Journal of Transport Geography 56 (2016) 157–164

Contents lists available at ScienceDirect

Journal of Transport Geography

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

Why cycling matters for Smart Cities. Internet of Bicycles for Intelligent Transport

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ARTICLE INFO

Article history:
Received 17 February 2016
Received in revised form 8 July 2016
Accepted 26 August 2016
Available online 25 September 2016

Keywords:
Smart Cities
Cycling
Sustainable Transport
Mobility
Intelligent Transport
Internet of Things

ABSTRACT

This article develops the concept of "smart velomobility" that is concerned with networked practices, systems and technologies of cycling. The concept draws on velomobility, Smart Mobility/Intelligent Transport Systems (ITS), Smart Cities and the Internet of Things (IoT). The article presents results from an empirical study, where 80 riders of a networked fleet of e-bikes discuss their experience of smart velomobility. The results show how digital and physical mobilities merge, the way riders of the networked fleet interact with the data, how they share the data and how they feel tracked (privacy). The conclusion sketches out future research of "smart velomobilities" and also points out the policy and innovation potential of cycling as active, sustainable and networked mode of transport in the context of Smart Cities and the Internet of Things.

1. Introduction

The areas of Smart Cities and the Internet of Things (IoT) are key areas of growth and attention for industry, policy and research. They are also of key importance for transport and mobility, illustrated by the applications of these technologies for intelligent transport and smart mobility (European Commission, n.d.; Greengard, 2015). However, cycling has not featured prominently in these developments (e.g. the European Commission's staff working document on IoT includes a section titled "Automated Driving/Smart Mobility" that does not reference cycling while "bike helmet" is the only reference to cycling in the entire document, see European Commission, 2016).

Compared to many other smart modes of transport such as intelligent cars, cycling is an important sustainable and active mode of transport. Many international bodies such as the European Commission acknowledge the positive effects of cycling, especially for public health and the environment (European Comission, 2015). There is also a growing body of research highlighting the diverse benefits of cycling for individuals and society (e.g. Fishman, 2016). Despite the multiple proven benefits of cycling, in most countries it remains marginalised compared to other modes of transport. Also, the majority of research and policies around cycling regard it as an offline activity and do not consider the networked aspects or the intelligent transport potential of velomobility sufficiently, as this article will show.

The first aim of this article is to combine the perspectives of cycling with Smart Cities and the Internet of Things to show the importance of cycling for smart mobility and intelligent transport (and vice versa). Based on this, and as part of the first aim, the article develops the concept of "smart velomobility" that is concerned with networked practices, systems and technologies of cycling.

The second aim of this article is to understand the lived experience of smart velomobility. The analysis of the empirical material therefore specifically focuses on how riders of a networked fleet of e-bikes discuss their networked practices of smart velomobility.

The article begins by drawing on literature on velomobility, smart mobility/intelligent transport, Smart Cities, apps and the datafication of cycling, smart bikes as Internet of Things, and the "code/space" model to develop the concept of smart velomobility. Next, it explains the method for gathering and analyzing empirical material from 80 commuters using electrically-assisted bicycles (also called "e-bikes") with a "smart" on-bike monitoring system in Brighton (UK). Then, the article reports the results. The discussion and conclusion suggests a future research agenda for smart velomobility and discusses its potential for policy and innovation.

2. Towards smart velomobility

2.1. Velomobility

The term velomobility (also often spelled "vélomobility") relates to research around cycling and mobility that happens by bicycle. For Horten, Rosen and Cox, velomobility describes their '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 et al., 2007). Recent research around

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http://dx.doi.org/10.1016/j.jtrangeo.2016.08.018
0966-6923/

velomobilities and cycling has been summarised (Fishman, 2016; Furness, 2010, 2007; Goodwin, 2013; McIlvenny, 2013a, p. 5), and considers, amongst others, embodied and multi-sensory aspects (Jungnickel and Aldred, 2014; Spinney, 2009), the arrangements of bodies and bicycles in group rides (McIlvenny, 2013a, 2013b), identity (Aldred, 2012), gender (Clarsen, 2014; Mackintosh and Norcliffe, 2007), touring (Pesses, 2010) and electrically-assisted cycling (Behrendt, 2016; Fishman and Cherry, 2015).

Koglin shows how bicycles are marginalised in transport planning in terms of physical infrastructure etc. in many places. He develops 'velomobility as a theoretical tool can help us to understand the complexity of cycling through the city and which power relations are connected to the politics of transport planning' (Koglin, 2015: 574). Drawing in this, velomobility can also help us to understand the power relationships of cycling in Smart Cities, and the politics of using intelligent technologies in transport planning with regards to different forms of mobility. Historically, in many Western (and non-Western) countries and cities, a modernist approach 'lead to power relations that favour the motorised traffic and thus marginalised bicycle traffic' (Koglin, 2015: 576). This trend seems to continue with today's ICT development around mobility, as I argue below. For example, if physical spaces often exclude cyclists (Koglin and Rye, 2014: 215), the same is increasingly true for digital spaces, and for code/spaces that merge both physical and digital aspects (see Section 2.4). While this article is not about transport planning, it does call for the inclusion of cycling in Smart City and intelligent transport planning.

Koglin and Rye's analysis draws out four key aspects of the 'politics of vélomobility', and this article argues that all of them are also relevant for digital/networked developments: First, the '[p]hysical movement from A to B' that concerns 'infrastructure for bicycling without obstacles and the creation of free and safe flow for cyclists' (Koglin and Rye, 2014: 220). Getting from A–B, physical movement and issues of infrastructure are no longer only about physical infrastructure, but also about digital/intelligent/smart infrastructure. Second, the '[p]ower relations in urban traffic space' that need to consider 'power relations between the different groups that share the urban traffic space and creating spaces where cycling is not marginalised' (Koglin and Rye, 2014: 220). Power relations might be reinforced if cycling is regarded as offline. Third is the '[*p*]ositive representations of bicycling' that entails 'a representation that is adapted and targeted to different groups of people and that creates a shared meaning of bicycling' (Koglin and Rye, 2014: 220). Representations of cycling should therefore also include smart/intelligent aspects. Fourth is the '[e]veryday practice and the experience of cycling' where 'infrastructure and bicycle planning must involve aspects of everyday life in order to make the cycling experience more pleasant' and easier (Koglin and Rye, 2014: 220). The experience and practice of cycling is different in the context of smart/intelligent technologies. This article touches on all four aspects, while the empirical material presented largely focuses on the fourth and last aspect by exploring the networked practices and experiences of cycling.

2.2. Smart Mobility, Intelligent Transport, Smart Cities and Internet of Things

"Intelligent transport", or Intelligent Transport Systems (ITS) concerns the use of networked technologies for transport, while intelligent transport geography (Pangbourne and Alvanides, 2014) focuses especially on the use of geospatial technologies. "Smart Mobility" is concerned with the same technologies, but tends to have a broader and more critical perspective on the use, experience and politics emerging around them. Despite some differences in approach, the terms intelligent transport and smart mobility are often used interchangeably, especially in the policy and industry context.

Within mobility studies, "smart mobilities" are explored with regards to networked people, things and environments. Büscher et al. hope that future "smart mobility" will entail 'producing, sharing and collaboratively analyzing mobility data, utilizing computation that non-experts can make palpable' and 'where technologies augment human reasoning about, and control of, the mobile society people enact everyday' (Büscher et al., 2012: 146) with the potential for surveillance and control as the flipside of the coin.

"Smart Mobility" is also described by Elliot and Urry's "Digital networks" scenario (one of their four scenarios for future mobilities) that features new products and services, many based on "smart" software (Elliot and Urry, 2010: 147–150). The authors consider that '[*w*]e may thus be close to a tipping point where personal vehicles come to be combined with a "smart" infrastructure so as to develop an integrated network system rather than a series of separate vehicles' (Elliot and Urry, 2010: 147). The "digital" aspect of this scenario pertains to the 'network system' of vehicles that would be 'integrated into networks of physical *and* virtual access' (Elliot and Urry, 2010: 147) [emphasis in the original]. Transport mobility is often understood as being concerned with physical access and mobile objects whereas virtual access and mobility is used for activities that replace physical travel, e.g. videoconferencing. Elliot und Urry's scenario highlights how virtual access and physical access are becoming an equally important aspect of mobility. Rather than conceptualising transport as mobile physical objects, the focus is now on the networked aspect of the convergence of physical and digital networks.

Civil liberties are a key concern in this scenario as it relies upon the real-time sharing of large quantities of personal data as 'people and their movements become recorded and classified' and 'system[*s*] of tracking and tracing will involve noticeable changes to the very fabric of social live, freedom of movement and lifestyles' (Elliot and Urry, 2010: 149–150).

The Internet of Things, often abbreviated as IoT, is an emerging concept around networked devices and people (e.g. smartphones) plus networked objects. The Internet of Things consists of large numbers of networked objects that 'become information and communication technologies as well as physical objects' (Dutton, 2014: 2). IoT technologies allow 'physical objects to store, send or receive information in ways that could transform the way we do things' (Dutton, 2014: 2) with key concerns around the sharing and ownership of data (Dutton, 2014: 9).

Smart Cities can be regarded as 'places where information technology is combined with infrastructure, architecture, everyday objects, and even our bodies to address social, economic, and environmental problems' (Townsend, 2013: 15). Gil-Garcia et al. (2015: 97) provide a useful overview of definitions and conceptualization of "Smart Cities" and propose that a holistic 'conceptualization of smart city needs to include, at its base, technology, management, and policy components'.

There is a close relationship between Smart Cities, the Internet of Things and Intelligent Transport as all three concepts rely on the increasing use and experience of networked and sensor technologies. Put simply, the Smart City tends to focus on the overall urban environment and infrastructure, while the Internet of Things is more concerned with the physical items that make up these networked environments. Intelligent transport is a key application scenario for both (see for example European Commission, n.d.). Technology, citizens and policy are equally important in all three, but technology is often presented as the dominant force by policy and literature. Across these concepts, cars and public transport are the key areas of commercial and academic interest with regards to the domain of transport – for example, autonomous vehicles such as driverless cars (Burns, 2013; Greengard, 2015: 167ff) – with cycling receiving very little attention from industry, policy and the academy.

The ease of measuring other modes of transport compared to cycling might further amplify the marginalisation of cycling in the context of Smart Cities and intelligent transport. Those modes of transport currently more dominant in most cultures especially cars, and to a lesser extend public transport, have seen more investment into making them smart and intelligent, for example through (real-time) data collection (GPS, 4G, smartcards) and traffic monitoring/routing systems. Their on-board power facilitates the (often power-hungry) sensors and networked technologies needed for this. In contrast, cycling remains a