bicyclists' route choices in the UK, bringing substantive empirical evidence for understanding daily cycling behaviours. The paper is in four main parts: description of the methods employed in this research and sample characteristics; spatial analysis to understand our sample's commonalities and differences with other areas; comparative spatial analysis of the primary tracks with "official" cycling network data of the study area; and, further discussion and conclusion part summarising the early findings of this research.

2. Study area

The choice of study area was informed by these considerations: practicality, convenience, and the fact that central part of Tyneside conurbation, around southern part of Newcastle upon Tyne, has the potential of registering traces of cyclists' movement behaviour. The Tyneside conurbation comprised the four main districts that make up the conurbation: Newcastle upon Tyne, Gateshead, North Tyneside and North Tyneside; adding Sunderland makes up Tyne and Wear region.

3. Methods: Data collection, processing and sample characteristics

3.1 Survey instruments

Three survey instruments were developed, in addition to the use of GPS devices and materials for the field campaign, for the purposes of this research; with the caution to avoid re-inventing the wheel. Four GPS devices were evaluated and QStarz BT-Q1000XT selected for the data collection (Yeboah et al., 2012a). Consent form and research statement were also prepared and added to the instruments in accordance with Northumbria University policy on Ethics.

3.2 GPS Tracking

Participants screened as *utility cyclists* carried the GPS device for one week (7 days) while filling the forms described earlier. The data collection wave is from October to November 2011. Literature suggests some variation of duration for GPS based data collection but most the studies are about one week (Anderson et al., 2010; Van der Spek et al., 2009). The log interval used in the design of this research is 5 seconds. *Utility cycling* meaning any cycling not done primarily for fitness, recreation such as cycle touring, or sport such as cycle racing, but simply as a means of transport.

3.3 Space Time Cube based data processing

Space Time Cube (STC) based processing is the idea of exploiting and using the STC space construct, as originally proposed by Hägerstrand (1970) and adopted by Kapler and Wright (2004), to edit raw GPS data by mainly visual inspection with additional data from maps and travel diaries (Yeboah et al., 2012b). By using STC in this way, the applicability and usability of the cube achieves a complete cycling of data cleaning, analysis and visualisation (Figure 1).

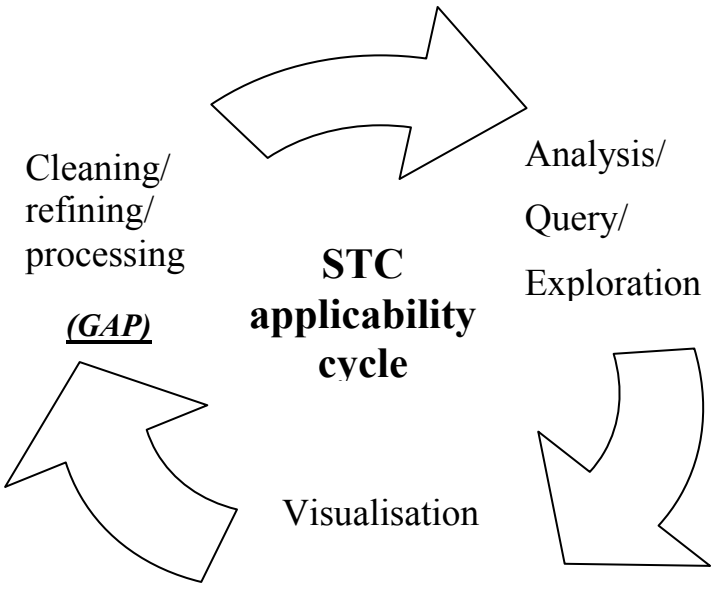

Figure 1: Space-Time-Cube applicability and usability cycle showing knowledge gap

3.4 Sample characteristics

Total number of cycle trips per given sample of 79 adult cyclists is 941; 319 trips made by females and 622 made by males. Weighted average distance per trip for both female and male were 6.7km and 5.4km respectively (see Table 1). Moreover, cyclists with high annual income commuted more as evidence by the sample (see Table 2).

Gender	No.	Over one week period per person Female distance value is weighted to control for gender imbalance – factor 52/27				
		TRIPS	KM (weighted)	Average KM/ TRIP	Average KM/ PERSON	MIN / MAX (trip)
Female	27	319	2137.4	6.7	79.2	0.25 km / 13 km
Male	52	622	3373.0	5.4	64.9	0.12 km / 36 km
Total	79	941	5510.4	5.9	69.8	

Table 1: Gender versus number of cycle trips and distance travelled

		Annual Household Income (trips & weighted distance travelled in km)		Total
		High *> £30,000*	Low *<= £30,000*	
Gender	f	182 1746.4 km	137 502.3 km	319 2248.7 km
	m	425 2575.9 km	197 797.2 km	622 3373.1 km
Total		607 4322.3 km	334 1299.5 km	

Table 2: Gender versus Annual Household Income crosstabulation against total of cycle trips and distance travelled

4. Sample commonalities and differences vis-à-vis available data

The secondary data used to set the scene in the exploratory part of this paper come from the geographical boundaries from the 2001 UK census data (from census.ac.uk) covering the five Tyne and Wear boroughs as well as the Tyne and Wear Household Travel Survey (TWJTWG, 2011). Although admittedly a cross-sectional survey it reveals detailed travel patterns across Tyne and Wear region using shortest straight line routes from origion to destination (see Figure 2). However, this survey lacks actual route choices of respondents since it was a stated preference survey suggesting gaps in route choice information which the sample data of this research contributes.

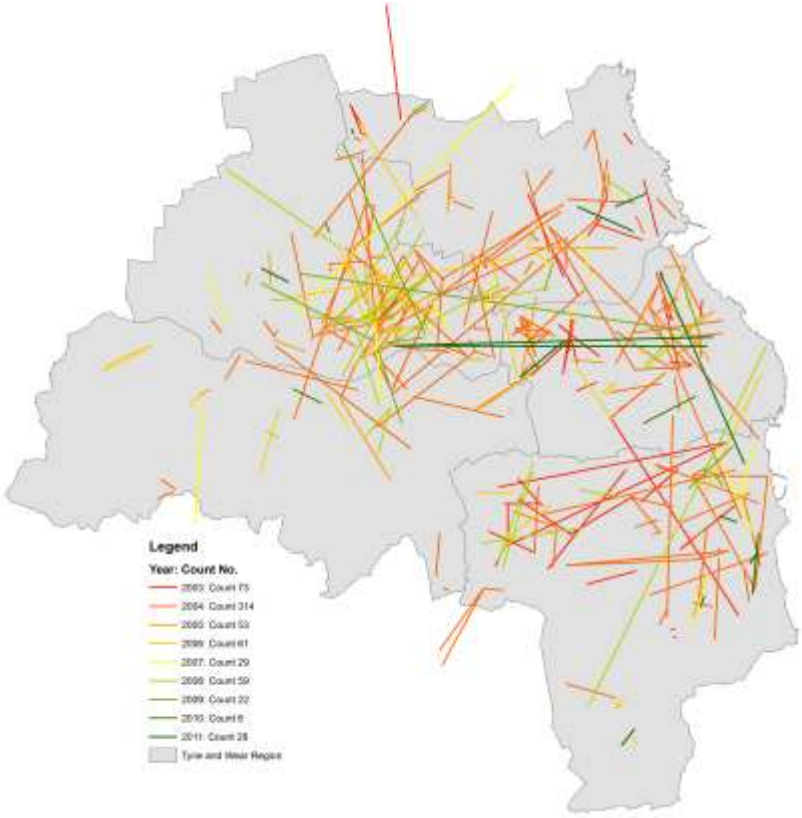

Figure 2: Cycling patterns from Tyne and Wear Travel Survey 2003 to 2011. Note: Survey has 700 cycle trips out of 87345 total trips. The map shows 645 plottable cycle trips as straight lines joining origin and destination.

5. The concept of corridor space analysis

Corridor space or region is defined as a buffer zone around cycle lanes/paths use for detecting cycle trips/cycle trip sections/other available cycle infrastructure. The concept is used to find cycle trips on/off/near the "official" cycle network in the study area (see Figure 3).

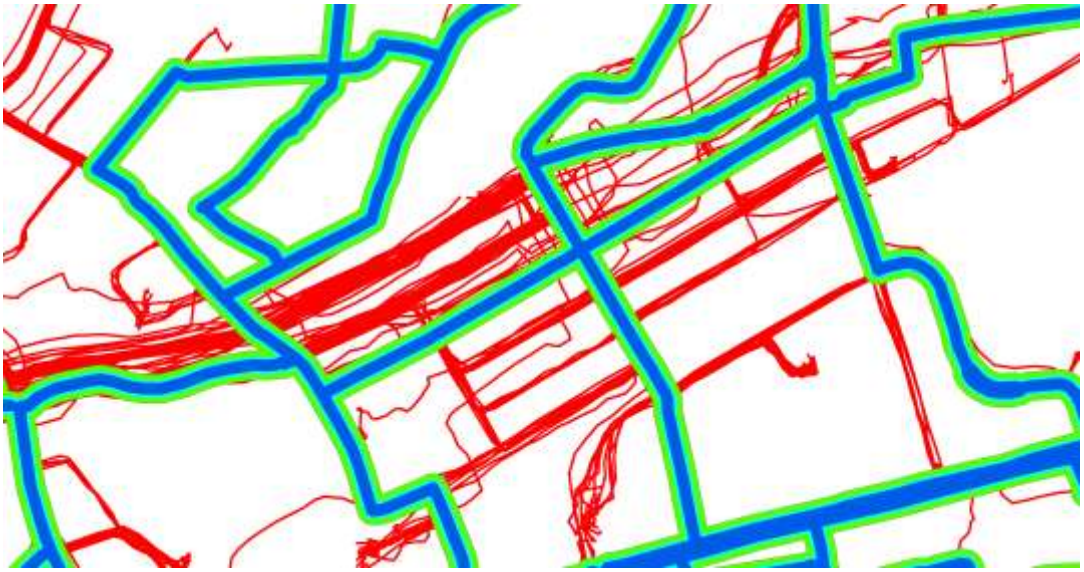

Figure 3: Corridor space definitions using a map: 10m Blue buffer equals cycle trips on network, 10 green buffer equals close to network trips and red is for cycle trips off the

network.

6. Application of corridor space analysis using cycle infrastructure data from Newcastle City Council (NCC)

Two multiple ring buffers (i.e., 0-10m and 10-20m) were created around the designated cycle network. Some corrections were made to the cycle network using OSM data. The "Identity" function in ArcGIS 10 was then used to identify cycle trips on/off/near the buffer zones. The result is then used to compute trip share on/off/near the designated cycle network; first for the all cycle trips (see Table 3), second for only home to work cycle trips (see Table 4), and all cycle trips except home to work trips (see Table 5). The spatio-temporal dimension of the cycle trip shares on/off/near the cycle network for only home-to-work trips is visualised in a space-time cube making the time dimension of trips more visible for easy graphical interpretation and understanding (see Figure 4).

All Trips		Off/On/Near Network - Corridor space characteristics (Weighted distance travelled in km / %)			Total
		Outside buffers (off network)	10m buffer (on network)	10-20m buffer (near network)	
Gender	f	695 km (32.5%)	1262 km (59.1%)	179 km (8.3%)	2136 km
	m	1167 km (34.6%)	1900 km (56.3%)	305 km (9.1%)	3372 km
Total		1528 km **(34.1%)**	2555 km **(57.0%)**	398 km **(8.9%)**	4481 km

Table 6: *All Trips: Gender & Cycling with Off/On/Near Network - Corridor space characteristics*

Only Home-to-Work Trips		Off/On/Near Network - Corridor space characteristics (Weighted distance travelled in km / %)			Total
		Outside buffers (off network) f: 20, m:49	10m buffer (on network) f: 20, m:50	10-20m buffer (near network) f: 20, m:50	
Gender	f	260 km (32.8%)	470 km (59.3%)	63 km (7.9%)	793 km
	m	493 km (36.3%)	741 km (54.6%)	123 km (9.1%)	1357 km
Total		753 km **(35.0%)**	1211 km **(56.3%)**	186 km **(8.7%)**	2150 km

Table 7: *Only Home-to-Work Trips: Gender & Cycling with Off/On/Near Network - Corridor space characteristics*

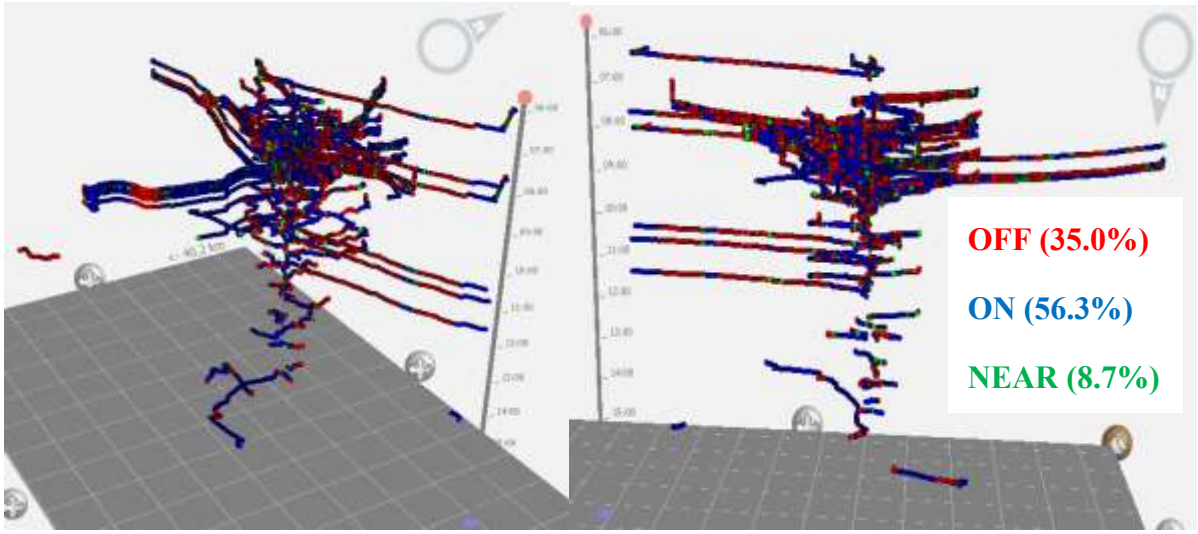

Figure 4: 3D Space-time map of only Home-to-Work Trips: Gender & Cycling with Off/On/Near Network - Corridor space characteristics

All Other Trips		Off/On/Near Network - Corridor space characteristics (Weighted distance travelled in km / %)			Total
		Outside buffers (off network) f: 27, m:52	10m buffer (on network) f: 27, m: 52	10-20m buffer (near network) f: 27, m: 52	
Gender	f	433 km (29.6%)	901 km (61.5%)	131 km (8.9%)	1465 km
	m	674 km (34.4%)	1159 km (57.5%)	182 km (9.0%)	2015 km
Total		1107 km **(33.1%)**	2060 km **(58.0%)**	313 km **(8.9%)**	3480 km

Table 8: All Other Trips: Gender & Cycling with Off/On/Near Network - Corridor space characteristics

Additionally, two more layers of data are considered: cycle parking layer and cycle crossing layer vis-à-vis the given sample cycleway revealed route choices (see Figure 5). Forty four parking features out of 224 were found 20m near the sample actual route choice paths. Two hundred and six crossings were identified within the corridor space with 120 labelled as, a junction type, pelican crossing and 81 as toucan crossing whiles 5 were unlabelled as crossings but rather bikeshops.

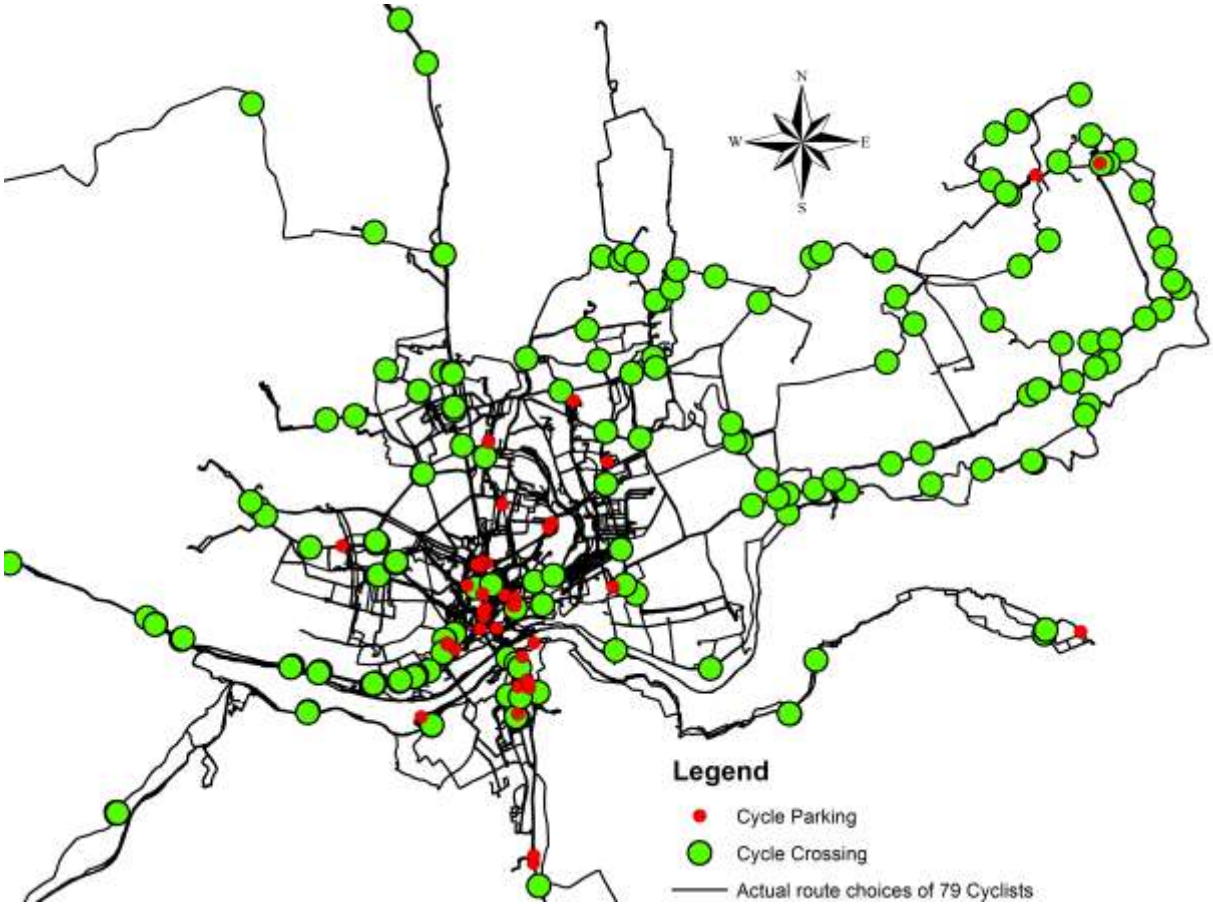

Figure 5: Map showing cycle furniture-crossings and parkings- with actual route choices of 79 Cyclists only cycling trips

7. Discussion and conclusions

This research has for the first time facilitated the collection and analysis of detailed bicyclists' route choices in the UK, bringing substantive empirical evidence for understanding daily cycling behaviours. Few published studies related to cycling have the uniqueness of the research design developed for this research study about utility cyclists which show actual route choice preferences within the study area. The triangulation of evidence using available secondary data further deepens the existing understanding of cycling patterns and infrastructure within the study area. Additionally, STC based data processing visual technique has the potential of allowing anyone who is familiar with the neighbourhood to easily clean a messy GPS dataset without any algorithmic knowledge of complex toolkits. Another novel concept introduced is the corridor space spatial analysis approach which offers a unique ways-and-means for understanding cyclists' interactions with the built environment which partly constitutes the cycling infrastructure.

Findings from the corridor space analysis suggest that 57% of cyclists from sample prefer cycling on the cycle network whiles 34.1% cycles outside the cycle network with 8.9% near the cycle network. Also, for all cycle trips, it was found out that females prefer to cycle on the network whiles males prefer outside the network. Same trend follows for only home-to-work cycle trips. However, these differences of gender and cycling corridor network infrastructure usage are not so significant. With 43% of cyclists still cycling outside the designated cycle network, it is imperative that policy initiatives are aimed towards investing

in cycling research and infrastructure. The frequencies of male cyclists who cross cycle crossings are almost four times (i.e., 3.8 times) that of female cyclists; suggesting that female cyclists may tend to avoid cycle crossings.

More cycle parking locations are available around the southern part of Newcastle upon Tyne suggesting perhaps the demand there is higher than the rest of the Tyneside conurbation. The collected data also shows high concentration of GPS traces around the area with high cycle parking. However, this may be due to the sample design criteria or simply the reality since part of both road and rail networks seem to be prevalent in the area. With increasing availability of micro data on active transport, the need to integrate active transport (i.e., cycling and walking) in transport demand models is paramount. Further work will aim at considering other modes taken by these cyclists to find out if cyclists often prefer integrated transport including cycling or simply just only cycling. Another important future research prospect in transportation research is to be able to reconstruct cyclists' travel behaviour; for example, using an agent based modelling and simulation (ABMS) approach.

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Biography

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