Transportation Research Part A 103 (2017) 327–342

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Electrically-assisted bikes: Potential impacts on travel behaviour

S. Cairns [a,*], F. Behrendt [b], D. Raffo [c], C. Beaumont [d], C. Kiefer [e]

[a] Transport Research Laboratory/University College London, United Kingdom
[b] University of Brighton, United Kingdom
[c] David Raffo Associates, United Kingdom
[d] Transport Research Laboratory, United Kingdom
[e] University of Sussex, United Kingdom

ARTICLE INFO

Article history:
Received 27 October 2015
Received in revised form 14 March 2017
Accepted 21 March 2017
Available online 12 July 2017

Keywords:
Pedelec
Electrically-assisted bicycle
Cycling
e-Bike
Electric mobility
Sustainable transport

ABSTRACT

This paper reports on a review of the European literature about the impacts of having an electrically-assisted bike available to use, together with results from a trial in the UK city of Brighton, where 80 employees were loaned an electrically-assisted bike for a 6–8 week period. In the Brighton trial, three-quarters of those who were loaned an e-bike used them at least once a week. Across the sample as a whole, average usage was in the order of 15–20 miles per week, and was accompanied by an overall reduction in car mileage of 20%. At the end of the trial, 38% participants expected to cycle more in the future, and at least 70% said that they would like to have an e-bike available for use in the future, and would cycle more if this was the case. This is consistent with the results of the European literature which shows that when e-bikes are made available, they get used; that a proportion of e-bike trips typically substitutes for car use; and that many people who take part in trials become interested in future e-bike use, or cycling more generally.

1. Introduction

Internationally, transport policy makers and urban planners are interested in encouraging cycling, given the potential to simultaneously achieve a number of goals – including addressing congestion; encouraging a switch from more polluting modes and thereby reducing local air pollution and greenhouse gas emissions; and increasing physical activity and thereby addressing obesity and a range of other health issues (see, for example, OECD/ITF, 2013; APPCG, 2013). Electrically-assisted bikes are one tool that may help to achieve this goal.

Electrically-assisted bikes – or 'pedelecs' – are those where pedalling is required, but the rider can choose to switch on battery-powered assistance to reduce the effort required. This type of bike varies in design detail but, in all cases, assistance cuts out when the rider stops pedalling or when the bike exceeds specified speed thresholds, as set out by legislation (25 kmph across Europe). Although they are less environmentally friendly and require less physical activity than using conventional bikes for the same journeys, the differences are small when compared with using other forms of motorised transport such as the car, and the activity required is still sufficient to count as at least 'moderate intensity' physical activity

* Corresponding author.
E-mail address: scairns@trl.co.uk (S. Cairns).

http://dx.doi.org/10.1016/j.tra.2017.03.007

(Simons et al., 2009; Gojanovic et al., 2011). The term e-bikes is often used as short-hand in this paper, though it should be noted that this work does not consider other types of bike which are powered by electricity, but do not require the rider to pedal.

This paper reports on a review and analysis of EU e-bike literature, together with specific results from a series of trials in the UK city of Brighton involving electrically-assisted bikes. The aim of the paper is to draw together a range of relevant material to assess three key questions for the UK context:

- Can having the opportunity to use an electrically-assisted bike alter the amount that people cycle?
- Can having the opportunity to use an electrically-assisted bike affect the use of other transport modes?
- Can having the opportunity to use an electrically-assisted bike for a trial period have an effect on travel behaviour after the end of the trial period?

Given significant differences in the factors determining travel choices, material from the rest of the world, for example, from China and the USA (e.g. Cherry and Cervero, 2007; Dill and Rose, 2012; Popovich et al., 2014), is not considered.

2. Literature review

2.1. Literature sources used

To provide context for the results from the Brighton trial, we compiled and analysed a considerable body of European evidence (available by 2015) which provides some insights on whether the availability of electrically-assisted bikes affects travel behaviour. The evidence is largely outside the academic literature, comprising individual project summaries, European project reports, website articles, and other non-conventional material (some of which is not published in English). Drawing together this material was a substantial research task in itself. Moreover, although many studies were aimed at answering similar questions (i.e. often related to the main questions asked in this paper), the methodologies used meant that data were not available in readily comparable forms, with a range of different metrics and reporting conventions used. Consequently, in presenting this literature, we have used a combination of tabular summary (where studies are reported in their own terms), and our own summary, where we have drawn out comparable metrics where they existed.

Table 1 provides details of the main relevant material identified, together with appropriate references. Evidence is drawn from Norway, Sweden, Austria, France, Belgium, Italy, the Netherlands, Germany and the UK. In some cases, the only data source is website text – this is clearly specified in the references.

2.2. EU evidence on how much e-bikes get used

The first research question addressed in this paper relates to whether having the opportunity to use an e-bike actually alters the amount that people cycle (or whether, in fact, the other barriers to cycling still prevent use). Table 2 summarises the main findings about e-bike use available from the literature. The evidence reviewed seems to support the hypothesis that e-bike trials or ownership do result in e-bike use, with some further clarification about the nature of use, including:

- Evidence about average distance travelled – with estimates of weekly[1] travel by those owning or trialling an e-bike including 15 km (Wolf and Seebauer, 2014), 19 km (Drage and Pressl, 2012; Eddeger et al., 2012), 27 km (Kairos, 2010), 29 km (Cappelle et al., 2003), 38 km (Mercat, 2013), 68 km (Fyhri and Sundfør, 2014), 71 km (Hiselius and Svenssona, 2014) and a distribution centred around 50-100 km (VCD, 2013).
- Evidence about the speed of e-bike travel compared to use of other modes – with work from both Graz (Drage and Pressl, 2012; Eddeger et al., 2012) and Flanders (Mobiel 21, 2014) suggesting that e-bikes may be comparable to, or faster than, public transport.
- Evidence that e-bikes can encourage relatively long cycle trips, with Engelmoer (2012) suggesting that, on average, e-bike commuters make longer trips than conventional bike commuters (9.8 km versus 6.3 km), Helms et al. (2015) suggesting that average e-bike trips are 11.4 km (compared to 7.1 km for conventional bikes) and various other studies reporting on relatively long distances for the average e-bike trip - 14.5 km for pedelec commuters in Flanders (Mobiel 21, 2014); 18 miles for a community loan scheme in the Brecon Beacons (Kidd and Williams, 2009), and 30 km for tourism trips in the Cairngorms (Sustrans, 2013).

2.3. EU evidence on travel behaviour impacts

The second main research question addressed in this paper is whether having an e-bike available to use has any impact on use of other modes. Key findings from the literature are summarised in Table 3. From these studies (including work in Aus-

[1] As evident from Table 3, some studies have reported on daily or annual, rather than weekly, travel. These have been converted to a weekly travel figure by multiplying by 7, or dividing by 52.

Table 1
Previous research about the travel impacts of electrically-assisted bikes.

Source	Project
Fyhri and Sundfør (2014)	In a Norwegian study, 61 people were selected to try an e-bike for 2 or 4 weeks, and their experiences were compared with a control group of 160 people.
Hiselius and Svenssona (2014)	A survey of 321 e-bike purchasers in Sweden was conducted.
Wolf and Seebauer (2014)	Between 2009 and 2011, more than 20,000 Austrian households received subsidies to buy an e-car, e-scooter or e-bike. In 2012, a postal survey provided data about 1398 people who received subsidies for e-bikes.
Kairos (2010)	In the 'Landrad' project in Vorärlberg, Austria, in 2009, subsidies for pedelec purchase were provided to 342 individuals and for 158 bikes at 93 organisations – a total of 500 pedelecs. 196 individuals provided full data feedback, and data were also provided about the bikes used by organisations.
Drage and Pressl (2012) and Eddeger et al. (2012)	In the 'Active Access' project in Graz, Austria, 20 people aged between 40 and 70 were lent pedelecs for a week each, in August 2010.
EPOMM (2014)	In Graz, Austria, as part of the EU BICY project, 20 pedelecs (and 4 normal bikes) were made available for free hire by guests at 7 hotels.
Eltis (2014)	In the Austrian city of Weiz, as part of the EU URBACT project in 2010, local car dealers were involved in a project where people having their car serviced were offered the use of a pedelec instead of a courtesy car, together with vouchers for use in the city centre if they took up the offer. 7 pedelecs and 7 dealers were involved.
Mercat (2013)	In Chambery, France, between 2009 and 2012, a €300,000 programme to promote e-bikes was implemented, including 50 events a year to enable employees to trial bikes; the provision of opportunities to rent an e-bike for 1–2 week periods; and purchase subsidies of €250.
Mobiel21	A survey of 369 pedelec commuters in Flanders was undertaken in spring 2014.
Cappelle et al. (2003)	As part of the EU E-Tour project, at Vrije University, Brussels, over 250 people were loaned pedelecs for 6–8 weeks, over a two year period.
Engelmoer (2012) reports on work by Hendriksen et al. (2008)	A survey of 1448 commuters was carried out in the Netherlands, of whom 28 were e-bike commuters.
Eddeger et al., 2012 (a)	The 'Try a pedelec' scheme was launched in the Eindhoven city region of the Netherlands, as part of a broader mobility management programme in 2010. 330 employees, at 14 companies tried a pedelec for their daily commute.
Eddeger et al., 2012 (b)	In an incentive scheme in Pescara, Italy, which started in 2010, a local company, FATER Spa, financed 60–70% of the cost of employees buying a pedelec, with the remaining cost deducted from employee pay over a 14 month period. 258 e-bikes were purchased in 3 years.
Wright (2013)	In Totnes UK, a community e-bike hire scheme was started in mid-2012, with 10 e-bikes deployed with neighbourhood groups.
Kidd and Williams (2009)	In a trial run by Talybont-on-Usk Energy in the UK, 2 e-bikes were hosted by 8 communities across the Brecon Beacons between April and October 2009.
Sustrans (2013)	In 2015, the Electric Bike Network was operating in 9 rural tourism areas of the UK, providing a hire network of over 100 pedelecs. In one of these areas, the Cairngorms, 162 people hired a bike during a four month pilot period.
VCD (2013)	In Germany, an online survey of 506 e-bike users was conducted between June and December 2012. Of these, 61% had bought their e-bike in 2011/12; 25% had owned their bike for 2–3 years, and 14% had owned it for more than 3 years. (Analysis of 4814 on-line responses about e-bike preferences was also undertaken, though is not reported here.)
Helms et al. (2015)	Research conducted in 4 regions of Germany provided detailed information from 70 existing e-bike users (energy and GPS data, travel diaries), plus 312 online trial participants (who provided travel diaries). Data was collected during 4 survey weeks over 1 year.

tria, France, Germany, the Netherlands, Norway, Sweden, Italy and the UK), it seems clear that when people have the opportunity to use an e-bike, a non-trivial proportion of the mileage travelled will be a replacement for car mileage. For those studies reporting the proportion of e-bike trips that were previously car trips, the proportions reported were 47–76% (Hiselius and Svenssona, 2014); 35% (Kairos, 2010); approx. 50% (Drage and Pressl, 2012); 40–70% (Wright, 2013); 41% all trips, 62% commuting trips (Helms et al., 2015); and 16% (Hendriksen et al., 2008). The Wolf & Seebauer work also suggests a small impact on car ownership.

2.4. EU evidence about trial impacts on future travel

The third research question addressed in this paper is whether having the opportunity to use an electrically-assisted bike for a trial period has a longer term effect on travel behaviour. Key findings from the literature are summarised in Table 4.

Data from Vorarlberg, Brussels, Weiz, Eindhoven, Talybont-on-Usk and the Cairngorms all suggests that a proportion of people who try-out an electrically-assisted bike become potentially interested in buying one, (in the order of 30–70%). The work in Vorarlberg also highlights that those involved in trials will potentially influence others, (Kairos, 2010). Some studies also report on a proportion of respondents who actually have bought bikes – this tends to be much smaller, although this is partly because 'after' surveys are typically done at the end of the trial period, rather than after a period of time. The work in Eindhoven, where a subsequent leasing scheme proved popular, is an interesting way of capitalising on the interest generated during the trial period.

Table 2
Literature evidence about electrically-assisted bike usage.

Source	Project
Fyhri and Sundfør (2014)	For those loaned an e-bike, the proportion cycling on the day before the survey rose from 30% to 52%, whilst reducing from 24% to 20% in the control group. The distance cycled per week also rose from 40.1 to 68 km, whilst in the control group, it reduced from 33.9 to 29.8 km.
Hiselius and Svenssona (2014)	For the e-bike owners, the average distance e-cycled per week was 71 km.
Wolf and Seebauer (2014)	Those purchasing e-bikes reported travelling an average of 794 km p.a.
Kairos (2010)	On average, individuals buying subsidised e-bikes cycled 1400 km p.a. (with individual results ranging from 40 km to 8000 km p.a.) The bikes used by organisations were used for an average of 1432 km p.a. (range 111–4000 km).
Drage and Pressl (2012) and Eddeger et al. (2012)	Within 1 month, 20 participants had cycled 1500 km in total, doing an average of 12 trips per week each. The average speed of travel was 23 km/h, which compared favourably with public transport speeds (11 km/h) and individual motorised transport (29 km/h).
EPOMM (2014)	In the Graz hotel hire scheme, as of October 2012, the pedelecs (and normal bikes) had been rented out 1100 times, had done between 180 and 940 km per bike, and had been on the road for about 3000 h.
Eltis (2014)	In the local car dealer project in Weiz, 3–4 pedelecs were loaned out per week.
Mercat (2013)	Those buying subsidised e-bikes reported using their ebikes regularly, covering, on average, more than 2000 km p.a. on their pedelec.
Mobiel 21 (2015)	For the pedelec commuters in Flanders, the average trip was 14.5 km (range 1–84), achieving an average speed of 42 km/h (for men), and 21 km/h for women, which compared with average speeds of 17 km/h for conventional bikes, 20 km/h for public transport and 35 km/h for cars.
Cappelle et al. (2003)	Participants in the Brussels e-bike trial scheme travelled an average of 4.2 km per day, and a total of 44,600 km.
Engelmoer (2012) reporting work by Hendriksen et al. (2008)	E-bike users were travelling an average of 9.8 km for commuting, compared with 6.3 km for users of conventional bikes.
Wright (2013)	Usage in the Totnes community scheme has varied between 181 and 677 miles (over a period of 9–11 months) for each e-bike.
Kidd and Williams (2009)	During the 6 month trial in the Brecon Beacons, the two e-bikes travelled 2714 miles, with an average ride length of 18 miles.
Sustrans (2013)	During the 4 month trial period, the total distance travelled by all of the pedelecs in the Cairngorms was 4903 km. For 36 surveyed users, the average distance cycled was 30 km, with and the median time was 3.43 h.
VCD (2013)	For the 506 e-bike users, 36% reported at least daily use, 58% reported at least weekly use, with the remaining 6% reporting that they used their bikes less frequently than that. For weekly distance travelled (averaged across the year), 93% reported that they typically travelled more than 20 km, with 61% reporting more than 50 km, and 25% more than 100 km. (5% were less than 20 km, and 2% were 'don't know'.) In terms of trip purpose, the most commonly reported options (where multiple answers were possible), were for a range of everyday trips (69%); for leisure trips (76%); and for commuting (49%).
Helms et al. (2015)	For the e-bike users, average trip length was 11.4 km, although 50% of all trips were under 9 km (with a peak at 4 km). In contrast, average bicycle trip length was 7.1 km.

Trials also potentially stimulate an interest in conventional cycling, as mentioned in relation to the work in Brussels, Talybont-on-Usk and the Cairngorms.

3. Brighton trial methodology

3.1. Trial overview

The literature described above has helped to inform primary research work, which comprised a series of trials in the UK City of Brighton (Cairns 2014; Behrendt 2016, www.smart-ebikes.co.uk). These involved loaning people an electrically-assisted bike for a 6–8 week period, whilst evaluating their experience via extensive data collection and evaluation, including a suite of surveys, on-bike monitoring of use, focus groups and semi-structured interviews.

Prior to this trial, evaluation of e-bikes in the UK was limited to studies in tourism areas (Sustrans, 2013) and community loan schemes (Kidd and Williams, 2009; Wright, 2013). This study aimed to evaluate the likely attractiveness of e-bikes to commuters in an urban context. Whilst impressive levels of take-up were being reported from other European countries, there was scepticism about their potential appeal in the UK, given lower levels of cycling more generally, and debate about whether cycling can ever be made attractive to a wider range of people than those who currently undertake journeys by bike, and, particularly, to car users.

Brighton was chosen because the local authority is interested in promoting cycling (including investing in appropriate infrastructure), and yet the city is hilly and windy. These conditions can be off-putting for conventional cycling, but are also deterrents that electrically-assisted bikes could potentially ameliorate. In constructing the trial, the aim was to select a group of people with the potential to change their behaviour, to hopefully provide proof of concept that this could occur.

Whilst the location chosen was very suitable in some ways, it is also noticeable that it has somewhat atypical travel patterns compared to the national average. Specifically, 2011 Census data on travel to work suggests that, whilst for England

Table 3
Literature evidence about impacts on use of other modes.

Source	Project
Wolf and Seebauer (2014)[a]	In the Austria-wide study, 37% of respondents reported that, since buying the e-bike, they had reduced car use for work trips; 40% reported reductions for shopping trips; and 40% reported reductions for leisure trips. There were also small net reductions in household car/motorbike ownership - 4% reported that they had reduced household car ownership, and 3% had reduced household motorbike ownership, whilst 1% had increased car ownership, and 2% had increased motorbike ownership.
Hiselius and Svenssona (2014)	The survey of e-bikes purchasers in Sweden asked participants about particular journey purposes that they used their e-bikes for, and how they were travelling previously (including whether the journey was a 'new trip'). Results varied with journey purpose – 3–12% of the e-bike journeys replaced walking; 4–16% replaced public transport; 15–26% replaced a conventional bike; and 47–67% replaced a car trip.
Kairos (2010)	In the Landrad project, for the individual participants, 52% of the trips done by pedelec were previously done by conventional bike whilst 35% were done as a car driver. It was estimated that approximately 230,000 car kilometres per year were substituted for pedelec use. 21% of purchasers were reported to have made substantial and long term changes to their travel behaviour.
Drage and Pressl (2012)	In the Active Access project, about half of the pedelec trips made substituted for car trips, equivalent to an average of 6 trips – 44 km – per participant per week.
Mercat (2013)	As a result of the e-bike programme in Chambery, 1.2 million km were reported to have transferred from car to e bike p.a.
Mobiel 21	In the survey of pedelec commuters in Flanders, 46% reported that they previously drove to work, and 58% reported that they used the car on days when they did not use the pedelec.
Fyhri and Sundfør (2014)	In the Norwegian project, the proportion of all kilometres travelled per day that were made by bike rose from 28% to 48% in the target group, whilst remaining constant at 20% in the control group.
Hendriksen et al. (2008)	Commute trips by e-bike were estimated to substitute for conventional bicycle (33%), car (16%), public transport (8%), motorbike/scooter (5%) and were new trips (38%). However, this was based on a sample of only 28 e-bike users.
Eddeger et al. (2012) (b)	In Pescara, 80% of employees buying a subsidised e-bike said that since having the pedelec, they used their car less.
Wright, 2013	In the Totnes community e-bike hire scheme, 40–70% of e-bike journeys were reported to be replacing car use.
Kidd and Williams (2009)	In the Talybont-on-Usk Energy trial, 67% of the mileage travelled (1818 miles) was reported to be replacing car miles.
Sustrans (2013)	Of those surveyed about their use of the Electric Bike Network hire scheme in the Cairngorms, 3 said they would have used their car if they had not used an ebike, 25 respondents said that they wouldn't have made the journey, 12 would have used a conventional bicycle and 9 would have walked.[b] It should be noted that this scheme was primarily aimed at tourists. The three people who would have used a car collectively cycled 74 km.
VCD (2013)	For the 506 e-bike users, 74% mentioned that the e-bike had replaced at least some car trips, with 21% reporting that it had exclusively replaced car use.
Helms et al. (2015)	For trips made by e-bike, 41% were previously made by car; 38% by conventional bike; 7% by public transport; 4% by foot; 6% were not made and 5% were made by other modes. In terms of distance, 45% of distance travelled was previously done by car. For commuting, 62% of trips were previously made by car.

[a] Wolf and Seebauer clarify that other data they have collected do not show the same level of behaviour change, although their other data compares sample behaviour with travel by the general population, whose characteristics are shown to vary markedly from the sample, and the comparisons are not equivalent (sample choices for the general population add to 100% whilst this is not the case for the sample participants, c.f. Table 3). The validity of the other data is therefore questionable.

[b] It appears that respondents could select more than one option as the number of respondents to this question is greater than the number who responded to the survey (49 compared to 41).

Table 4
Literature evidence on the impacts of e-bike trials for future travel behaviour.

Kairos (2010)	In the Landrad project in Vorarlberg, each privately-owned e-bike was tried out by an average of 7 other people. The e-bike owners estimated that 50% of these informal testers went on to buy an e-bike.
Cappelle et al. (2003)	In the Brussels E-Tour project, at least 36% participants reported that they cycled more kilometres with their conventional bike after the trial. 56% men and 43% women also reported that they were prepared to buy a pedelec after the trial, although researchers also report that less than 3% had done so at the time of the survey work.
Eltis (2014)	In the Weiz local car dealer project, 30% of those who borrowed a pedelec were interested in buying one.
Eddeger et al. (2012) (a)	Of the 330 employees who tried a pedelec in Eindhoven, 70% said that they were considering buying a pedelec and 5% stated that they intended to do so immediately. A leasing scheme was subsequently established, attracting more than 50 people.
Kidd and Williams (2009)	As a result of the Talybont-on-Usk Energy trial, in the post-trial surveys completed by 61 people, 41% of respondents said that they would consider buying an electric bike. Six people were known to have done so by October 2009 (the end of the trial period). Those contacted also mentioned making more use of conventional bikes and/or were considering purchasing shared community electric bikes.
Sustrans (2013)	In the Electric Bike Network hire scheme in the Cairngorms, of the survey respondents, 85% stated that it was likely/very likely that they would cycle e-bikes more often in the future, and 74% said that this was the case for conventional bikes. In a follow-up survey of 8 respondents, 3 had purchased an ebike since their experience with the scheme and 2 reported that they were cycling conventional bikes more often. Two of those who had bought e-bikes were using them to replace car journeys, with an estimated combined saving of 187 km by car per week.

(excluding London), 66% people drive to work, 11% walk, 7% take the bus, 4% take the train and 3% cycle; in Brighton and Hove Unitary Authority, the equivalent figures are 40%, 22%, 15%, 11% and 5%.[2] The low levels of car driving, and high levels of walking did have some effects on results, as discussed later.

3.2. Nature of the trial activities

Two major employers were involved in the trial. Through a full staff survey at each, employees were asked to express their interest in borrowing an electrically-assisted bike, together with accessories (a helmet, lock, lights, reflective gear and pannier plus an optional child seat and child helmet). The surveys specifically advised that "*ability to cycle is not required. We are keen to involve people with a whole range of experience – from people who cycle a lot, through to people who have never cycled*".

Selected participants were required to complete (free) e-bike training to the UK Bikeability level 3 standard, which, in most cases, comprised a two-hour on-road training session, although training time varied with proficiency (Behrendt and Robinson, 2014). At bike hand-out, the project lead explained the nature of the trial, and that participants could contact the research team or a (specific) local bike shop if they encountered any problems. Participants were advised that they could use their bikes as much, or as little, as they wished, and that there was no requirement to use them for commuting.

Trials took place in four waves of 20 people each over two years – in 2012 and 2013 (between June and November), resulting in an overall sample size of 80. Participants were loaned either a Raleigh Dover or a Raleigh Velo-Cite e-bike, drawn from a research fleet of 35 bikes comprising both cross-bar and step-through models.

3.3. Trial participants

There were 609 respondents to the full staff surveys. Of these, approximately 40% (241 people) were interested in being part of the trial after receiving detailed information about what it would involve. These comprised both cyclists and non-cyclists, including 48 people who had not cycled in the previous year, and 3 people who could not ride a bike.

Participants were then selected based on two types of criteria. First, to try to ensure uniformity of sample, priority was given to:

- Those who said that, if they participated, they planned to use the bike for commuting, at least some of the time.
- Those who were planning to use the bike for the whole journey (although there was interest from various people who wanted to combine bike and rail use).

Second, given a particular interest in examining the potential for promoting e-bike use to achieve carbon savings and major shifts in travel behaviour, priority was given to:

- People currently driving to work and/or who were frequent car drivers.
- People who were not currently cycling to work (particularly non-cyclists) and/or less experienced cyclists.
- People who had relatively low levels of physical activity.

Given initial experience, priority was also given to those living within 1–10 miles of work, as being those most likely to change their behaviour.

The sample was never intended to be representative of the general population. Instead as previously explained, the intention was to select a group of people with the potential to change their behaviour, as proof of concept that this could occur.

In practice, selection was an iterative process and was balanced by the need to have a roughly even split of men and women (to ensure selection compatibility with the fleet mix of cross-bar and step-through bikes); by trying to ensure representation from different age groups (as part of the qualitative research remit); and by matching with people's availability, which changed during the course of the project (not least due to house moves). Notably, the bikes also have a maximum weight bearing capacity of 125 kg. Therefore, eight people who were over, or close to, this weight limit were excluded on safety grounds.

In total, 80 people took full part in the trials – completing both before and after surveys, and contributing to the qualitative research. Their characteristics are given in Table 5.

In brief, then, the sample consisted of 80 employees, selected on the basis that they were interested in being part of the trial, with a spread of characteristics, but some selection bias (compared to all those expressing interest) towards those with the most potential to change their travel behaviour, in terms of cycling more or driving less.[3]

[2] Data source: Office of National Statistics CT0050 – Method of Travel to Work. All usual residents aged 16–74. Those who worked mainly from home and not in employment have been excluded. Bus means 'bus, minibus or coach', while drive to work means 'driving a car or van'.

[3] For everyone replying to the surveys (whether interested in borrowing a bike or not), there was a relatively low proportion of drivers, and a relatively high proportion of people living within 1 mile of work, compared to national average data for commuters, reflecting Brighton's specific characteristics.

Table 5
Details of the trial participants.

Topic	Characteristic	Number of participants	% of the sample
Gender	Men	36	44
	Women	44	56
Age	20–29	16	20
	30–39	25	31
	40–49	19	24
	50–59	16	20
	60+	4	5
Car use	Drive a car more than once or twice a year	50	63
	Drive a car at least one day a week	37	46
	Drove a car to work at least one day in the previous week[c]	28	35
General cycle use	Ridden a bike in the last year	62	78
	Cycled (all the way) to work at least one day in the previous week[c]	8	10
Comfortableness cycling in traffic	Very comfortable	29	36
	Quite comfortable	30	38
	Neither comfortable nor uncomfortable	14	18
	Quite uncomfortable	7	9
	Very uncomfortable	0	0
Cyclist classification[d]	I am a regular cyclist	9	11
	I am an occasional cyclist	36	45
	I do not currently cycle but am interested in doing so	34	43
	I do not currently cycle and have no interest in doing so	1	1
Distance from work[a]	Less than 1 miles	3	4
	1 to less than 2 miles	17	22
	2 to less than 3 miles	16	20
	3 to less than 5 miles	16	20
	5 to less than 10 miles	21	27
	10 to less than 25 miles	6	8
Physical activity in the last week[a]	Less than 30 min	17	22
	At least 30 min but less than 2½ hours	26	33
	At least 2½ hours but less than 5 h	22	28
	5 h or more	14	18
Physical activity during a typical week[b]	Less than 30 min	10	26
	At least 30 min but less than 2½ hours	14	36
	At least 2½ hours but less than 5 h	9	23
	5 h or more	6	15

[a] One participant said 'don't know' to this question.
[b] Only two waves of trial participants were asked this question (40 people). One participant said 'don't know'.
[c] Participants were asked how they travelled to work on each day in the preceding week to the survey.
[d] Question asked at an early stage in the full staff survey, prior to explaining the trial opportunity.

3.4. Data sources

Data about bike use, impacts on other travel behaviour, and future travel choices, were available from before and after surveys conducted with all trial participants. All participants also took part in interviews and/or focus group discussions (50 interviews and 11 focus groups with 2–4 participants) and the material was coded and analysed in NVivo.

In addition, all bikes were fitted with the 'Smart E-bikes Monitoring System' (SEMS) – a monitoring system developed to run on the e-bikes without trial participant intervention, and to submit data about the bike use in real time to a remote server, (Kiefer and Behrendt, 2015). Given some development issues during the 2012 trials, a full set of data was not available for all bikes. In some cases, participants were asked to keep paper records to supplement the monitoring data and/or an odometer was added to the handlebars to get a record of total distance travelled. However, there were 3 cases where it was not possible to obtain accurate information of this nature. Consequently, as a minimum, for 77 participants, we have two headline figures from the bike monitoring – the number of days that the bikes were used during the trial periods, and the total distance travelled by the bikes. For a sub-set of participants, we also have a more detailed data set, which can be used to understand patterns of use in more detail, though that is not the focus of this paper.

One of the strengths of the project has been the opportunity to triangulate between the different data sets to get a proper understanding of what really happened. In particular, we compared people's assessment of how much they cycled during a typical week of the trial, with the mileage recorded by the GPS tracker, and with the interview data about how people said they used the bikes. In general, the data sources were remarkably consistent, albeit with two caveats.

First, from the interview data, it is clear that people's circumstances shape their perceptions of use. For example, some of the highest mileage users reported that they didn't use the bikes as much as they had hoped (but their survey data on how much they used the bikes was similar to their GPS reading). Equally, there were some people who reported using the bike a lot for commuting, but because they lived close to work, their total distance cycled was low compared to other trial participants.

Second, it was notable how much 'background disruption' to people's lives there was within the 6–8 week period that people participated in the trial. Specifically, following qualitative feedback from our first wave of trials, all subsequent 60 participants were asked whether there were "*any periods where you were unable to use the bike because you were off sick, or on leave, or moving house, or similar personal reasons?*" (and, if yes, please provide more details). 72% (43 people) reported that there had been (including holidays, family commitments, sickness or injury, moving house and being away from the office). Moreover, the non-use time periods reported were quite substantial. Consequently, in many cases, the GPS records of mileage travelled were often lower than those implied by multiplying up people's reporting of their 'typical weekly mileage' by the number of weeks when they had the bike available.

In the following results section, each data source is reported in its own terms. Where relevant, mean and median values are given in the paper, since not all results were symmetrically distributed (indicating the value of median data), but, equally, mean values provide a more direct way of summarising the overall behaviour of the sample.

4. Results

4.1. Did the e-bikes get used?

At the time of our study, there was considerable debate within the UK as to whether the availability of an e-bike would be sufficient to overcome the usual deterrents to bike use such as traffic and weather. Therefore, the first research question to be answered was whether the e-bikes got used?

The GPS (and additional paper records)suggest that, in total, the bikes travelled more than 9500 km - or 5900 miles - during the four trial waves. Meanwhile, the survey data provides the participants' overall estimation of how often they used the bikes, as shown in Fig. 1. Table 6 provides an overall summary of the typical usage statistics.

As evident from the figure and table, there was a group of participants who made little use of the bikes during their 6–8 week trial. Specifically, 4 people reported using the bikes less than once a month; whilst 9 reported using them only once or twice a month. Seven people estimated that their typical weekly mileage during the trial was zero. In contrast, 60 people – three-quarters of the sample - reported that they were typically using the bike at least once a week during the trial period.[4]

Averaged across all participants, weekly mileage was in the order of 15–20 miles a week; time spent cycling was about 120–150 min (2–2.5 h); and number of days commuted to work by bike was around 2. This fits reasonably well with the overall figures for bike usage, which implies that, during the trial period, the total distance travelled was in the order of 50–80 miles per person, and the bikes were used for an average of 11–14 days per person. (The figures seem reasonably consistent, given that, as already discussed, most trial participants were not able to use the bike for the full 6–8 week period.) The 15–20 miles per week also falls within the range suggested by the literature, as discussed in Section 2.2.

Meanwhile, Table 7 gives an indication of what the bikes were used for. Commuting comes out as the dominant purpose. Cycling for pleasure was the second most common purpose, although participants generally used the bikes for a wide range of activities, including shopping, leisure, business travel, visiting friends and family, etc. It should be noted that the averages hide significantly different patterns of individual use. For example, one participant used the bike on 18 days to take their child to nursery.

4.2. Impacts on travel behaviour

4.2.1. Overall impacts

The next section reports the trial results about whether having the opportunity to use an electrically-assisted bike affects use of other modes, particularly given policy interest in whether e-bike use would ever substitute for car use.

Specifically, in the after survey, all participants were asked: "Compared to before the trial, how did the amount of travel that you do by other means change during the trial (for all types of journeys not just work)? Please indicate 'about the same' if you did not travel by this mode either before or during the trial." The results are shown in Table 8 and Fig. 2. As indicated there, and consistent with the EU literature reported in Section 2.3, the biggest impacts were on car driving, with 34 people (43% of the sample) reporting that they travelled less as a car driver. There were also reductions in bus use and walking, counterbalanced to some extent, by some increases in walking and cycling (of non-trial bikes).

As already noted, Brighton and Hove has lower levels of car driving and higher levels of walking than other parts of the UK, and, before the trial, only 50 participants reported that they drove a car more than once or twice a year, whilst only 37

[4] We understand that participants answered the question in relation to the weeks when they were able to use the bikes, excluding periods of holiday, sick leave, etc.

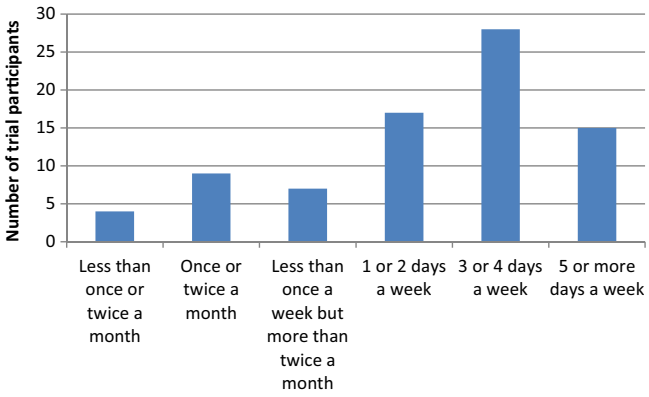

Fig. 1. During the trial period, how often were you using the trial bike?

Table 6
Average usage statistics for the 80 trial participants.

	Number of trial participants where value was zero	Mean	Median	Range
GPS data				
Miles cycled during the trial	0	82	49	1–456
Days that the e-bike was used	0	14	11	1–52
Survey data[a]				
Number of days commuted to work by bike during a typical week of the trial[b]	14	2.2	2	n/a
Average weekly mileage during a typical week of the trial, on the trial bike	7	20.7	14.5	0–90
Average time (in minutes) spent cycling during a typical week of the trial, on the trial bike	7	150.5	120	0–720
Greatest distance (in miles) cycled in 1 day, on the trial bike	n/a	10.4	8	1–50
Greatest time (in minutes) spent cycling in 1 day, on the trial bike	n/a	83.7	60	10–300

[a] 10 participants said 'don't know' to average weekly mileage; 2 participants said 'don't know' to average weekly time; 7 participants said 'don't know' to greatest distance cycled; and 2 participants said 'don't know' to greatest time spent cycling.
[b] The sample size for this question was only 60 participants, as the question was added after the first trial wave.

Table 7
Purposes that the e-bikes were used for.

	Number of participants that used the bike for this purpose	Mean number of days for those who used the e-bike for this purpose (*excluding* those who did not do so)	Mean number of days for those who used the e-bike for this purpose (*including* those who did not do so)
Commuting	72	15	13
Travel between work sites	27	3	1
Other business travel (i.e. travel during the course of work)	10	3	0
Education (including escorting children to school or college)	5	5	0
Shopping	37	6	3
Other escort and personal business (e.g. doctors, post office etc.)	30	4	2
Visiting friends (either at home or elsewhere)	34	5	2
Cycling for pleasure	47	5	3
Other leisure, including entertainment and day trips	20	4	1

participants reported that they typically drove a car at least one day a week. In other locations, impacts on car driving might therefore be expected to be even greater, whilst the impacts on walking might be less.

Table 8
Changes in travel reported by participants.

	Car driver	Car passenger	Cycling (not the trial bike)	Walking	Running/ Jogging	Bus	Train	Motor-cycle/ scooter/moped
Much more	0	0	7	1	0	0	1	0
Slightly more	0	1	6	6	1	2	0	0
About the same	43	59	44	43	65	50	63	62
Slightly less	19	8	3	20	3	11	4	2
Much less	15	7	17	10	4	16	10	6
Don't know	3	5	3	0	7	1	2	10

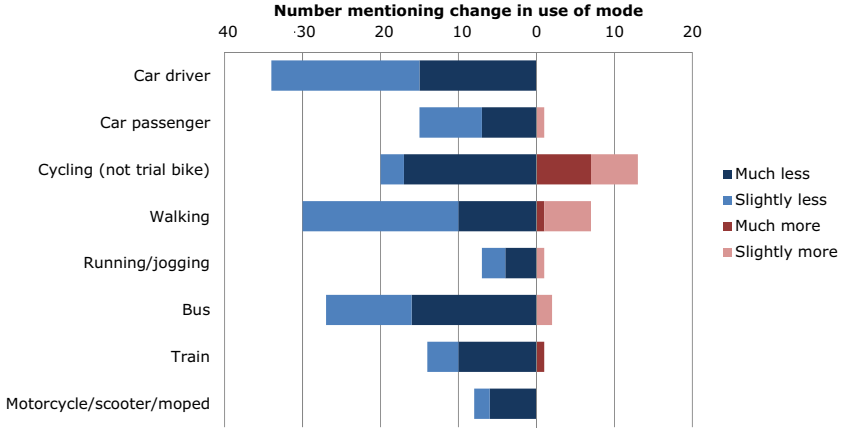

Fig. 2. Changes in travel reported by participants.

4.2.2. Impacts on car use

To obtain more detail on the impacts on car use, in both the before and after surveys, all trial participants were asked: "*In the last week, how many miles did you drive (for all types of journeys, not just work)*?" (In the after survey, 'last week' would have referred to the last, or penultimate, week of the trial).

72 participants provided an estimate, of whom 52 did not give zero as their answer to both questions. The results are shown in Table 9. Given initial results, additional question variations (asking about typical travel) were added to assess the accuracy of answers. These provided reasonably consistent findings, providing additional confidence in the results.[5] The overall implication is that there has been a reduction in car miles travelled which is in the order of at least 20%.

4.2.3. Impacts on active travel

To assess the impacts of the trial on the amount of active travel undertaken by participants, there were several additional measures in the survey. First, we asked participants to self-assess whether their total amount of cycling changed during the trial (compared to previously). As shown in Fig. 3, 5 people reported a decrease; 14 reported no change, whilst 61 (76%) reported an increase.

We also asked a question about how participants perceived that their general physical activity had changed during the trial (in comparison to before the trial). Although some participants (7 people) felt that their physical activity had decreased, a high proportion (59%, 47 people) reporting that it had increased, with 17 of those (21% of sample) reporting that it had been a major increase.[6]

We also asked a more detailed question, where participants were asked to estimate the number of minutes that they spent walking and/or cycling and/or running in total, for the 'last week', in both the pre-trial and post-trial survey (where the post trial surveys were timed to ensure that 'last week' would have been the penultimate or last week when participants had their bike). Following experience in the first trial wave, additional questions were added. Specifically, in the pre-trial

[5] 27 people answered a question about typical car mileage in survey one, and car mileage 'last week' in survey 3. The means of their answers were 73 and 83 miles respectively, and the median was 50 miles in both cases. In survey 4, 60 people answered a question both about 'typical car mileage', and car mileage 'last week'. The means of their answers were 33 and 44 miles, and the medians were 19 and 20 miles respectively.

[6] 25 people reported 'no change'; 1 person said 'don't know'.

Table 9
Average miles driven in the last week.

	Before trial		During trial	
	Mean	Median	Mean	Median
All participants (72 people[a])	54	28	43	16
Participants recording mileage in either the before or after survey (52 people[b])	75	50	59	40

[a] 8 participants have been excluded as they responded n/a to the 'before' survey question.
[b] This row also excludes those people who said they did zero miles in the last week for both before and after surveys (20 people).

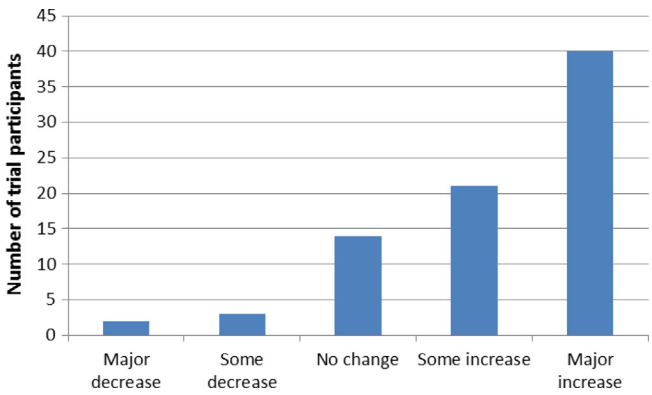

Fig. 3. Changes in time spent cycling. ~Question asked was: "Compared to before the trial, how did the total amount of time you spend cycling change during the trial (for all types of journeys not just work)? (Please consider the total amount of time spent cycling on all bikes, not just the trial bike.)".

survey, participants were also asked to give an estimate for the time "usually" spent on such activities "at this time of year", and in the post trial survey, the same question was asked for "a typical week of the trial".[7] Results are shown in Table 10.

The overall impression from these results is that there has been very little impact on the total time spent undertaking active travel for the sample as a whole, as substantial increases in the amount of time spent cycling have been largely offset by reductions in the amount of time spent walking. As previously highlighted, this will partly be due to Brighton's culture of relatively high walking levels. It should also be noted that this substitution may have enabled people to make journeys faster, to make them at a higher level of physical intensity (with consequent health benefits), or to make them in a more enjoyable way, as discussed in the next section.

4.2.4. Qualitative reporting of travel behaviour impacts

Participant interviews revealed a range of themes about the effects of using the trial bikes for journeys that were previously driven, walked, or made in some other way. Some were negative (such as feeling more vulnerable on a bike than in car; being unable to use mobile media; and having to do more preparation to travel). Being able to pop into shops was listed as both easier and harder. Positive themes were that the bikes were faster, that it was a nicer journey than the car, and that journey times were more predictable. Some example quotations were as follows:

"*I used to get the bus or walk so it has cut the time hugely.*"

"*I was quite surprised . . . I could actually get to work and be in my office quicker than if I drove.*"

"*I loved the air, getting out of my box in the car, and suddenly you notice everything around you.*"

"*It is a feeling of being more energised on the days I've cycled to work.*"

4.3. Impacts on future travel plans

4.3.1. Anticipated impacts on future travel choices

The third key research question considered was whether having the opportunity to use an electrically-assisted bike for a trial period has a longer-term effect on travel behaviour. Specifically, at the end of the trial period, participants were asked a series of questions about their plans for cycling and e-bikes, with some of the results shown in Figs. 4–6.

[7] Question wording also specified that estimates should be for all type of journeys not just work (including going for a walk, bike ride or run for pleasure) and provided clarification on how to complete the question. The question about travel 'last week' was asked first, and asked participants to complete an estimate for each day, whereas the usual/typical questions, which followed on from that, asked for a weekly total. We were aware that this was a particularly demanding question, and it was asked relatively early in the survey, to try to avoid participant fatigue.

Table 10
Impacts of the trial on active travel.

	Before trial			During trial		
	Mean	Median	Range	Mean	Median	Range
Last week, how much time did you spend walking and/or cycling and/or running in total each day (for all types of journey, not just work)? In minutes						
Walking	339	295	0–1170	264	238	0–1200
Cycling	47	0	0–840	19	0	0–360
Trial bike	n/a	n/a	n/a	103	30	0–600
Running/jogging	16	0	0–320	10	0	0–225
Total	401	320	0–1580	397	320	0–1200
At this time of year/during a typical week of the trial, approximately how much time do you/did you usually spend walking and/or cycling and/or running per week (for all types of journey, not just work)? In minutes[a]						
Walking	293	240	0–900	213	150	0–1200
Cycling	72	0	0–660	154	150	0–600
Running/jogging	25	0	0–540	9	0	0–200
Total	391	300	0–1680	376	300	0–1200

[a] This section of the table combines results from two questions, one in the 'before' survey asking about usual travel 'at this time of year', and the other asking about travel 'during a typical week of the trial'. In both cases, the sample size was 60. One person responded 'don't know' for all modes to the 'at this time of year' question and have therefore been excluded from the data.

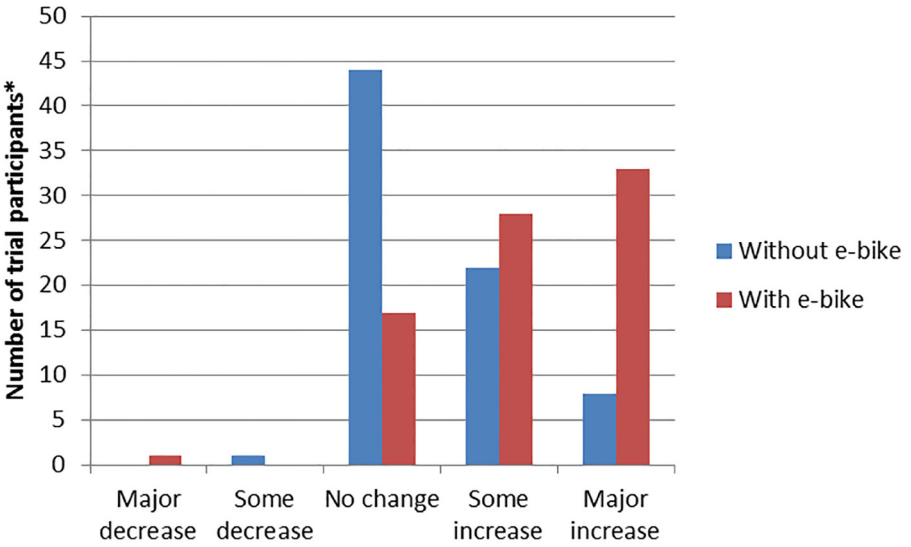

Fig. 4. Expected changes in the total amount of time spent cycling. (* 5 said don't know 'to without e-bike' and 1 said don't know to 'with e-bike).

First, participants were asked "*Compared to before the trial, how do you expect the total amount of time you spend cycling to change in the future* (for all journey purposes, not just work)*?*", followed by the same question with the added phrase "*if you had an electrically-assisted bike available to use*". As shown in Fig. 4, 30 participants (38%) reported that they expected their cycling time to increase in the future. This number increased to 61 (76%) if an e-bike were available.

Second, participants were asked "In the coming month, roughly how many days per week do you expect to commute to work by bike?", with the follow up question "In the coming month, if you had an electrically-assisted bike available to use, approximately how many days per week would you expect to commute to work by bike?" As shown in Fig. 5, the proportion of participants saying that they would cycle to work at least one day a week increased from 29% to 73%, if they had an e-bike available.

Third, participants were asked to rate, on a scale of 1–7, first "Would you like to have an electrically-assisted bike available to use in the future?", and second, "How likely is your household to buy an electrically-assisted bike in the next few years?" What emerges here is the clear disparity between responses – whilst 56 participants (70%) gave a value of more than 4 for whether they would like to have an e-bike, only 18 did so in terms of whether they were likely to buy one.

4.3.2. Changes in behaviour one year after initial survey work

At both Brighton employers in the trial, follow-up surveys were conducted one year after the initial survey work took place, in the spring. Trial participants were encouraged to reply, and responses were received from 62 of the 80 original participants. For these respondents:

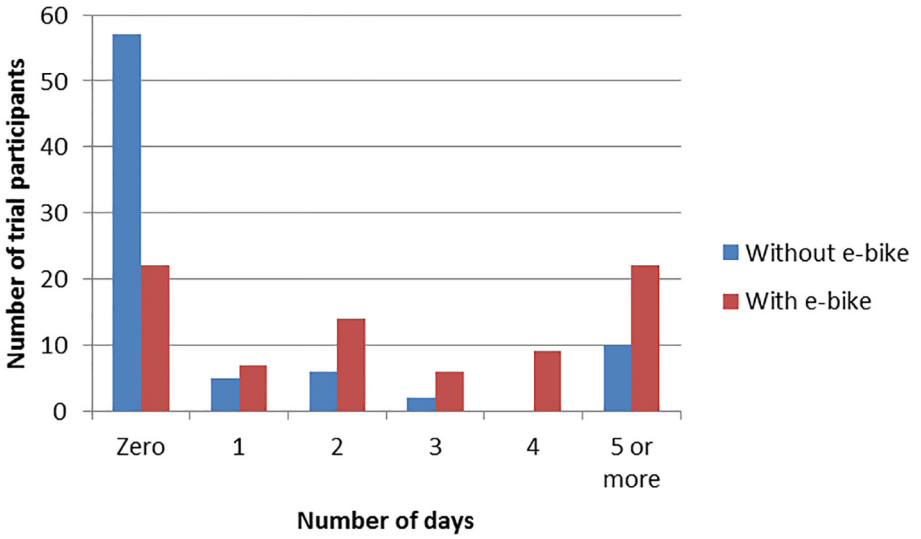

Fig. 5. Expected number of days per week cycled to work in the coming month.

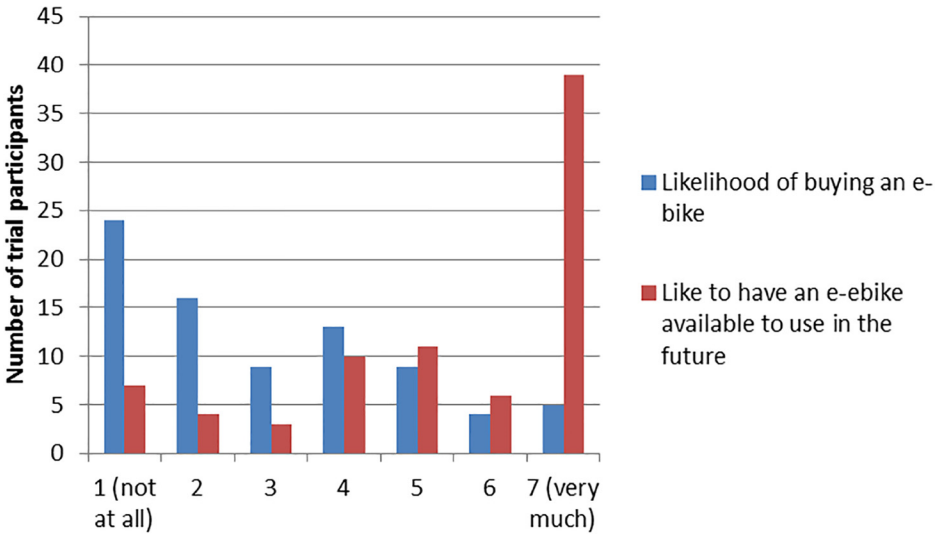

Fig. 6. Future ownership preferences and plans.

- 5 people (8%) reported that their household owned an electrically-assisted bike (although one person owned it prior to the trial).
- 22 people (35%) reported that the amount of cycling that they had done in the last year had increased, compared with the preceding year (whilst 12 said no change, 3 reported a decrease and 25 said that they didn't currently cycle).

Of the 62 respondents, 39 of those from the second year of trials were asked a more detailed question about whether their involvement in the trial had led to particular changes. In their responses, 17 said that it had caused them to 'cycle more'; 4 said 'drive less'; 8 said 'buy or otherwise obtain a conventional bike'; and 2 said 'buy or otherwise obtain an electrically-assisted bike'. In addition, 18 said that, compared to last summer, they expected the total amount of time that they would spend cycling this summer to increase (compared to 16 who said no change, and 5 who expected it to decrease). The closed questions on the survey were backed up by participant comments:

"*I took part in the e-bike scheme last Autumn and got the e-bike bug. Since 1st April, I now cycle to work as often as I can.*"
"*Participation in the e-bike trial encouraged me to invest in a bike. I chose a Brompton fold-up bike as it fits more easily in my small flat.*"
"*Change made to try and save costs on petrol. I think I cycled enough last year to save about 1 tank of fuel or about £70.*"

"*Bought an ebike and now commute by bike instead of car.*"

4.4. Differences between participants

This final results section considers data from the Brighton trial in relation to all three research questions. So far, the data in this paper has related to characteristics of the trial participants as a whole. However, it is clear that there were very different impacts on the trial participants, depending on how much they used the bikes. An initial expectation was that there would be distinctive patterns of usage (e.g. groups of 'high users' and 'low users'). However, as shown in Fig. 7, there was a continuum of use, rather than distinct clusters. The GPS data was also used to divide participants into 5 bands, depending on the total distance that they travelled on the e-bikes, and the data analysed accordingly. Results are shown in Table 11.

5. Discussion and conclusion

This paper reports on a review of European literature (see Section 2), together with primary fieldwork in Brighton, aimed at assessing whether (a) providing people with the opportunity to use an e-bike actually results in them doing so; (b) how any usage affects use of other modes; and (c) whether doing so in a trial context then has any impacts on future travel choices.

In the Brighton trial, of the 80 commuters who were loaned an electrically-assisted bike, three-quarters chose to use it at least once a week, (albeit that periods of holiday, sickness etc precluded use every week). Averaged across all participants, weekly mileage was in the order of 15–20 miles a week; time spent cycling was about 2–2.5 h; and the number of days commuted to work by bike was around 2. In total, the trial participants cycled more than 5900 miles during the trial. These findings are consistent with results from other EU literature suggesting that e-bike trials or ownership do tend to result in e-bike use, often for a substantial amount per week, and for relatively long journeys (compared to conventional cycling). Specifically, 8 studies were identified providing estimates of travel by users (ranging from about 15 km to 75 km per week), together with work from Germany and the Netherlands suggesting that e-bike trips are typically about 50% longer than conventional bike trips. Although it should be noted that participation is often self-selecting, in both our trials, and commonly reported in the literature, it is found that the proportion of people who are interested in getting involved in such activities is often very high.

For the Brighton trial, during the trial period, the biggest effect of borrowing the bike was on car driving, with a 20% reduction in car miles driven averaged across all participants. There were also reductions in bus use and walking, counterbalanced to some extent, by some increases in walking and cycling (of non-trial bikes). Many participants reported increases in time spent cycling, and in their overall physical activity. However, separate assessment of the average *time* spent actively travelling showed no change – largely because, averaged across the sample as a whole, increases in time spent cycling were counterbalanced by reductions in time spent walking. It should be noted that Brighton has relatively low levels of car driving, and high levels of walking, so sustainable mode-shift effects could be greater in other contexts. Analysis of EU literature (including work in Austria, France, Germany, the Netherlands, Norway, Sweden, Italy and the UK) shows that when people have the opportunity to use an e-bike, a non-trivial proportion of the trips made are a replacement for car trips. The specific reported proportion of substituted trips varies substantially from study to study, ranging from 16% (albeit for a very small sample) to 76%, with four studies reporting figures of at least 50%. However, it should be noted that this is the proportion of e-bike trips that were previously car trips, rather than the proportion of car mileage that has been replaced (since this is a less commonly reported metric). Impressive overall reductions in car kilometres travelled have been reported from Vorärlberg and Chambery.

In terms of travel behaviour after the trial, 38% of the Brighton participants expected to cycle more in the future. At least 70% reported that they would like to have an e-bike available, and that, if this was the case, they would be likely to cycle more in the future, and they would be likely to cycle to work at least one day a week. One year after their initial involvement, 5 trial participants reported that their household owned an electrically-assisted bike, and a variety of other positive effects were reported, in terms of propensity to cycle. Data from Vorarlberg, Brussels, Weiz, Eindhoven, Talybont-on-Usk and the Cairngorms also suggests that a proportion of people who try-out an electrically-assisted bike become potentially interested in buying one, (in the order of 30–70%), with some of those studies also suggesting that trials can stimulate greater interest in conventional cycling. The research in Vorarlberg also found that those involved may influence others to consider e-bikes, and, in Eindhoven, a successful e-bike leasing scheme had been introduced following an initial trial.

In the Brighton trial, looking at individual patterns of use showed a continuum, rather than distinct groupings. The fifth of trial participants who made the most use of the bikes were typically cycling an average of more than 40 miles a week, whilst the middle fifth were cycling approximately 15 miles a week, and the bottom fifth cycled an average of 2 miles a week. The implication is that e-bike use is not a niche activity that appeals to a small minority of keen users, but something that fits into different people's lives to differing extent.

In brief, then, in Brighton, about three-quarters of those borrowing bikes made regular use of them; there were significant associated reductions in car driving; and reported positive impacts on propensity to cycle. Moreover, if participants had an e-bike available for future use, then, given their experience of riding one, a large proportion reported that they would cycle more for commuting, and in general. These results are backed up by findings reported from other EU e-bike trials and pro-

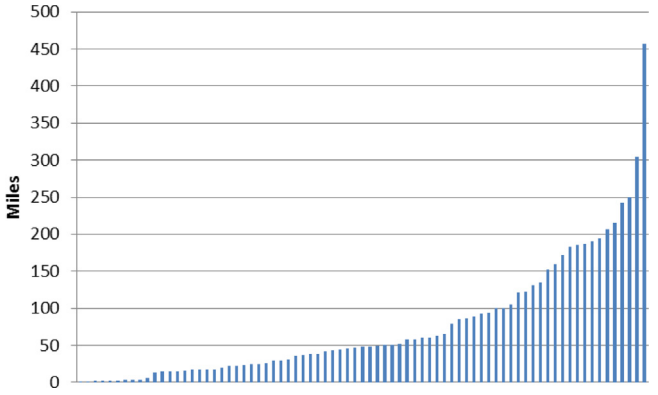

Fig. 7. The distribution of distance cycled by individual trial participants (sample: 77).

Table 11
Usage statistics for the 80 trial participants (average values for each quintile).

Mean results for the different quintiles[a]	1 - Lowest users	2	3	4	5 - Highest users
GPS data					
Miles cycled during the trial	7	25	48	88	210
Days that the e-bike was used	3	8	13	17	26
Survey data[b]					
Number of days commuted to work by bike during a typical week of the trial[c]	1	2	2	3	3
Weekly mileage during a typical week of the trial	2	10	15	27	42
Time spent cycling during a typical week of the trial (mins)	37	86	149	221	246
Greatest distance cycled in 1 day (miles)	4	6	10	12	18
Greatest time spent cycling in 1 day (mins)	42	51	85	91	132

[a] The quintiles are based on the 77 participants with data, using the following groupings: lowest users 16 participants, middle users (2, 3, and 4) 15 participants each, and the highest users 16 participants.
[b] 10 participants said 'don't know' to average weekly mileage; 2 participants said 'don't know' to average weekly time; 7 participants said 'don't know' to greatest distance cycled; and 2 participants said 'don't know' to greatest time spent cycling.
[c] The sample size for this question was only 60, as the question was added after the first trial wave.

jects – where the specific figures vary, depending on the type of scheme involved – but the generic findings seem robust. The implication is that identifying ways of providing people with attractive access to e-bikes could therefore help to achieve a range of benefits, and, compared with other policy measures, not least those to promote electric cars, measures to encourage the uptake of e-cycling potentially present a relatively low-cost/ high-impact way of encouraging more sustainable travel.

Acknowledgements

This research is based on a research project funded by the UK Research Councils Digital Economy and Energy Programmes/EPSRC, grant EP/J004855/1, led by the University of Brighton, entitled 'Smart e-bikes: understanding how commuters and communities engage with electrically-assisted cycling', www.smart-ebikes.co.uk. Grateful thanks to the reviewers of this paper, the funding organisations, the advisory panel, the trial participants, and to the other partner organisations involved in the study, namely Raleigh, Bupa International, Brighton & Hove City Council, Baker Street Bikes and M's Cycles.

References

All Party Parliamentary Cycling Group, 2013. Get Britain Cycling. Wordpress.com.
Behrendt, F., 2016. Why Cycling Matters for Smart Cities. Internet of Bicycles for Intelligent Transport. J. Transp. Geogr. 56, 156–164.
Behrendt, F., Robinson, M., 2014. E-Cycle Training: Electric Bikes Brighton experience. Technical Note <www.smart-ebikes.co.uk>.
Cairns, S., 2014. Electrically-Assisted Bikes: Part of the Toolkit for Mainstreaming Cycling? Cycle City Leeds, 2/5/14.
Cappelle, J., Lataire, P., Timmermans, J., Maggetto, G., Van den Bossche, P., 2003. Electrically Assisted Cycling Around the World. Report from the European E-Tour (Electric Two Wheelers on Urban Roads) Project.
Cherry, C., Cervero, R., 2007. Use characteristics and mode choice behaviour of electric bike users in China. Transp. Policy 14 (3), 247–257.
Dill, J., Rose, G., 2012. Electric bikes and transportation policy. Transport. Res. Rec.: J. Transport. Res. Board 2314 (December), 1–6. http://dx.doi.org/10.3141/2314-01.
Drage, T., Pressl, R., 2012. Pedelec-Test (in Andritz) in The Context of the European Union Project Active Access. <www.active-access>, EU, 2010–2012.
Eddeger, C., Lewis, T., Ditrich, J., Kubova, M., Daude, P., Forderer, W., Acunzo, N., Simeone, M., Daggers, T., Ditewig, R., 2012 (a + b). Best Practices with Pedelecs, Go Pedelec! <www.gopedelec.eu> (With additional data downloaded about the Italian example from www.fater.it in 2014).

Eltis, 2014. Pedelec rental system at local car dealers in Weiz. Austria. Only data source website text: <http://www.eltis.org/discover/case-studies/pedelec-rental-system-local-car-dealers-weiz-austria> (accessed 31st October 2014).
Engelmoer, W., 2012. The e-Bike: Opportunities for Commuter Traffic (Masters thesis Energy and Environmental Sciences). University of Groningen.
EPOMM, 2014. Hotel bike rental scheme for Graz, Austria. Only data source website text: <http://www.epomm.eu/index.php?id=2771&lang1=en&study_id=3737> (accessed 31st October 2014).
Fyhri, A., Sundfør, H.B., 2014. Ebikes – Who Wants to Buy Them and What Effect Do They Have? Institute of Transport Economics, Norwegian Centre for Transport Research, Oslo.
Gojanovic, B., Welker, J., Iglesias, K., Daucourt, C., Gremion, G., 2011. Electric bicycles as a new active transportation modality to promote health. Med. Sci. Sports Exerc. 43 (11), 2204–2210.
Helms, Kämper, Lienhop, 2015. Pedelction - Mobilitätsmuster, Nutzungsmotive und Verlagerungseffekte. In: Conference Paper At Nationaler Radverkehrskongress, Porsdam, 18–19 May 2015.
Hendriksen, I., Engbers, L., Schrijver, J., 2008. Elektrisch Fietsen, Marktonderzoek En Verkenning Toekomstmogelijkheden. TNO/BOVAG.
Hiselius, L.W., Svenssona, Å, 2014. Could the increased use of e-bikes (pedelecs) in Sweden contribute to a more sustainable transport system? In: 9th International Conference on 'Environmental Engineering, 22–23/5/14, Vilnius, Lithuania.
Kairos, 2010. Landrad – *Neue Mobilität Für Den Alltagsverkehr in Vorarlberg*. Endbericht, Bregenz.
Kidd, A., Williams, P., 2009. Talybont Energy – Electric Bike Trial Report. Talybont on Usk Energy Ltd, Brecon. https://talybontenergy.co.uk/community-projects/electric-bike-trial-2009/.
Kiefer, C., Behrendt, F., 2015. Smart e-Bike Monitoring System: real-time open-source and open hardware GPS, assistance and sensor data for electrically-assisted bicycles. J. IET Intell. Transp. Syst., 1–10 http://ietdlorg/t/xQe+Kb.
Mercat, N., 2013. 2009–2012: Four Years of e-Bike Development Policies in Chambéry, Velo City, Vienna, 13th June 2013.
Mobiel 21, 2014. Only data source website text: <http://www.mobiel21.be/en/content/97-pedelec-commuters-love-their-bikes> (accessed 10th July 2015).
OECD/International Transport Forum, 2013. Cycling, Health and Safety. OECD Publishing/ITF. http://dx.doi.org/10.1787/9789282105955-en.
Popovich, N., Gordon, E., Shao, Z., Xing, Y., Wang, Y., Handy, S., 2014. Experiences of Electric Bicycle Users in the Sacramento, California Area. Travel Behav. Soc. Hong Kong Soc. Transport. Stud. 1 (2), 37–44. http://dx.doi.org/10.1016/j.tbs.2013.10.00.
Simons, M., Van Es, E., Hendriksen, I., 2009. Electrically assisted cycling: a new mode for meeting physical activity guidelines? Med. Sci. Sports Exerc. 41 (11), 2097–2102.
Sustrans, 2013. Electric Bicycle Network in the Cairngorms National Park: Monitoring Report. Sustrans, Edinburgh.
VCD, 2013. Das E-Rad — mit Recht Hoffnungsträger urbaner Mobilität?. <http://www.e-radkaufen.de/fileadmin/user_upload/besser-e-radkaufen/e-Rad_presse/VCD_Hintergrundpapier_E-Rad_Nutzerumfrage.pdf>.
Wolf, A., Seebauer, S., 2014. Technology adoption of electric bicycles: a survey among early adopters. Transport. Res. Part A 69, 196–211.
Wright, J.R., 2013. Totnes eBikes: The Totnes Community Electric Bicycles Project Report. Document downloaded from the web in 2014.