Why cycling matters for electric mobility: towards diverse, active and sustainable e-mobilities

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Why cycling matters for electric mobility: towards diverse, active and sustainable e-mobilities

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ABSTRACT
This paper proposes the concept of e-velomobility. E-velomobility covers practices, systems and technologies of electrically-assisted cycling where velomobility’s pedal-power combines with e-mobility’s battery/motor assistance to propel the rider. The concept draws on research and policies around e-mobility, velomobility and e-bikes. Results of an analysis of qualitative material from a UK trial of e-bikes illustrate how e-velomobility is experienced. The empirical material and the conceptual approach show e-velomobility as a distinct and important form of mobility with implications for research agendas and e-mobility policy. E-velomobility and the more diverse understanding of e-mobility suggested in this paper could support a shift of strategies and policies towards more active and sustainable as well as less expensive modes of e-mobility than the current focus on electric cars.

Introduction
This article shows how e-velomobility is an emerging and distinctive form of mobility that draws on existing discourses and practices around electric cars and cycling. This contributes to the field of mobility studies, with its concern to explore social formations, practices, structures, meanings and politics of the mobile world (Cresswell and Merriman 2011; Sheller 2014; Sheller and Urry 2006). The research is guided by concerns for active and sustainable forms of mobility. It explores how e-cycling with its combination of leg and battery power can be conceptualised. The article also considers the embodied and lived experience of e-bike users, and how insights from both the conceptual and empirical work can translate into policy and further research, for example through shifting the understanding of e-mobility from car to bicycle.

To do this, the article first considers the politics of a car-centric understanding of e-mobility. Next, it discusses velomobility – forms of mobility around cycling. Drawing on both e-mobility and velomobility, the article develops the concept of e-velomobility and then introduces key research literature in the area. After the method section, results from a UK-based study are presented to get at the actual experience of e-velomobility. Drawing on both the empirical results and the theory, the article concludes with a discussion of how e-velomobility could inform future policy around electric mobility.

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The politics of e-mobility

E-mobility plays an important role in many visions of future and/or low carbon mobilities. E-mobility – short for electric mobility – is an umbrella term for mobilities involving electric vehicles, i.e. vehicles that rely on an electric motor for at least some of their propulsion with the power coming from an on-board battery (e.g. car or bike) or an off-vehicle source (e.g. train). These technologies have been around as long as the internal combustion engines found in most of today’s vehicles but have not been in use as widely, especially not in individual modes of transport such as cars. In light of sustainable mobilities, e-mobility has attracted significant attention over the last couple of decades. Electric vehicles are often regarded as the best out of the current options for lowering the carbon footprint of travel (Kollosche 2014) and ‘in the public debate, e-mobility is presented as the ultimate solution to nearly all transport problems’ (Schwedes, Kettner, and Tiedtke 2013, 72). Critical perspectives to e-mobility include those that question the hype around e-mobility by analysing media discourses (Schwedes, Kettner, and Tiedtke 2013) and those questioning the sustainability of moving emissions from tailpipe to power plant (Thomas 2012).

Urry introduced the term automobility that ‘can be conceptualised as a self-organising autopoietic, non-linear system that spreads world-wide, and includes cars, car-drivers, roads, petroleum supplies and many novel objects, technologies and signs’ (2004, 27). The mainstream understanding of e-mobility is heavily biased towards the car, re-phrasing automobility as electric mobility. This conflation of e-mobility and e-automobility could be understood as a convenient extension of automobile culture that does not require a more fundamental rethinking of our automobility world. The term ‘electric vehicles’ is therefore typically used as synonym for electric cars (e.g. Kemp et al. 2010) and there are many examples for the conflation of electric mobility and electric automobility (Dijk, Orsato, and Kemp 2013; Leurent and Windisch 2011) because ‘e-mobility has by and large been communicated in the context of sustainable mobility and its central idea is an urban e-car’ (Schwedes, Kettner, and Tiedtke 2013, 72).

Many countries, including most European countries, and many Asian states have introduced some form of financial incentive to kick-start or accelerate the uptake of electric cars. An analysis of a broad range of economic instruments in the largest 16 EU economies shows that sales tax applies to both e-bikes and e-cars, but as of 2010, a tax break is only implemented for e-cars in 7 out of 16 countries and four countries give subsidies for electric cars (Kley, Wietzsche, and Dallinger 2010). These ‘one-time support schemes are often more practical and more appreciated by the customer if paid at the time of the initial investment’ (Kley, Wietzsche, and Dallinger 2010, 16). Eight countries offer a reduction in the annual vehicle tax; these recurring instruments ‘score higher with respect to effectiveness and efficiency, but are often smaller in total volume’ and overall, the study shows ‘that EVs are economically unattractive [for buyers] in every European country except Denmark and Norway’ (16). This quote is also an example of conflating electric vehicles (EVs) with electric cars.

E-velomobility and the more diverse understanding of e-mobility suggested in this article, could support a shift of strategies and policies towards more active and sustainable as well as less expensive modes of e-mobility than the current focus on electric cars.

The following figures give some indication of budgets for the economic, regulatory, suasive and organizational instruments in some countries: Germany 2009–2013: 1 billion plus 500 million for R&D, the UK has committed over GBP800 million until 2010, Spain announced 600 million between 2009 and 2012, and France announced programs of 100 million in 2009, all on a mix of measures and some announced, some already spent (Leurent and Windisch 2011). These financial figures and policy measures illustrate that the majority of the e-mobility field is not concerned with changing the culture of automobility. If mentioned at all as part of e-mobility discourses or scenarios, e-bikes are often regarded as an intermediate step towards ‘proper’ e-mobility with electric cars: ‘the use of electric two-wheelers may enhance consumer acceptance of electric mobility in general’ (Dijk, Orsato, and Kemp 2013, 143) or as part of a ‘transport mix’ (Elliot and Urry 2010; Kollosche 2014). However, the most widespread mode of e-mobility already in use today is e-cycling. Overall, e-mobility ‘growth has been particularly rapid in the non-car segment, including pedelecs, three-wheelers, e-bikes and e-scooters’ (Rode et al. 2014, 30).
For example, there is a stark contrast between the popularity of electric cars and electric bicycles in China, the former languishing despite aggressive government incentives (Tyfield 2014, 594; Tyfield and Urry 2012, 9), the latter so popular that they attracted bans in some areas. In China ‘e-bikes are relatively inexpensive and make up a significant portion of transportation mode share’ (Shao et al. 2012) and the country is estimated to have more than 100 million e-bikes (Weinert et al. 2008; Yang 2010) making up 83–92% of the global market (Hurst and Gartner 2012). The vast majority of these are ‘twist-and go’ or moped style e-bikes, i.e. pedaling is not required or not possible. A ‘happy policy accident’ in China ‘has seen explosive growth in the sales of electric bikes since 1998’ and this ‘was triggered by Chinese local governments’ efforts to restrict motorcycles in city centers’ (Yang 2010). Electrically-assisted bikes are rarely distinguished in figures for China and other Asian countries; figures tend to cover both e-velomobility and e-motobility in one category (see section ‘e-velomobility’ below for more detail on this).

Outside Asia, electrically-assisted bicycles make up the majority of e-bikes. Sales figures for Europe vary, including figures of 1 million e-bikes for Western Europe in 2010 (Hurst and Gartner 2012), 854,000 for Europe in 2012 and 1,139,000 in 2014 (Confederation of the European Bicycle Industry 2015, 22) with 400,000 sold in Germany alone in 2013 (Bryant 2014) and about 170,000 in the U.S. in 2014 (Benjamin and Poynter 2014). EU sales have doubled between 2010 and 2014 (Confederation of the European Bicycle Industry 2015, 22), underlining how dynamic this emerging market is. For the UK, sales of 50,000 are reported for 2014, representing 4% of the EU sales (Confederation of the European Bicycle Industry 2015, 23).

### Velomobility

The concept of velomobility relates to mobilities research around cycling. The term velomobility (also often spelled ‘vélobility’) tends to be used as a phrase to capture mobility that happens by bicycle. The term is often used in parallel, or in opposition to the term automobility.

Watson argues that the systems of automobility (as introduced above) and velomobility share that for both ‘[a] range of elements, relationships and actors […] crowd around [a] technological artifact’ (Watson 2013, 121). In the past, velomobility has had similar self-expanding properties as automobilities (121ff.). Watson discusses how automobility and velomobility compete for people’s time, for road space, for resources, and in discourse, with ‘enormous competitive advantage in recruiting practitioners and sustaining performances’ of automobility (124). ‘As with the automobile, the bicycle affords the rider individual freedom of mobility under the promise of technological progress’ (Walks, Siemiatycki, and Smith 2015, 238) and we might see a revival of this with the current increase in interest in cycling and cycling technologies, including ‘electric’ ones. Horton, Rosen and Cox use the term velomobility to ‘signal the parallels and connections between our interests and those of researchers into “automobility”, but also to distinguish our specific concern for the materialities of cycling technologies, the practices of cycling, and the systems which constitute and are constituted by those materialities and practices’ (Horton, Rosen, and Cox 2007). Drawing on Cresswell’s ‘Politics of Mobility’ (2010), Koglin and Rye develop a theoretical framework for cycling in urban and transport planning that they call ‘politics of vélobility’. It takes into account the ‘physical movement of cyclists,’ the ‘power relations in urban traffic spaces,’ the ‘representation of bicycling’ and ‘experience of the movement’ (Koglin and Rye 2014, 220).

The popularity of cycling has varied greatly across time and space (Goodwin 2013). Most of us today are not exposed to ‘large-scale velomobilities’ unless living in countries such as the Netherlands or China, but historically, many countries experienced it (Horton, Rosen, and Cox 2007). Recently, cycling has seen a (or, rather another) rise in popularity in many Western countries, and also a profile rise in the media. For example, in the UK the miles cycled have increased by 20% between 1998 and 2013 (Department of Transport 2013), while in the US the number of cycling trips has doubled between 2001 and 2009 (The League of American Bicyclists 2013); both countries with low cycling rates over recent decades (Furness 2010; Horton, Rosen, and Cox 2007).

Over the last decade or so, cycling has been considered increasingly in several fields of research including mobility studies. Rosen et al. give a brief overview of cycling research, focussing on historical,
sports, engineering/design/planning and medical (Horton, Rosen, and Cox 2007) and set the scene for cycling research from outside these fields, including the sociology and politics of cycling. They underline that
cycling is profoundly relevant to a whole range of important contemporary debates, about how we move around and with what consequences, about the appropriate pace and scale of everyday life, about how we treat our bodies, our communities and our planet, and the very viability of human futures. (10)

There are several articles with overviews of recent cycling mobilities research (see e.g. Furness 2010, 2007; Goodwin 2013; McIlvenny 2013a, 5). Velomobilities research has considered identity (Aldred 2012; Fincham 2007; Skinner and Rosen 2007; Steinbach et al. 2011), touring (Pesses 2010), the arrangements of bodies and bicycles in group rides (McIlvenny 2013a, 2013b), gender (Clarsen 2014; Mackintosh and Norcliffe 2007) as well as embodied and multi-sensory aspects (Jensen, Sheller, and Wind 2014; Jungnickel and Aldred 2014; Jones 2005; Lugo 2013; Spinney 2007, 2009), amongst many others. Velomobility can be part of ‘utopian urbanism’ as discussed by Furness – one of the first to use the term – in his analysis of Critical Mass (Furness 2007, 299). An underlying concern of these diverse approaches to researching cycling cultures, practices and politics is that ‘the [current] rise of velomobility constitutes an important component of a socially and environmentally sustainable future’ (Walks, Siemiatycki, and Smith 2015, 237).

E-velomobility

Drawing on the concepts of e-mobility and velomobility (see Figure 1), this article suggests the term e-velomobility as both a useful designation and a means to investigate mobilities research into e-cycling. E-velomobility includes practices, systems and technologies of e-cycling; it revolves around e-bikes (short for electric bicycle). Before presenting a more detailed definition of the term at the end of this section, an exploration of the field helps to clarify the terminology in this area.

E-bikes are not common in all countries and the designation e-bike is itself used inconsistently in the popular press and also sometimes in the academic literature. There are a number of different terms for two wheelers with an electric motor, including E2W (the short form for electric two-wheeler), e-bike (the short form of electrically-assisted bike or bicycle), electrically-assisted bicycle, pedelec (short for pedal electric bicycle) and EPAC (short for Electrically Assisted Pedal Cycle). They fall roughly in three categories, depending on the kind of assistance given by the motor and the amount of pedaling possible or required (see Figure 2). These categories are not clear-cut but give a useful overview.

The first category comprises electrically-assisted bicycles (technically defined as pedelecs). They look and work similarly to ordinary bicycles but have a small electric motor (powered by a rechargeable battery) that can be switched on to assist the rider. The amount of assistance from the motor reduces with increasing speed and cuts out altogether once the bike reaches 15 mph or if the rider stops pedaling. This means that pedelecs can be ridden like an ordinary bike or in assisted mode when switching on the motor (or a mix of both depending on circumstances). Electrically-assisted bicycles

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Figure 1. Relationship between e-mobility, velomobility, automobility, e-velomobility and e-automobility. Source: Author’s illustration.
are subject to different regulations around the globe. For the European Union, the regulations specify that to be classified as 'assisted cycle' the maximum wattage is 250 W and the maximum assisted speed is 25 km/h; above these they would be classified as 'motorcycle' (European Commission 2002). Many countries (including the UK) further specify that the assistance can only be electric – not petrol-driven. Electrically-assisted bicycles are popular in many European countries, and their popularity is on the rise in the US, Australia and other Western countries. ‘Fast’ electrically-assisted bicycles are also available and increasingly popular in some countries (e.g. Germany) and allow the rider to be assisted up to 45 km/h. They are typically subject to licensing and/or tax.

The second category of e-bikes give assistance to riders regardless of them pedaling or not. This means that users can choose to pedal with assistance, to use their bikes ‘moped-style’ (no pedaling), or to pedal them without assistance. These e-bikes are often referred to as ‘throttle-controlled’ or ‘twist and go’ style.

The third category of e-bikes comprises scooter or moped-style bikes where pedaling is not required and hardly possible. Their configurations (and legislation) concerning their amount of power and speed vary (e.g. regarding the difference between electric moped/scooters and motorbikes). The last two categories of e-bikes are very popular in many Asian countries, especially China (see above section on the politics of e-mobility).

The term electric two wheeler (E2W) is often seen as the broadest one as it covers all three categories introduced above. However, it does not cover those with three or four wheels (Cox and Van De Walle 2007), for example tricycles (trikes) or rickshaws for transporting people or loads and that could fall into any of the three above categories. These two-, three- or four-wheelers might also feature partial or full enclosure (Cox and Van De Walle 2007).

Unless indicated otherwise, the terms ‘e-bike’, ‘electric bike’ and ‘electrically-assisted bicycle’ are used interchangeably in this article to reflect this common practice and where this distinction is unimportant or cannot be made. However, the argument of this article focuses mainly on electrically-assisted bicycles, and the original research discussed later was conducted with this type of e-bike.

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**Table 1.** Common and variation of e-bike types.

<table>
<thead>
<tr>
<th>Common</th>
<th>Speed Range</th>
<th>Style</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike</td>
<td>Electric</td>
<td>Moped</td>
<td>Partial or Full</td>
</tr>
<tr>
<td>Motor</td>
<td>Electric</td>
<td>Moped</td>
<td>Partial or Full</td>
</tr>
<tr>
<td>Battery</td>
<td>Electric</td>
<td>Moped</td>
<td>Partial or Full</td>
</tr>
</tbody>
</table>

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**Figure 2.** Simplified overview of e-bike types with regards to assistance and pedaling. Source: Author’s illustration.

Note: These include both e-velomobility and e-motomobility.
This article argues that e-velomobility is distinct from those forms of e-mobility where pedaling is not required for propulsion, for example those revolving around electric mopeds or scooters. Drawing on Pinch and Reimer’s (2012) ‘moto-mobilities’, I would term electric mobility with non-pedal propelled two-wheelers e-motomobility. There is also a range of e-mobilities revolving around boards with battery and motor that require varying degrees of form of bodily engagement (but not pedaling), such as electric skateboards, scooters and hoverboards. These could be termed e-boardmobilities. Mobility scooters and electric wheelchairs are further types of e-mobility that are neither pedal-powered nor automobile; revolving around those with specific mobility needs. The diverse understanding of e-mobility proposed here acknowledges the wide range of different needs around mobility and assistance, rather than furthering distinctions between assisted and non-assisted mobility. There are many different ways of combining electric assistance with human-powered propulsion and many different design approaches to this. These examples illustrate the diversity of e-mobility, all of which would be worthy of more academic research and more policy attention. The types of e-mobility listed in this section are related to but distinct from e-velomobility.

Drawing on all these considerations, this article now proposes a definition of e-velomobility. E-velomobility is concerned with practices, systems and technologies of e-cycling, specifically around electrically-assisted bicycles (pedelecs) where a combination of pedal-power and (optional) electrical assistance propel the rider (see Figure 3). E-velomobility is related to, but does not include (moped-style) electric two-wheelers where no pedaling is required, as human-powered pedaling is regarded as a key feature of velomobility – both with and without ‘e’. In terms of use, the majority of e-velomobility revolves around two-wheelers, but those with more wheels (e.g. trikes or rickshaws) are also included, as long as pedaling is required. E-velomobility then gives us a new form of mobility and designates a subject for mobilities research. The terms e-velomobility and e-cycling are used interchangeably in this article.

**E-velomobility research**

The following section draws on key literature on e-cycling from a range of research fields to further sketch out the field of e-velomobility and to frame the empirical material presented later. The increasing academic attention to electric bikes comes mainly from the fields of transport research and engineering, with some consideration from cycling research, urban planning and public health research, with less attention from the mobility field.

E-bikes are an important factor towards making transport more sustainable and towards reducing carbon emissions. Electric bikes ‘emit substantially less pollution per kilometer than cars based on life-cycle emissions analysis’ (Shao et al. 2012, 4) as can be seen in Figure 4, and both assisted and moped-style e-bikes in the Chinese context ‘emit several times lower pollution per kilometer than
motorcycles and cars, have comparable emission rates to buses and higher emission rates than bicycles’ (Cherry, Weinert, and Xinmiao 2009, 281). It is important to keep in mind that the type of battery and the method of electricity generation impact on the results of lifecycle analysis (Cherry, Weinert, and Xinmiao 2009, 281; Li, Qian, and Chen 2014).

How do electrically-assisted bicycles (not ‘twist and go’ or moped-style e-bikes) fare in terms of physical activity? Even when used on the highest power setting, the effort required is sufficient to count as at least moderate intensity physical activity (Gojanovic et al. 2011; Simons, Van Es, and Hendriksen 2009). The intensity of electrically-assisted cycling is ‘sufficiently high to contribute to the physical activity guidelines for moderate-intensity’ (Simons, Van Es, and Hendriksen 2009, 2097). If integrated into everyday life, for example by commuting to work by e-bike three times a week (riding to work with assistance, home without), and assuming the mean commuter cycling distance in the Netherlands of 4.3 km then the ‘public health recommendations for physical activity are met’ (2100). This makes e-bikes a ‘comfortable and ecological transport modality, helping sedentary people commute to work and meet physical activity guidelines’ (Gojanovic et al. 2011, 2204) as they ‘help to encourage active travel amongst groups who traditionally undertake less exercise’ (Cairns et al. 2015, S17).

E-bikes challenge long-standing assumptions about the speed and range of cycling, especially in relation to specific groups. While regular bikes and walking is also often faster than driving a car in dense urban environments, the assistance opens up this speed-advantage to more people. Electrically-assisted bicycles allow for more acceleration when starting e.g. at traffic lights or on hills (but without the dramatic acceleration known from motorbikes), often give riders a more uniform overall speed (many hover around the top end of the assisted speed), and increase the range of what is considered a cyclable distance significantly. In combination with car traffic slowing down dramatically in many urban areas, e-bikes challenge assumptions about how ‘fast’ cars are and how ‘slow’ bicycles are. This article supports Cox’ argument that ‘the field of pedelecs and electric bikes is rapidly changing and appears to be a major growth area and one which will have considerable impact on the use of transit space in

Figure 4. Comparison of the CO₂ emissions of using a car and an e-bike for a 5 mile and 15 mile round journey made 200 days per year, based on (Shao et al. 2012). Source: Author’s illustration based on (Shao et al. 2012).
future’ (Cox 2008, 155). E-bikes might encourage more people to cycle – or encourage people to cycle more (Cairns et al. 2017). They make it easier to cycle uphill, against the wind, with heavy loads (children, grocery shopping) or for longer journeys. They also have benefits for commuters who want to arrive unruffled, older age groups, people with physical limitations, tourists and last mile delivery of goods.

Research engaging with Western locations include an interview-based study of e-bike users in California (US) (Popovich et al. 2014), European research on the potential of pedelecs ‘for society and the economy’, ‘their promotion as products’ as well as ‘their problems and opportunities’ (GoPedelec 2012), the UK-based study reported in this paper (see also Cairns et al. 2017), motivations of e-bike users in Germany (Paetz, Landzettel, and Fichtner 2012), a study in a hilly city in Austria (Drage 2012), and research on e-bikes as solution for the last-mile issue of accessing public transport in a range of EU countries (Nelson and Aditjandra 2012, 340).

There are a range of publications with an Asian or Chinese focus, including a survey-based analysis of e-bike users in Shanghai (An et al. 2013), an observational study in China focused on safety regulations (Du et al. 2013) a discussion of the use of e-bikes and behaviour of e-bikes users in China (Cherry and Cervero 2007; Wei et al. 2013), a comparison of the unplanned success of e-bikes in China to the failed subsidised approach to introducing e-bikes in Taiwan (Yang 2010), research on the safety of e-bike riders in China (Yao and Wu 2012) and their behaviour at intersections (Tang et al. 2012) as well as considerations of the relationship between e-bike ownership and the built environment in China (Zhang et al. 2013).

Cox discusses e-bikes in general and specifically the situation in China and warns: ‘If the e-bike is treated as simply a step on the road to car use, then the situation will revert to an extremely unsustainable path’ (Cox 2008, 187). I agree with his view that it ‘is therefore vital to ensure that e-bikes are valued as a mode in their own right’ including ‘clear recognition within legislation and in the provision of appropriate facilities’ (Cox 2008, 187).

Cargo e-bikes have also received academic attention, both in terms of personal and business use. Cargo bikes are designed to carry loads and to facilitate this they might have two, three or four wheels and can feature a partial or full enclosure and/or a trailer, presenting specific design considerations for bike and environment (Cox 2008). The extra load carried makes electric assistance a key feature of many modern cargo bikes. In the light of the growing popularity of online shopping and home delivery there is a growing issue around last-mile delivery to which cargo e-bikes present a sustainable solution. The existing and potential of implementation across Europe has been discussed (FGM-AMOR, ECF, Outspoken, and CTC 2014) and Gruber et al. consider the ‘substitution of cars by electric cargo bikes for inner-city courier shipments’ and identify that ‘[c]ritical factors for actual implementation appear to be electric range, purchase price and publically available information’ (Gruber, Kihm, and Lenz 2014, 53).

Fishman and Cherry’s (2015) overview of e-bike literature provides further examples of geographic and topical approaches to e-bike research. This paper contributes to the ‘several important gaps in knowledge’ the authors identified by linking e-bike research to debates around e-mobility and related policy (Fishman and Cherry 2015, 88).

The use of e-bikes is regarded critically by some cyclists and cycling bodies. For example, in 2012, I attended a House of Lords (UK) e-bike event that was boycotted by all cycling groups that were invited. If velomobility could be regarded as critiquing automobilities, then e-velomobilities might do the same, but at the same time also critically engage with cycling culture and some of its assumptions, for example about what constitutes ‘proper’ cycling. E-bikes might be particularly appealing to those who currently use other (less sustainable or active) modes of transport, if cycling needs to be made ‘irresistible’ (Pucher and Buehler 2008), then electric assistance might just do that for many of those who do not currently cycle (much).

**Method**

After analysing discourses, research and policies relevant to e-velomobility, the article now turns to the lived practice of e-velomobility to illustrate how e-velomobility is experienced, embodied and
performed. The qualitative material presented in the next section shows how the concept of e-velomobility plays out in the actual accounts of those experiencing e-cycling during a 6–8 week trial period. This section explains how the research material was collected and analysed.

The accounts of e-velomobility discussed in the following section are selected from interviews, focus groups and surveys that were carried out as part of the ‘smart e-bike’ research project. The research was UK based, a country where cycling has not been as popular as in many other EU countries and where the uptake of e-bikes has been slower and later than in many of these. Specifically, the research took place in the south-coast city of Brighton and Hove (referred to as Brighton throughout this article), a city with a hilly topography (surrounded by the South Downs) and an often-windy seafront. Brighton and Hove City Council has a track record of investing in cycling infrastructure (Brighton and Hove City Council 2016). According to the census, the percentage of people cycling to work in Brighton & Hove has risen from 2.7% in 2001 to 4.9% in 2011 (Brighton and Hove City Council 2011).

A fleet of 35 e-bikes were used for fieldwork between 2012 and 2013. The material used in this paper stems from lending these bikes to 80 commuters for six to eight week periods. The quantitative material is discussed elsewhere (Cairns et al. 2017; Kiefer and Behrendt 2015). The material presented in this paper has not been previously published. The qualitative material from 50 interviews, 11 focus groups (2–4 participants each) and survey fields was transcribed and coded in NVIVO. Using an inductive approach (grounded theory), the choice and description of the nodes was informed by a team review of a sample of the material, and the coding framework was adapted during the process of coding the full sample. The coding process was informed by the interdisciplinary background of the team and also by a shared appreciation of the importance of barriers and facilitators as well as human and contextual factors. The key aspects of the coding framework (i.e. the ‘high-level’ NVIVO nodes), in no particular order, are: action (e.g. parking, lifting or riding an e-bike), attitude (positive, negative, mixed, other people’s views), context (e.g. location, weather), emotional response (e.g. enjoyment, fear, pride), timeline (e.g. pre-trial, during training), sensory experience, whether something was perceived or described as barrier or facilitator, and 19 ‘issues’ (e.g. behaviour change, ownership, e-bike/parts/properties). For this paper, the material coded under nodes relevant for the experience of e-velomobility was reviewed and key quotes were chosen from the results.

Results

This analysis attends to the complex experience of e-velomobility to complement the research on e-cycling presented earlier that tends to have a transport rather than a mobilities approach. E-velomobility focuses on the complex interactions between bodies, bikes, electric motor and battery, urban environment and other road users, recognising ‘that mobility and movement are entangled with relations of power, identity and embodiment’ (Spinney 2009, 823). This analysis follows the tradition of an embodied and multi-sensory approach to cycling research (Jungnickel and Aldred 2014; Spinney 2007, 2009). The four key themes of the results – experiencing e-velomobility, engaging with batteries, feeling judged, and cost – are now discussed in detail.

Experiencing e-velomobility

E-velomobility relies on propulsion from both rider and electric motor, as defined earlier in this article (see Figure 3), and the following quote illustrates how this is articulated as part of the experience. One participant responded that to those unfamiliar with e-cycling ‘I had to explain how it’s power assisted and you have got to keep pedalling’. In addition to traditional bike features such as gears or brakes that form part of the experience of velomobility, for e-velomobility, the battery powering and the e-bike motor it powers becomes an integral part of the experience, and riders negotiate the amount of assistance used in relation to using their own body power: ‘it’s that balance, you use more battery power, or use more leg power’. These quotes show how the materialities, practices and systems of velomobility
(Horton, Rosen, and Cox 2007) are present in the experience of e-velomobility, but also how they are distinctly different in terms of engaging with the electric assistance.

The experience of riding with the assistance is often particularly well expressed in accounts of people’s first active encounter with e-velomobility. This is illustrated by a trial participant reflecting on their first times they rode an e-bike:

Switching from the normal mode to e-bike mode when you are going and switching the battery on it is just like [it] pushes you from behind. It is kind of cool the first days, I wasn't used to it, I would look behind like is somebody pushing me. [...] I think the battery part is the most exciting for me.

The importance of the battery and assistance for e-velomobility is confirmed by others: ‘it was about having the electronic battery’ on the bike. What comes out very clearly across most of the qualitative material is, that it is the distinct nature of e-velomobility that makes it an attractive option for those who participated in the trial, the combination of velomobility and e-mobility made the difference for them. Therefore, making cycling an option, and an attractive one at that is also a key part of experiencing e-velomobility: ‘I think that knowing that you have got that motor even though you are tired and you think shall I go for a short cycle it really tips the balance in favour of cycling’.

As discussed earlier, for Horton, Rosen, and Cox (2007) ‘practices’, and for Koglin and Rye (2014) ‘physical movement’ are key to velomobility. The accounts of trial participants show how e-velomobility is distinct in terms of practices and physical movement: ‘you need to learn to cycle it in a slightly different way from a conventional bike’ for example in terms of anticipating the terrain ahead and whether assistance is needed, or in relation to the higher speed of riding. E-cyclists always need to pedal, ensuring physical mobility and health benefits over less active forms of transport (Cairns et al. 2015). Their active role in propelling themselves is a key aspect of the embodied experience of e-velomobility. This experience is shared with other cyclists: ‘in their everyday practices cyclists re-interpret the use of road and public spaces according to their distinctive embodied experience’ (Spinney 2009, 825). However, it is also distinct, as reported above, and confirmed by other e-bike research: ‘Almost all participants recounted having to “re-adapt” to cycling by learning to moderate their speed and to anticipate the reactions of other road users’ (Jones, Harms, and Heinen 2016, 46).

The experience and practice of e-velomobility is also expressed with regards to feelings of confidence and safety. Notions of safety and confidence are part of the cyclists identity negotiations (Aldred 2012) and this paper shows how they play out for e-cyclists. Several e-bike users on the trial reported feeling more confident in traffic: ‘having a bit more power makes you feel a bit more confident’, for example in ‘places where you sort of need a bit of speed’ and where you would feel ‘hesitant’ otherwise, such as roundabouts. Having the assistance on the bike also made several riders experience increased safety – ‘it did make me feel safer’ – and several comments linking increased feelings of confidence and safety with practices of e-velomobility.

Keeping a constant speed is another aspect of the practice of e-velomobility and experiencing e-cycling: ‘it helps to keep you moving at a constant speed’. This participant explains how they would keep a constant speed by adjusting the amount of assistance to the terrain and weather conditions they encountered: ‘I could see that on the flat if it was very windy then you could increase it [the assistance] to medium or occasionally high but usually on the flat you don’t need a lot because it’s very easy going’. The more constant speed of e-cycling makes journey times more predictable, as reported in several interviews and focus groups. Furthermore, the constant speed is also beneficial for sociable cycling such as family or group rides where some or all riders might have electrically-assisted bikes.

Battery, charging and range

In addition to its relation to materialities and practices of velomobility, e-velomobility also relates to e-automobility experience and practice, for example in terms of engaging with a battery and a motor. Some of the distinct practices of e-velomobility are reflected in comments pertaining to riders’ engagement with the bike’s battery, requiring skills and routines that are distinct from velomobility,
and more closely related to e-automobility. Dealing with the battery and its charging is described as unproblematic by most trial participants: ‘You take the battery out and plug it in – no problem’. Another one elaborates: ‘rather than charging it on the bike, in the evening when I go back, I’d just take the battery off inside and actually get it charged for the next day’. Others found it a bit of a hassle: ‘having to remember to charge, then remove the battery, get the charger, plug it, put it in, you know, press a button to see the lights’.

Discussions around battery life and range are another common thread between users of electric cars (Franke et al. 2012) and e-cyclists: ‘the batteries never last as long as what they say they do’, as one trial participant observes, and another one feels that ‘the battery is annoying to have to keep charging it all the time’, and a third one asking for the ‘battery to last longer’. The experience of battery life is directly related to range anxiety.

Range anxiety is reflected in worries around how far battery charge will get the user (Franke et al. 2012) – something that is experienced by both ‘auto’ and ‘velo’ e-mobility, but with an important distinction. With an electric car, once the battery runs out cars are immobile, while you can still ride an e-bike without the assistance as you can still ride it as a normal bike, albeit with less ease: ‘I only made it half way’ home ‘before the battery ran out’ as one trial participant reported. The remaining trip is discussed as ‘a looooong cycle back home’. Another participant states that ‘if you run out of battery it’s actually quite hard to cycle’ but also considered that they might have been spoiled by getting used to the assistance. These comments confirm other findings around battery use and range anxiety of e-bike users (Dill and Rose 2012; Jones, Harms, and Heinen 2016).

Feeling judged

Another way of looking at the discussion of how e-velomobility is similar to, but also distinct to velomobility is how e-cyclists feel judged by others who might perceive riding an e-bike as ‘lazy’ or as not ‘proper’ cycling. This is present in reactions that trial participants experienced from other road users, as the following comment in a focus group illustrates: ‘lots of comments about “isn’t it cheating”’. These reactions are often related to a lack of knowledge about e-velomobility: ‘there are a number of people who have that misconception that you just take your feet off and cruise and put it into top gear and away you go kind of thing’. These judgments are sometimes internalised by e-cyclists, especially those who were regular cyclists in the past: ‘in the back of my mind there is always this feeling “you cheated”’. Other qualitative e-bike researchers also report how users have to legitimize themselves against perceptions of cheating (Dill and Rose 2012; Jones, Harms, and Heinen 2016) and how stigma operates around e-cycling (Popovich et al. 2014). This shows how identities operate in the context of e-velomobility, compared to velomobility (Fincham 2007; Skinner and Rosen 2007).

Aldred’s discussion of the role of stigma in relation to cycling identities is highly relevant to the e-cyclist comments above. The UK is one of ‘[t]hose societies socially and spatially dominated by motor vehicles to the detriment of other road users’ and therefore ‘likely to generate essentialised and stigmatised “cyclist” identities’ (Aldred 2012, 253). Aldred’s research shows how problematic cycling identities remain in the UK where cycling is still not seen as ‘normal’ (252). E-cyclists are part of these problematic and stigmatized UK cycling identity processes. However, e-cyclists are not the only kinds of cyclists that are ‘othered’ by cyclists. Rather, the culture of othering and stigmatising operates not only between cyclists and motorised traffic, but also between cyclists: ‘Cyclists drew boundaries around “who counts” as a cyclist, drawing or breaking links with others who cycle, and making moral judgements (e.g. labelling as “risky”) about other cyclists’ behaviour’ (268). Othering of e-velomobility by cyclists as ‘cheating’ is part of this culture. This aspect might be amplified in a context where e-velomobility is still an emerging aspect of cycling culture, rather than part of the mainstream, such as in some other EU countries, though it does exist in those countries too. E-cyclists could therefore be understood to have a double stigma, from car users and from non-assisted cyclists.

Aldred explains ‘cyclists are expected to power their vehicle themselves, with “getting there under your own steam” defined as an intrinsic part of the practice of cycling’ whereas this is not part of car
culture (Aldred 2012, 260). Specifically, ‘[u]sers of motor vehicles are not expected to exert themselves physically, and the power source is separate from the person guiding the vehicle’ (260). However, this definition of cycling is challenged by e-velomobility where a combination of ‘own steam’ and a power source and motor external to the cyclist’s body propel the rider.

**Cost**

For the UK experience of e-velomobility, the perceived high cost of the initial purchase price of an e-bike is a major barrier for the uptake of this mode of transport (Cairns et al. 2017). One trial participant summarizes this common sentiment as follows:

> At £1700 I couldn’t afford to buy that. Do I think it’s good? I think it’s great because I think it makes you think you can go to certain places that you perhaps wouldn’t on a normal bike you know if you’re not feeling too energetic and it still requires you to exercise which is good.

The negative role of the perceived high purchase price of e-bikes is confirmed by other UK e-bike research (Jones, Harms, and Heinen 2016). In Brighton, several trial participants compared the purchase cost to that of a moped, vespa or used car (not considering the running cost). An electrically assisted bike is much cheaper than an electric car (and has much lower running costs), but it has a much higher price tag than the average bike purchase cost in the UK. While in many other countries in the EU (e.g. Netherlands or Germany), bike prices in the lower thousands are very much socially accepted (for both traditional and e-bikes), the UK is an example of a country where investments in bikes are expected to be in the low hundreds. Combined with the increasingly difficult financial situation for many UK residents, the purchase of an e-bike is out of reach for many who are attracted to this mode of transport. This is especially pertinent in the context of the financial incentives used to stimulate electric car uptake, as discussed earlier.

**Discussion and conclusion**

This article developed the concept of e-velomobility, covering practices, systems and technologies of e-cycling, specifically around electrically-assisted cycling where velomobility’s pedal-power combines with e-mobility’s (optional) electrical assistance to propel the rider.

This article also reported the results of a UK research project to show how e-velomobility was experienced by trial participants. The e-bike users reflected on the way they experienced the distinct nature of e-cycling in terms of a complex interplay of bodies, bicycles, batteries, motors, physical environment as well as social and cultural context. The accounts showed how the combination of leg and battery-powered mobility is central to the embodied experience. The active, physical movement that is key to velomobility (Koglin and Rye 2014) as well as cyclists’ identity negotiations around safety and confidence (Aldred 2012) are experienced differently by users of electrically-assisted bicycles.

The research material showed how e-velomobility experience features aspects of ordinary cycling, but also aspects of driving electric vehicles such as cars, for examples in terms of engaging with the battery charging and issues such as range anxiety, also confirmed by the literature (Dill and Rose 2012; Franke et al. 2012; Jones, Harms, and Heinen 2016).

Participants reported how they felt judged by others, confirming other research that also reports how e-bike users can feel stigmatized (Popovich et al. 2014) and how they have to legitimize themselves against perceptions of cheating (Dill and Rose 2012; Jones, Harms, and Heinen 2016). Interestingly, the research material showed how e-cyclists could be understood to have a double stigma, having to legitimize themselves in both relation to car users (that perceive them as cyclists) and in relation to non-assisted cyclists (who often perceive them as ‘cheating’).

The cost of e-bikes is perceived as a major barrier to ownership, an important aspect of contemporary e-velomobility in the UK, as confirmed by other research (Jones, Harms, and Heinen 2016). Overall,
drawing on the empirical material and the literature, this article has demonstrated how e-velomobility emerges as a distinct form of e-mobility.

E-velomobility extends work around velomobility, including Horton, Rosen, and Cox’s (2007, 10) discussion of how a cycling-perspective towards engaging with bodies and communities as well as the pace and scale of cycling presents an alternative way of considering our global future and sustainable transport solutions. The on-board battery and motor of e-bikes make these important aspects of cycling available to more people and for more types of journeys. This then allows e-velomobility to sit alongside, or even amplify ‘velomobility […] [as] important component of a socially and environmentally sustainable future’ (Walks, Siemiatycki, and Smith 2015, 237). However, traditional definitions of cycling are also challenged by e-velomobility because it features a combination of ‘own steam’ and a power source plus motor external to the cyclist’s body to propel the rider.

The term electric mobility (e-mobility) covers types of mobility that involve vehicles that rely on an electric motor for at least some of their propulsion. This article has shown how the mainstream use of the term e-mobility conflates it with e-automobility so that ‘e-vehicles’ become largely synonymous with ‘electric-cars’ (Dijk, Orsato, and Kemp 2013; Kemp et al. 2010; Leurent and Windisch 2011). Most discourses and policies around e-mobility could therefore be understood as extensions of automobile culture. This article has also demonstrated how this translates into e-mobility budgets (for economic, regulatory, persuasive and organizational instruments) that are almost entirely about e-cars and hardly consider other forms of e-mobility such as e-velomobility. This is in stark contrast to the fact that e-mobility’s ‘growth has been particularly rapid in the non-car segment, including pedelecs, three-wheelers, e-bikes and e-scooters’ (Rode et al. 2014, 30).

This article argues for a more diverse understanding of electric mobility, challenging the conflation of e-mobility and automobility. Returning to its basic definition, this more diverse understanding of e-mobility would consider a wide range of forms of mobility that involve vehicles that rely on an electric motor for at least some of their propulsion. This variety would cover a diversity of e-mobilities in terms of the size, price and ownership models of vehicles, of how many people (and/or how much load) can be carried, how many wheels the vehicle has, in terms of the relation of physical and assisted propulsion required, etc.

It is this last point that requires a distinction – into (a) forms of e-mobility where at least some propulsion comes from the user’s body, requiring some physical activity and (b) forms of e-mobility where no physical activity of the user is needed to propel the vehicle. While there is more of a continuum than a rigid division between both – for example, public transport (including electric vehicles) often requires users to walk to and from the stops/stations – the distinction is important in terms of physical activity and health implications. There are forms of e-mobility that can be understood as active transport, while others are much less so. I would therefore like to introduce the term of active e-mobility where at least some propulsion comes from the user’s body – requiring some physical activity – in combination with (optional) propulsion from an electric motor. E-velomobility is one example of active e-mobility. Other examples could include electrically-assisted kick scooters, skateboards, wheelchairs and any other form of mobility that combines an optional electric motor with wheels and some physical activity. These active modes of e-mobility tend to consume significantly less electricity than electric cars (making them more environmentally sustainable), deliver health benefits by being more active (making them more socially sustainable) and have lower purchase costs for the consumer (making them more economically sustainable).

E-velomobility, as discussed in this paper, is as an example of active e-mobility with relatively high user uptake compared to other active modes of e-mobility. Compared to electric cars, e-bikes consume less energy, are a more affordable mode of transport and have potential health benefits. Compared to ‘traditional’ cycling, e-cycling might appeal to those not currently interested in cycling (much) or encourage existing cyclists to cycle more (Cairns et al. 2017). It becomes clear that increasing the uptake of e-velomobility would help towards multiple policy goals such as health, sustainable and active transport, and business innovation. However, despite their much lower cost compared to electric cars, the
purchase price of an electrically-assisted bike is still higher than a traditional bicycle and puts it out of reach for many who would use one and benefit from shifting their transport towards e-velomobility. Therefore, we need a change in policy support for e-mobility – shifting from a focus on cars towards understanding e-mobility as a diverse concept. The budgets for economic, regulatory, suasive and organizational instruments should support a range of e-mobilities, including active modes such as e-velomobility.

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