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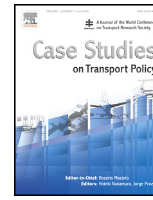

Cycling promotion schemes and long-term behavioural change: A case study from the University of Sheffield

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ABSTRACT

Cycling has a range of health, environmental and economic benefits compared with motorised forms of transport. There is a need to encourage more cycling, yet previous evaluations of cycling promotion schemes have been inconclusive about what works. A case study of a cycling promotion scheme at the University of Sheffield – the Cycle Challenge – is used in this paper to examine commuting behaviour and long-term behavioural shifts towards cycling in response to outside intervention at the organisational level. The Cycle Challenge was designed to encourage more people at the University to cycle through inter-departmental competition. Cycling behaviour was recorded before the Cycle Challenge and two years after the scheme's completion. It was found that seventy five percent of participants who were not already regular cyclists reported increased cycling, yet the overall impact of this shift was limited because the majority of participants already cycled regularly. This failure to attract new cyclists suggests recruiting non-cyclists should be a priority in future schemes. Moreover, our study has methodological implications. Current strategies for evaluating the positive impact of cycle initiatives may overestimate the savings by neglecting the tendency of people to resume routine behaviour in the long run. Studies evaluating modal shift should therefore include provision for monitoring long-term behavioural change to provide input into estimated economic, environmental or health metrics of success.

1. Introduction

Cycling has a range of benefits to both individuals and wider society. It offers an accessible form of physical activity for many people, and regular physical activity has a number of health benefits, including reduced risk from cardiovascular disease, cancers and diabetes (Department of Health, 2004; Manley, 1997; Saunders et al., 2013), improvements in cardiovascular fitness and risk factors (Oja et al., 2011), and overall mortality rates (Kelly et al., 2014). Motorised transport has been identified as a causal factor behind the 'obesity epidemic' (Caballero, 2007), suggesting a return to active transport for everyday journeys would have large health benefits. Physical activity has also been shown to support mental well-being and reduce mental health problems such as depression and anxiety (Department of Health, 2004; Manley, 1997). Given that 61% of men and 71% of women in England do not meet recommended levels of physical activity[1] (Craig et al., 2009), regular cycling offers an opportunity to improve public health and reduce the burden on health services.

Environmental benefits of cycling are also frequently cited as a reason for uptake on the individual level (Gatersleben and Haddad, 2010) and as a motivation behind pro-cycling interventions by local, regional and national authorities (Blank et al., 2012; Pucher and Buehler, 2008). The economic benefits of cycling have been identified as reduced congestion (and faster journey time), increased worker productivity and reduced travel costs for individuals (Saelensminde, 2004; Tilahun et al., 2007). However, most comprehensive economic analyses identify reduced expenditure on health as the most important saving (Jarrett et al., 2012; Rutter et al., 2013). There is now strong evidence to suggest that the health benefits of increased life expectancy vastly outweigh the

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[1] Based on previous definition of at least five occasions of moderate or vigorous activity of at least 30 min duration per week. Guidelines have now changed to be at least 150 min over a week of moderate activity in bouts of 10 or more minutes. See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213740/dh_128145.pdf.

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health costs of accident risk and exposure to air pollution (Hillman, 1993; Rojas-Rueda and Nazelle, 2011). Health benefit:cost ratios of cycling have been identified as 20:1 in the UK (Hillman, 1993) and more than 70:1 in Barcelona (Rojas-Rueda and Nazelle, 2011). A recent meta analysis about the health impacts of active travel overall (walking and cycling) concluded that the evidence to date provides "consistent support for the positive effects on health of active travel" (Saunders et al., 2013; p. 12). There is also evidence to support the 'strength in numbers' hypothesis that cycling becomes safer per kilometre as the number of cyclists increases (Pucher and Buehler, 2008). Guidance has recently been published (Kahlmeier et al., 2014) that provides methods for assessing the health and economic impacts of cycling which should allow such impacts to be ascertained more accurately from future intervention studies.

Despite the multi-faceted benefits of cycling and the fact that riding a bicycle is something most adults in Britain can do. Eighty five percent of adults in the UK can cycle (Department for Culture, Media and Sport, 2011a), and cycling is the third most common recreational or sporting activity carried out by adults in Britain (Department for Culture, Media and Sport, 2011b). However, only 2% of all trips made in Britain are completed using a bicycle (DfT, 2013). There is much potential for increasing the number of journeys that are taken using a bicycle; for example, 38% of all trips in Britain are less than two miles, and 66% are less than five miles (DfT, 2013). Research in London suggests there are potentially 4.3 million trips per day that could be made by bicycle, yet nearly two thirds of these trips are made by car (Transport for London, 2010). In the UK there have been a number of national policies and local interventions to promote cycling (e.g. DoT, 1996; DfT, 2004; Gaffron, 2003; see Golbuff and Aldred, 2011, for a review of UK cycling policy over the last four decades), but the lack of increase in cycling rates over the last three decades suggests these have had limited success (Parkin, 2003; Cabinet Office, 2009). Aldred (2013a) suggests that cycling in the UK has been marginalised with the car dominating infrastructure, for example car parking often taking precedence over cycling infrastructure for example. The low uptake of cycling can therefore be seen as a result of cultural and societal factors, and there is a need to enhance the position of cycling within local as well as national cultures if cycling activity is to increase (Aldred and Jungnickel, 2014). This may be starting to happen in the UK, evidenced for example by the increase in cycling advocacy groups (Aldred, 2013b). One approach to developing the cycling culture and increase cycling activity is to implement interventions designed to encourage and support cycling behaviour.

A range of research has examined the effectiveness of different activities designed to encourage cycling behaviour (e.g. Davis, 2010; Brockman and Fox, 2011; Bowles et al., 2006; Bauman et al., 2008; Ogilvie et al., 2004; Yang et al., 2010). Recent work at the University of Sheffield (Blank et al., 2012; Johnson et al., 2012) has systematically examined a range of evidence relating to the effects of interventions to promote cycling and walking. As with other reviews (Ogilvie et al., 2004; Yang et al., 2010), the evidence was largely inconclusive. Cyclist-friendly facilities, such as secure storage, showers, and changing facilities at schools and workplaces, were found to be important, especially for promoting long-distance cycle commutes (Johnson et al., 2012; p. 9) However, long-term effects are rarely examined in follow-up work and when they are, ambiguity remained about which aspects of the interventions had the most positive outcomes (Blank et al., 2012), or behavioural change appeared to be limited and difficult to attribute directly to the intervention (Transport Scotland, 2013).

Universities can provide useful case studies of travel behaviour and travel intervention schemes. They are generally large employers thus providing a potentially large sample of commuters, and because University buildings are generally close to each other, being on campus, they effectively provide a single workplace destination, meaning a focus can be applied to where commuters have travelled from (Lavery et al., 2013). Universities can also provide insights into two distinct populations—students and staff. Indeed, it has been suggested that students are an important segment of the travelling population but their travel behaviour is not well understood (Khattak et al., 2011). A number of previous studies have examined travel behaviour at Universities (e.g. Cole et al., 2008; Delmelle and Delmelle, 2012; Eom et al., 2009; Miralles-Guasch and Domene, 2010; Shannon et al., 2006; Whalen et al., 2013). These have shown that cycling as a mode of transport at Universities is low, often accounting for less than 10% of trips. These low proportions suggest there is scope for increasing the levels of cycle commuting amongst University communities, making them good candidates for cycling promotion schemes. For example, Miralles-Guasch and Domene (2010) found that there was "significant potential for increasing the modal share of walking and cycling trips to the campus" (p. 461) given the proportion of the university community who lived within a walkable or cyclable distance. Shannon et al. (2006) also found that 37% of students and 39% of staff living within 8 km of University were confident they could cycle to University even though only 10% and 14% of these populations currently cycled. It is therefore informative to examine what effect cycling promotion can have within a University context.

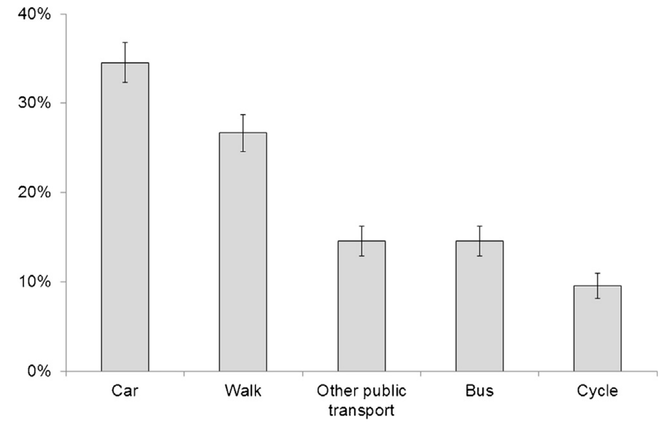

Fig. 1. Proportion of staff respondents travelling to work by mode. Error bars show 95% confidence intervals.

In this article we provide a case study of travel behaviour at the University of Sheffield, with a particular emphasis on cycling as a means of commuting. As part of this case study we examine the long-term behavioural effects of a cycling promotion scheme at the University. We focus in particular on staff at the University, as previous studies examining transport at Universities have often focused on the student population but this group tends to have differenet sociodemographics and travel behaviour to the wider general population (Khattak et al., 2011).

2. Commuting behaviour at the University of Sheffield

Data from the University of Sheffield's 2011 Travel Survey were analysed to provide information about the dimensions of commuting behaviour. The survey received responses from 1,743 members of staff (31% of all staff at the University in 2010/11) and 1448 students at the University (6% of all students at the University in 2010/11). Only data relating to staff are reported in this paper as this information is thought to be most informative regarding commuting: the student population are unrepresentative of a typical group of commuters as they have atypical

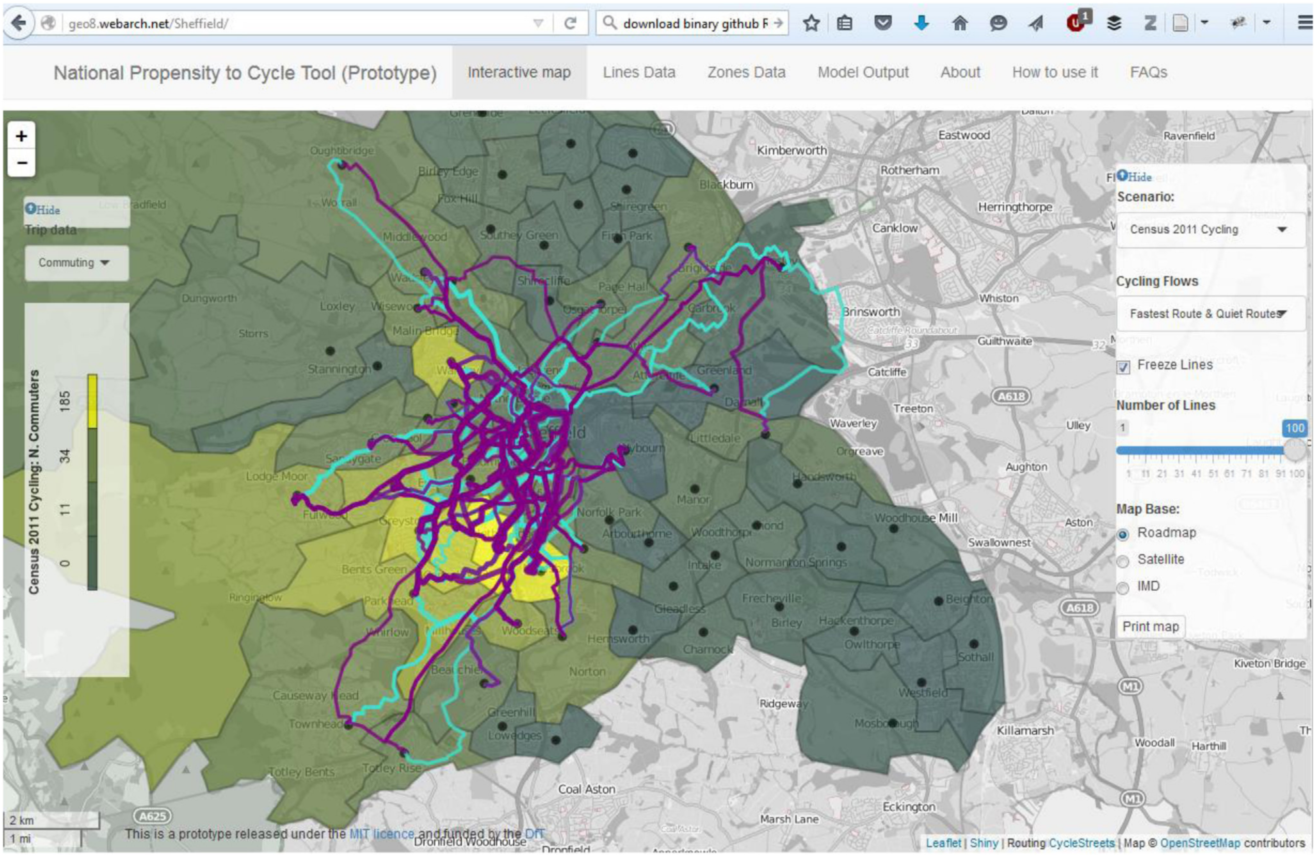

Fig. 2. Visualisation of route-allocated flows from the Propensity to Cycle Tool (PCT), from http://geo8.webarch.net/Sheffield/ (Lovelace et al., 2015). Purple and turquoise lines represent 'fastest' and 'quietest' routes created by the CycleStreet.net API ('Fastest' meaning most direct route and 'quietest' meaning avoiding busy roads with high volumes of traffic).

commuting patterns and mode choices. The age and gender profiles for staff were similar to that for the wider University staff population so it was assumed the Travel Survey provided a representative sample of all staff at the University. Information is presented about three aspects of commuting:

1. Mode of travel.
2. Commute distance.
3. Commute time.

2.1. Mode of travel

Fig. 1 shows the proportion of University staff travelling to work by different modes of transport[2]. The car is the dominant mode of transport, with 35% of staff commuting by this mode. Ten percent of staff cycle to work. This is higher than the national average of 2% of people commuting by bicycle although still well below the proportion of staff who travel to work using motorised methods of transport. Previous research at a University has also found that the car is the main method of tarnsport, with around 8% of staff cycling to work (Shannon et al., 2006).

2.2. Commute distance

Respondents to the Travel Survey provided their home postcodes and these were used along with a generic University location at the heart of the campus to calculate home-to-University distances.[3] Various route-allocation methods were tested, the most promising of which seemed to be the use of the CycleStreets.net API (see Lovelace et al., 2015): simpler 'shortest path' algorithms produced seemingly unrealistic routes. However, we decided to use Euclidean distance in the end, because of the high correlation between route and network distance observed for Sheffield data based on CycleStreets.net (Fig. 2) and the uncertainties around the true origin, destination and routes taken. The noise added through these factors would likely outweigh any benefit of perceived 'accuracy' of distances derived from route-allocated distances.

The University of Sheffield's campus is relatively dense, with the large majority of departmental and administrative buildings located within a 1 km^2 area. Descriptive statistics for home-to-University distances are shown in Table 1. Note that median figures are quoted as the data is positively skewed and therefore not normally distributed.

The median Euclidean home-to-University distance for staff at the University is 4.7 km. Those travelling to University using motorised modes tend to live further away than those who cycle or walk to work. The average distance a cyclist commuter travels is

[2] The survey asked "Thinking about the journeys you normally make as part of a typical week, please identify your main mode of transport", and participants could select from 8 options. These have been collapsed into 5 categories for reporting in this paper.

[3] Distances calculated were shortest network distances using road layers within ArcView GIS.

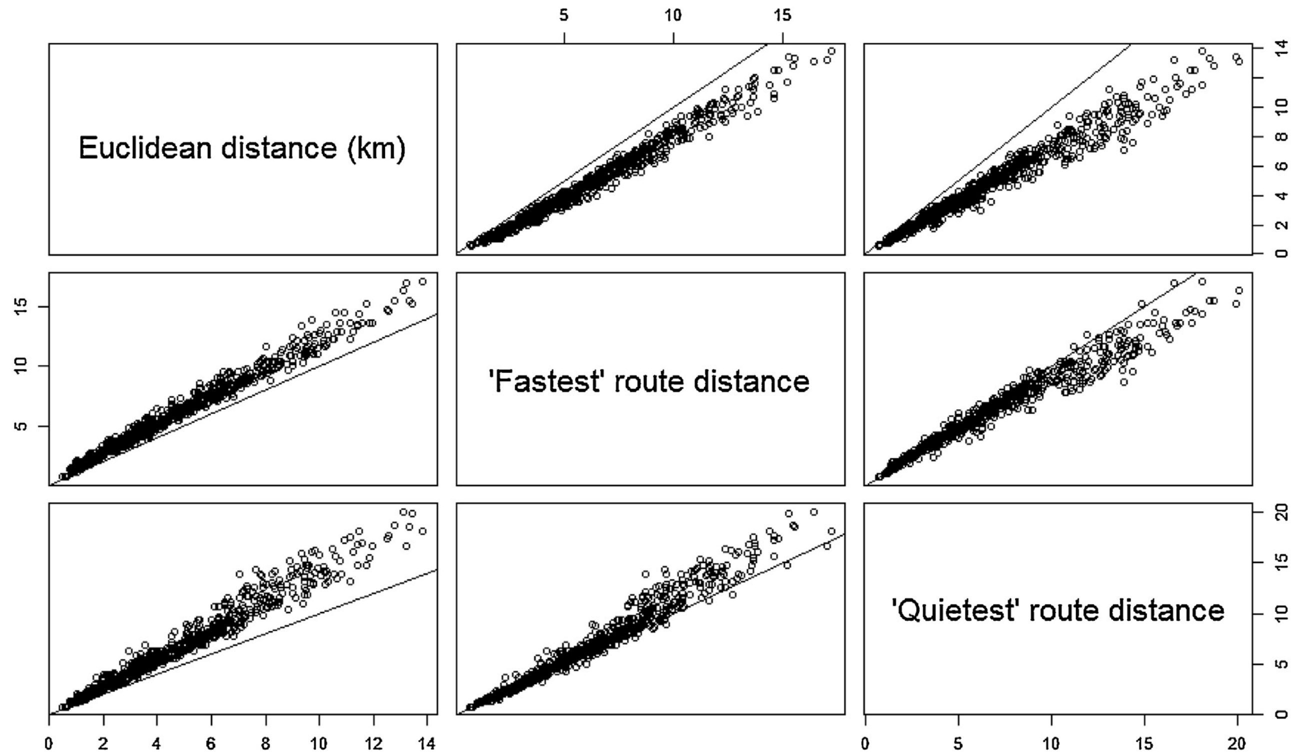

Fig. 3. Scatter plot matrix showing the correlation between route-allocated and Euclidean distances for 690 representative OD pairs in Sheffield. *r* values of 0.990 and 0.981 were found between Euclidean and 'fastest' and 'quietest' routes, respectively. Mean values for Sheffield for the 'fastest' and 'quietest' routes were found to be 1.307 and 1.402 respectively.

3.6 km, with 73% of cyclist commuters travelling 5 km or less, and 91% travelling 8 km or less. This compares with 64% of cyclist commuting staff travelling less than 8 km in a previous study at an Australian University (Shannon et al., 2006).

We also analysed home-to-work data from the 2001Census to provide some validation of the commuting distance information derived from the University's Travel Survey. Origin-destination pairs at the detailed Output Area (OA) level were used.[4] Although University buildings spread across a number of OAs in Sheffield the centre of the campus is located in one OA, 00CGFX0055. This OA predominantly has only University buildings in and is the only OA used in this analysis, as other OAs are likely to include a number of non-University buildings—see Fig. 2

Fig. 3 indicates that the University of Sheffield draws its staff from a wide area. People travel from all parts of the city although the highest density flows (represented by lines) tend to originate from the historically wealthier West of the city. There are a total of 625 OA origins present in the data, 125 of which are located outside Sheffield. Based on the Euclidean distance between OA origin-destination centroids, the distribution of distances travelled by University of Sheffield staff was analysed. Euclidean distances, as opposed to network distances, were used in this case due to the large number of OAs from where people travel, making network analysis for the entire origin–destination matrix unrealistic.

The median of these straight line distance to work values was 3.8 km; the mean was 8.5 km. The reason for this disparity between mean and median is that the distribution of trips is highly skewed (Fig. 4). Excluding those who commute more than 50 km to work (who are likely to commute less frequently), the mean distance dropped to 5.7 km, whilst the median dropped only slightly, to 3.7 km. This compares with a median home-to-University distance from the Travel Survey of 4.7 km (see Section 2.2). The Travel Survey distance is network distance, but this (and information on detours due to other factors such as parking and traffic) is not available for Census home-to-work data. However, assuming a 'circuity' factor of 1.4 for the UK (Ballou et al., 2002) the median network home-to-work distance can be estimated from the Census data as 5.2 km. This compares favourably with the network home-to-work distance calculated from the Travel Survey of 4.7 km, and provides some validation of this data source.

Table 1
Median and variability for staff home-to-work distances (km) from the University Travel Survey.

Mode of transport	Median	Interquartile range
Walk	1.9	1.4–2.8
Cycle	3.6	2.5–5.3
Bus	5.0	3.6–8.2
Other public transport	9.8	4.7–23.2
Car	10.6	5.0–19.8
All modes	4.7	2.6–11.4

2.3. Commuting time

The Travel Survey asked respondents to estimate how long their commute to work normally takes.[5] The median estimates for staff members are shown by mode of travel to work in Table 2. Cyclists have the shortest commute to work in terms of time, based on self-

[4] The dataset of commuter flows for the entire UK was provided on a CD from the data portal NOMIS (see http://www.nomisweb.co.uk and search for "origin-destination" for further information). This dataset contains almost 6 million origin–destination pairs; these were cut down to include only those for which the destination output area contain University of Sheffield premises.

[5] The survey question was "How long does your normal commute take (in min)?".

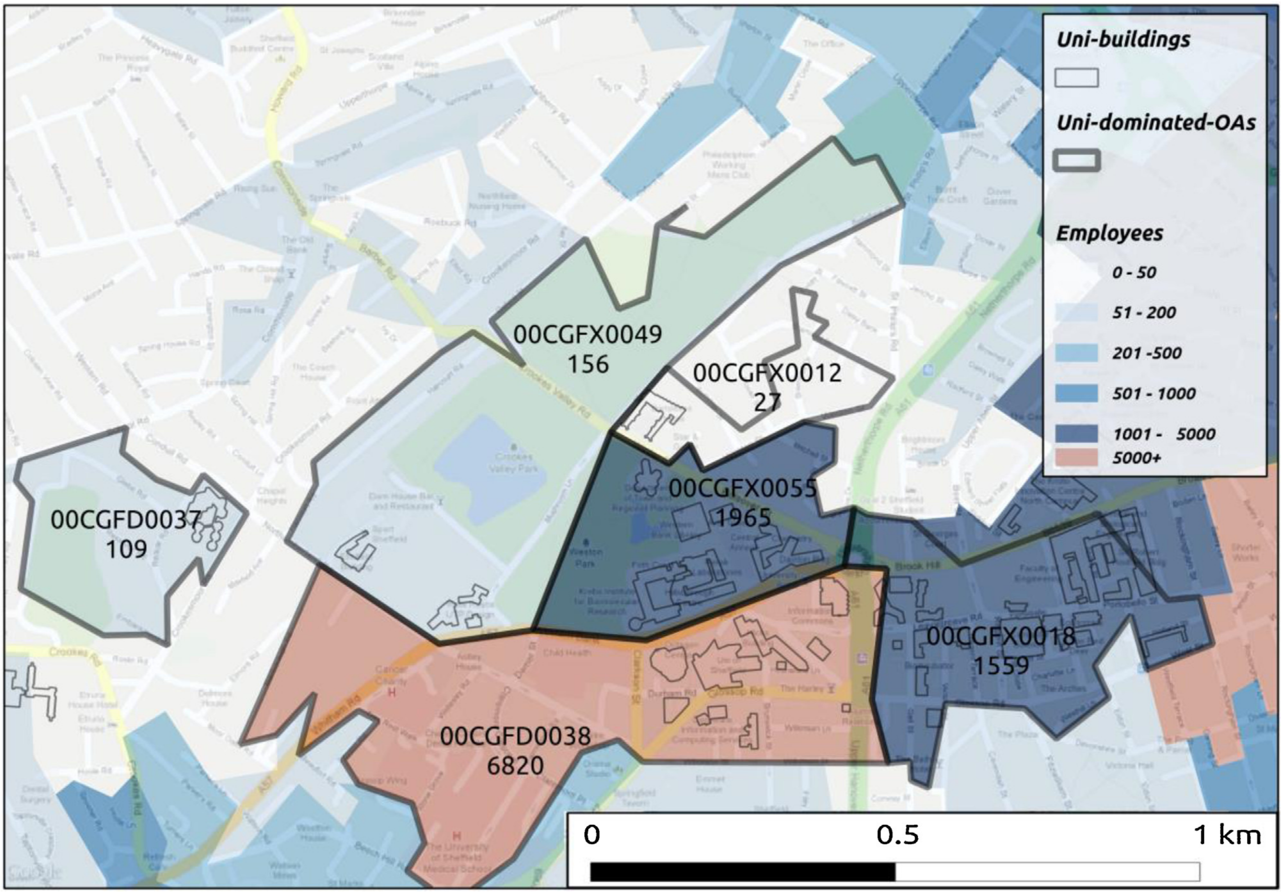

Fig. 4. Output areas surrounding the University of Sheffield. Areas dominated by the University (abbreviated to 'Uni') are those in which most of the work-time population are thought to work for the University. The label for each highlighted zone is the zone code (above) and the number of people who work in that zone (below).

reported estimates. These commuting times do not take into account distance from work though. To account for this, the average commuting time per kilometre has been calculated, in order to compare different modes of travel kilometre-for-kilometre. These are also shown in Table 2. At 4 min per kilometre, cycling represents one of the quickest forms of commuter transport, and takes only slightly longer than commuting by car, kilometre-for-kilometre. Previous research has also estimated the travel time and compared this with distance (Miralles-Guasch and Domene, 2010), and found a similar commute time per km for cycling (4.3 min).

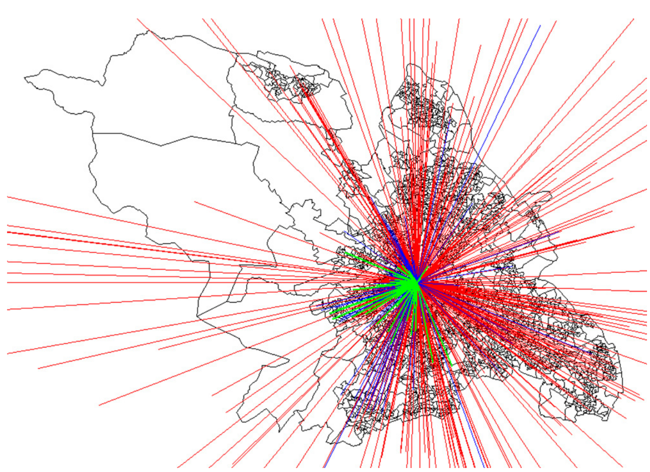

Fig. 5. Commuter flows to the University of Sheffield (zone 00CGFX0055) from the UK. Red, blue and green lines represent small to large flows (1–4, 5–7 and 7 plus respectively). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3. The Cycle Challenge

The "Cycle Challenge" was a cycling promotion scheme carried out at the University of Sheffield during November 2009, administered by the cycling charity organisation CTC (the Cycling Tourist Club). The scheme includes provision for "data capture" and operates nationwide, offering great potential for comparative studies.[6] A second Cycle Challenge was also carried out between May and July 2010. These Cycle Challenges were behavioural change programmes, designed to encourage more people at the University to cycle. Each Cycle Challenge had three aims:

1. Encourage non-cyclists to take up cycling.
2. Encourage occasional cyclists to start cycling more often.
3. Encourage people to cycle for transport purposes.

The 2009 and 2010 initiatives were virtually identical in nature and are examined and referred to in the rest of this article as a single "Cycle Challenge". The basis of the Cycle Challenge was as a workplace challenge in which departments at the University competed against each other to see who could get the most employees and students to ride a bike (for at least 10 min).

[6] See http://www.ctc.org.uk/category/tags/workplace-cycle-challenge.

Table 2
Average estimate of commuting time for staff, by usual mode of travel.

Usual mode of travel	Median commuting time (min)	Commuting time interquartile range	Commuting time per km (min/km)	Commuting time per km interquartile range
Walk	25	15–30	12	10–14
Cycle	15	12–25	4	3–6
Bus	40	30–50	7	5–10
Other public transport	45	30–70	5	3–6
Car	35	25–45	3	2–4

Table 3
Frequency of cycling amongst participants during 12 months prior to Cycle Challenge.

Cycling behaviour	Cycling category	Number of participants	Proportion
Not at all	New cyclist	24	8%
Maybe once or twice		31	11%
1–3 times a month	Occasional cyclist	33	12%
Once a week		23	8%
2–3 days a week	Regular cyclist	48	17%
4 or more days a week		129	45%

The Cycle Challenge aimed to utilise elements from a number of behavioural change theories. These included:

- Self-perception theory (e.g. Bem, 1972)—giving someone a positive experience of cycling will provide their strongest perceptions of that behaviour.
- Self-efficacy theory (e.g. Bandura, 1977a)—engaging people in cycling activity will enhance their perception of what they are able to achieve, and that cycling is not an unattainable behaviour.
- Social learning theory (e.g. Bandura, 1977b)—people learn through observation of other people's behaviour, and will be more likely to adopt the behaviour themselves if they see it resulting in positive desired outcomes.
- Community-based social marketing (e.g. McKenzie-Mohr, 2000)—most behaviours can be broken down into sub-behaviours, each of which has its own perceived barriers and benefits. Addressing these sub-behaviours can lead to increases in the overall target behaviour, if selected appropriately.

Participants were required to sign up on a specially designed website for the scheme and log details about any cycle trips that were made, including the distance covered. Various team and individual prizes were offered as an incentive for people to take part. Although there was no verification of details logged to prevent false reporting, the prizes offered were not of such value that 'cheating' was anticipated. The details of the logged rides are not analysed in this case study so if any false reporting did occur it should not impact on the findings reported here. In July and August 2012 a follow-up survey was carried out with participants from the 2009 and 2010 Cycle Challenges. This was designed to reveal any long-term changes in cycling behaviour and understand views and attitudes towards cycling and cycling promotion initiatives. In this article we only report data relating to cycling behaviour.

4. Method

4.1. 2009/2010 Cycle Challenge baseline survey

An online survey collected baseline data from participants when they registered to take part in the Cycle Challenge. This collected information on their cycling behaviour and basic demographic information. Participants were categorised as being a "New Cyclist", "Occasional Cyclist" or "Regular Cyclist", based on their response to the question: "Before taking part in the Challenge, roughly, how often have you ridden a bicycle in the past 12 months?" (see Table 3 for categorisation of responses).

4.2. Participants

Data from 488 individual participants who took part in the 2009 and/or the 2010Cycle Challenge were collected through the baseline survey. This included 361 participants in the 2009 initiative and 210 participants in the 2010 initiative. These numbers include 83 people who took part in both years. The total 488 participants represented 99% of all people who took part in either Cycle Challenge. Staff at the University constituted 59% of survey respondents with 41% being students. Only data from staff respondents is reported in the following analysis. 30% of staff were aged under 35.

4.3. Follow-up survey

The baseline survey recorded email addresses for all participants in the Cycle Challenge, and during July and August 2012 a follow-up survey was issued via email to all Cycle Challenge participants.[7] This survey collected information about current cycling behaviour and attitudes towards cycling, views on the Cycle Challenge and other cycling initiatives, and participant demographics. Entry into a free prize draw to win a £50 online shopping voucher was offered as an incentive to complete the survey. The online survey was open for a period of ten days. All 488 respondents from the original baseline survey (both staff and students) were sent a link to the online follow-up survey in 2012. However failed mail delivery messages indicated 175 of the email addresses used for the survey invitations were no longer in use.[8] A total of 81 completed responses to the survey were received. This represents a 26% response rate if previous respondents with invalid email addresses are excluded from the total potential sample. 91% of respondents to the follow-up survey were members of staff, with 9% being students. Only data from the staff responses are reported in the following analysis. 22% of staff were aged under 35.

[7] The email contained a link to the online survey, hosted by the survey website SurveyGizmo.

[8] This was perhaps to be expected given the staff and student turnover at the University since 2009 when the first Cycle Challenge baseline survey was carried out.

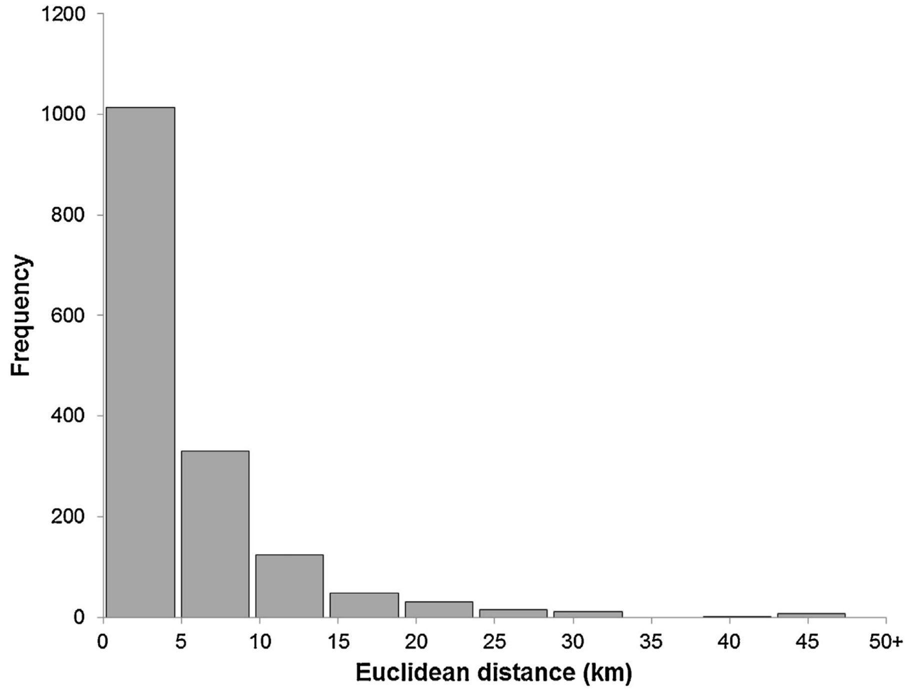

Fig. 6. Histogram of the Euclidean distances travelled to work by commuters to the University of Sheffield, as implied by origin-destination commuter flow data.

5. Results

5.1. Participants' original cycling habits

The proportion of staff participants classed as New, Occasional or Regular cyclists before the Cycle Challenge is shown in Table 3. This shows that 111 participants were New or Occasional cyclists, and 177 participants were Regular cyclists. The cycling rate amongst participants was generally much higher than the national average, with just 8% of residents in Great Britain cycling 3 or more times per week (DfT, 2013), compared with at least 45% amongst the Cycle Challenge participants—see Table 3.

5.2. Long-term increases in cycling

Respondents to the follow-up survey were asked "Did the Cycle Challenge encourage you to cycle more?". Nearly half (47%) said they had been encouraged to cycle more. One reason this proportion may not have been higher is because a high proportion of respondents (62%) were already regular cyclists before the Cycle Challenge, and so were not in a position to cycle more. This was supported by analysis of responses to an open text question asking respondents why they were not encouraged to cycle more if they had answered 'No' to the question. Nearly all explanations related to already cycling as much as they could. Only one explanation related to a different reason, which was not having enough time to cycle more.

The follow-up survey also asked respondents how regularly they currently cycled, based on the last 12 months. This period was used firstly to ensure consistency with the question used in the original baseline survey, and secondly to ensure sustained cycling behaviour was being measured and not just a snapshot of a short period of time. The same question phrasing and response categories were used as those in the original baseline survey and respondents were placed in the same categories of New, Occasional or Regular cyclists. A comparison was made between respondents' current cycling behaviour and their cycling behaviour before the Cycle Challenge, to provide an indication of any longitudinal change that had occurred. Table 4 shows the type of cyclist category participants classed themselves as prior to the Cycle Challenge and 2–3 years later, during the follow-up survey.

Overall, 26% of the respondents had increased the frequency of their cycling since the original Cycle Challenge (highlighted in the shaded cells in Table 4). However, the high number of participants who were originally classed as Regular cyclists limits the number who could actually increase their cycling frequency. When considering those participants who had scope to increase their cycling frequency (New and Occasional cyclists prior to the Cycle Challenge), 75% did actually increase cycling frequency, based on self-reported behaviour (New cyclists becoming either Occasional

Table 4
Cycling behaviour amongst participants pre-Cycle Challenge and post-Cycle Challenge. Note: Frequency and (proportion) shown. Proportions are those within cyclist type prior to Cycle Challenge, and may not sum to 100% due to rounding. Shaded cells indicate those participants whose cycling frequency has increased since Cycle Challenge.

		Cyclist type prior to Cycle Challenge(baseline survey)		
		New cyclists	Occasional cyclists	Regular cyclists
Cyclist type after Cycle Challenge (follow-up survey)	New cyclists	2 (15%)	1 (7%)	6 (11%)
	Occasional cyclists	2 (15%)	4 (27%)	9 (17%)
	Regular cyclists	9 (69%)	10 (67%)	38 (72%)

or Regular cyclists, and Occasional cyclists becoming Regular cyclists).

Respondents were asked what their main mode of transport to work was. A breakdown of responses is shown in Fig. 5. Cycling was the main mode of commuting for 63% of respondents. This is a much higher proportion than the wider University population (the University's Travel Survey indicates only 10% of staff commute by bike). Regular cyclists were more likely to cycle to work than other respondents (88% compared with 4%). Respondents who were not classed as regular cyclists tended to either travel by car (50%) or walk (29%). Respondents to the follow-up survey were also asked to estimate, to the nearest five minutes, how long it takes them on average to commute to work. A Mann–Whitney U-test showed that the median estimated commute time for cyclist commuters was significantly lower compared with that of other commuters (medians = 21 min versus 32 min, $U = 267$, $p < .001$). However, there was no significant difference between cyclist commuters and other commuters in terms of the distance they lived from the University (medians = 4.5 km and 5.9 km respectively, $U = 347$, $p = .338$). This suggests distance may not have been a factor in causing the difference in commuting times between cyclists and non-cyclists, suggesting cycling can be a relatively quick mode of transport to work (Figs. 6 and 7).

5.3. Cycle commuting potential

Although a University may not be a typical type of workplace, motorised transport is still the most dominant mode of travel for commuting to work. The median home-to-work distance for staff at the University is about 5 km, based on results from the University's Travel Survey and 2001Census home-to-work data. Further analysis of commute distances by mode of travel shows the median home-to-work distance for car commuters is 10.6 km. However, 25% of car commuters live within 5 km, and 40% live within 8 km. We believe 8 km to be a meaningful threshold for two reasons. Firstly, it is a distance that can be cycled in a reasonable amount of time, given commuting times for other modes of transport. For example, University staff who commute by car take on average 35 min to get to work (see Section 2.3). Based on the commute time per kilometre for cyclist commuters, 35 min would allow someone to cycle 8.75 km (see Table 2). Therefore, cycling 8 km would take no more time than the average commute time for car users. Secondly, 8 km has been defined as a cycleable distance in previous research (Transport for London, 2010; Shannon et al., 2006).

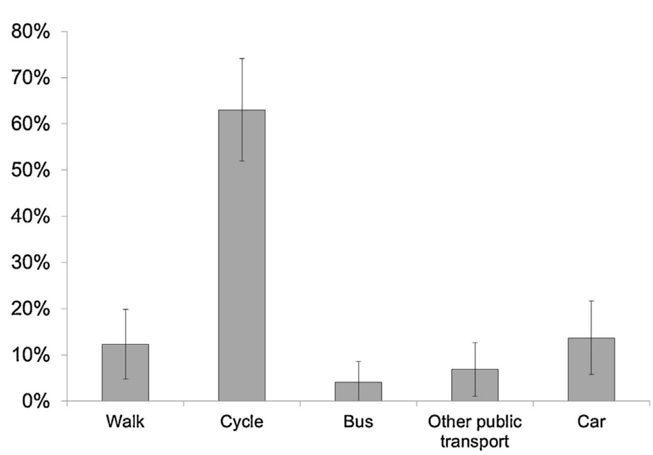

Fig. 7. Proportion of Cycle Challenge follow-up survey respondents travelling to work by different modes. Error bars show 95% confidence intervals.

These results suggest that 40% of car users live within the potentially cycleable distance of 8 km from the University, suggesting there appears to be great potential for modal shift from car to cycle commuting at the University of Sheffield. Our analysis from the Census data also showed that 57% of University commuters lived within an inferred network distance of 8 km. Sheffield has a relatively low density compared with other cities, and a large proportion of academics commute from the countryside. A shift to cycling in other similar organisations could therefore be even greater. Shifting work and travel habits including the rise of telecommuting could see this potential grow: cycling 8 km is more feasible if it is undertaken 3 days a week rather than 5 days a week. Also, technological developments such as electric bicycles could further increase the accessibility of cycling in the future.

6. Discussion

This article describes a case study of commuting behaviour and a cycling promotion scheme at a University in the UK, with an emphasis on whether long-term behavioural change occurred. The Cycle Challenge was a promotional scheme designed to encourage more cycling amongst people at the University. The Cycle Challenge had some long-term success, as 75% of participants who had the scope to increase their cycling frequency reported that they were indeed cycling more frequently when asked 2–3 years later, although this proportion is based on a relatively small sample. However, it is not certain that any increase in cycling frequency can be attributed to the Cycle Challenge, as no comparison or control group was available. When asked whether the Cycle Challenge had encouraged them to cycle more only 47% of all respondents answered yes, and this increased to only 50% for those participants who reported they were cycling more frequently than they were prior to the Challenge. In addition, the absolute numbers of those who had increased their cycling frequency was relatively low, largely because the Cycle Challenge attracted a high number of participants who were already regular cyclists and who could not realistically increase their cycling frequency any further. This is a flaw common with other interventions of this nature (e.g. Bowles et al., 2006) or not considered when promotion schemes are evaluated (Yang et al., 2010).

One of the key difficulties with travel behaviour and commuting in particular is the routine nature of the activity. Commuting is habitual and therefore intrinsically difficult to influence (Verplanken et al., 2008). This factor needs to be addressed if future interventions to encourage cycling are to be more effective. A promising scheme that has been proposed to tackle this 'embedded' nature of commuting behaviour is to introduce promotional activities at a time of contextual change in the potential participant (Arbuthnott, 2009). Context is a major determinant of habitual behaviour and a change in context can open a "window" into the behaviour making it more likely to be influenced (Verplanken et al., 2008).

As highlighted in our introduction, there is a lack of evidence about what makes a cycling promotion scheme or initiative successful. This is problematic for decision makers developing new schemes to maximise cycling uptake amongst habitual car drivers. To build this evidence base, a body of informative and practical evaluations of promotion schemes is required, to which this paper contributes. One important element of any evaluation is the impact on long-term behaviour, and whether activity results in a longitudinal shift towards cycling. Based on our review of previous cycling evaluation studies, and other systematic reviews (Yang et al., 2010; Ogilvie et al., 2004; Blank et al., 2012; Johnson et al., 2012) we have found that rates of long-term behavioural change are particularly under-reported.

Our focus has therefore been on the long-term impacts of the Cycle Challenge. After two years, the finding that 75% of respondents have increased the rate of cycling but that only around half of these attributed the change to the Cycle Challenge suggests the scheme was moderately successful at changing behaviour, although this conclusion is based on a relatively small sample of respondents. The question that this raises is: why was the scheme not more successful? The attribution of causality is difficult, but it is a question that deserves consideration in the context of planning future cycling initiatives and their evaluation.

Our findings suggest that long-term behavioural change is important to monitor. The implications of such behavioural change should be included in evaluations of the efficacy and impact of cycling schemes, and the design of interventions should include an assessment of their evaluability during planning stages (Leviton et al., 2010). This point is especially important when remembering that many of the most important benefits of cycling uptake (economic, environmental and health-related) accrue over the long term: it is no good from the perspective of the climate or public health if modal shift lasts only the duration of a particular scheme. What is needed is system change (Beddoe et al., 2009). The likely implications of scenarios of amplifications of initial shifts or a 'regression to the mean' has rarely been discussed in past research. However, these mutually reinforcing wider impacts are arguably the most important for determining the overall impact of cycling schemes: some of the most important benefits of cycling now may only be realised long in the future.

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