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Smart cycling futures: Charting a new terrain and moving towards a research agenda

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ABSTRACT

The future of cycling is about to change. At least, this is apparent if we are to believe the multitude of innovators, start-ups, incumbent industries, policy actors and consultants proposing to harness the power of digital techniques to improve and transform cycling experiences, infrastructures, and gadgets. This 'smartification of cycling' is a phenomenon that is increasingly attracting attention and a variety of interests, fuelled both by the processes of transitioning to smart mobility and a boom of attention to cycling in cities worldwide. However, proposed cycling futures, both implicit and explicit, receive little critical scrutiny. Here, we fill this gap by mapping smart cycling innovations and their key features. We examine how innovations are believed to change the way cycling is practiced, made sense of and governed. Using a constructivist grounded theory approach, we analyse 86 website texts of smart cycling innovations and systematically outline changes envisioned by innovators. Having identified tensions between and within a range of promised futures, we conclude that smart cycling futures are multiple and contested, just as cycling *presents* are. Therefore, we propose a number of questions for further research to advance a more nuanced understanding of the range of futures of smart cycling in academic thinking and potentially to support decision-making at different levels of governance. Understanding diverse, contested, embodied and embedded cycling presents is part and parcel of imagining and co-creating (smart) cycling futures.

1. Introduction

> We want to effectively incorporate cycling into connected and smart transport networks of the future. Smart cities will be driven by technology, which, if properly implemented, has the power to introduce a behavioural change. Such change is needed for the widespread adoption of new concepts and smarter and cleaner modes of transport, such as bike sharing schemes and multimodal integration.
>
> - Bulc, 2016, European Commissioner for Transport.

Cycling experiences a boom of attention from policy-makers and scholars across the world (Fishman, 2016). The same can be said about the 'smartification' of mobility (Manders et al., 2018). The latter is increasingly imagined as a seamless service whereby the customary distinctions between public/private and collective/individual start to disappear, e.g. through the mobility-as-a-service paradigm (Docherty et al., 2017). While currently most hype is centred on driverless vehicles, smart cycling technologies are also attracting interest from communities, businesses and decision-makers, at urban, national and transnational governance levels. These innovations can potentially alter how cycling is experienced, understood and governed. Arguably, the specificities of cycling as a distinct – strongly embodied, highly interactive – mode of transport call for more sensitivity towards these kinds of questions than other modes (Larsen, 2014; Vivanco, 2013; Te Brömmelstroet et al., 2017).

Smartification of cycling is a phenomenon that attracts interest both of stakeholders traditionally interested in cycling, as well as new communities, organisations and industries, with potential for new alliances emerging around narratives of smart technology, liveability and environmentalism. A variety of smart cycling devices, such as connected helmets, connected bicycles, smart glasses and other accessories,

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enter the production phase supported by enthusiastic funders on platforms such as Kickstarter and Indiegogo. These developments might challenge Behrendt's observation that cycling is still mainly perceived in mainstream transport planning policies as an "offline activity" (Behrendt, 2016, p. 157). We argue that in order to understand the mechanisms and impacts of these possible changes we need to better understand the diverse landscape of innovations developed, supported and promoted by individuals, companies, and state and non-state actors.

Smart cycling innovations as of yet have not been systematically reviewed and their potential role in future mobility systems has not been thoroughly discussed. Studies that focus specifically on smart cycling innovations in transport geography are scarce (exceptions are Behrendt, 2016; Schwanen, 2015; Spinney and Lin, 2018). 'Smartification' of cycling has been indirectly addressed in methodological discussions on the use of GPS-tracking data to study route choice, for example (see an overview in Chen et al., 2018). Additionally, reviews of the role of information and communication technologies (ICT) in (transitions to more sustainable) mobility have discussed ICT developments in cycling. These studies mention technologies that facilitate the use of bike-shares and their applications that gather cycling data both for individual (motivational) use and for infrastructure and policy development (Banister and Stead, 2004; Gössling, 2018; Sunio and Schmöcker, 2017; Witlox, 2015). Additionally, Behrendt (2016) has argued for more focused attention to be paid to 'smart velomobility' in light of the benefits of cycling and its supposed marginalisation in smart cities discourses.

In this paper we map and analyse the landscape of smart cycling innovation and identify its key features: what does it say about the imaginaries of the futures of smart cycling and about how mobility presents are contested or maintained? If we are to engage with smart cycling futures, we need to understand where we are (not) going, and perhaps more importantly: what and where we are departing from. This will increase our awareness of what is being sold, which will allow us to reflect on its desirability and potential negative externalities, instead of sleepwalking into them.

The questions leading our mapping and analysis are: What kind of ideas about cycling, cyclists and cycling environments are brought to the fore by individuals and companies that produce and promote smart cycling innovations? How do they give meaning to/make sense of smart cycling? What is emphasized and what stays in the shadows?

Below, we first introduce the theoretical background of the research, drawing on mobilities research and science and technology studies, and explain the methodology of the study. We then proceed to discuss our findings, organized around seven themes that emerged from the analysis: the bicycle; the relationship between the cyclist and the bicycle; the relationship between the cyclist and social environment; the relationship between cyclists and spatial environment; the experience and meaning of cycling; governing cycling; the cyclist: identities and lifestyles. In the concluding section of the paper we discuss the key directions for future research and the limitations of the study.

2. Theoretical embedding

2.1. Meanings of mobility

We draw on research that emphasizes the meanings of mobility, most notably Cresswell (2001, 2006), Adey (2010). According to Creswell (Ibid), mobility is an entanglement of physical movement, meaning and practice. Our interest here is mainly in the meanings of mobility that can be conveyed through representations of movement in texts and imagery and are important to consider since they "can shape social relationships, and … alter the way we think about and act towards them" (Adey, 2010, p. 38). Meanings, or "ideological codings" (Adey, 2010), of mobility thus both *reflect* attitudes towards particular social practices in specific contexts and *shape* those practices, contributing to the production of relationships between people, places and things (Adey, 2010, p. 82; Cresswell, 2001, p. 20). Since mobilities are always "produced and given meaning within the relations of power" (Cresswell, ibid), they are differentiated along the lines of gender, class, ethnicity, and so forth. While in terms of mobility practices, this means that some groups may be enabled to move faster or more comfortably than others, in terms of meaning, some mobilities may be deemed as desirable, modern or ethical while others as dangerous, shameful or criminal. While positive representations may lead to investment in particular types of infrastructures and facilitate particular mobilities, negative perceptions may lead to exclusion of particular groups, violence against certain mobile subjects or failure to account for particular needs in policy and planning. How mobile subjects are imagined is thus crucial in understanding 'the politics of mobile futures' as these imaginaries 'may subsequently become normalized as narratives, knowledges, strategies and interventions that reshape the conditions of everyday life for the future of these imagined citizens' (Jensen and Richardson, 2007, p.138). Following this, it is crucial to interrogate representations of cyclists and cycling in innovation discourses.

2.2. Scripts of innovations

Our research is informed by the ways of thinking about innovations (or any deliberately designed objects) introduced by science and technology studies. In particular, we use the notion of "script" (Akrich, 1992; see also Cox, 2017) – a set of presumptions about how an object should be used as well as a set of implicit assumptions about the world in which this object would work. Every designed object carries such "script" and with it also a vision of the world, however implicit this may be. As such, "…technical objects have political strength. They may change social relations, but they also stabilize, naturalize, depoliticize, and translate these into other media" (ibid, p. 222), or – to paraphrase Latour (1990) – technology is politics made durable. As an illustration of how design shapes social relationships, Yaneva (2009) describes how staircases, elevators and conference room arrangements enable "the university order, academic collaboration, collegiality and educational philosophy" rather than merely reflect it (p. 282), making particular relationships between people, things and places possible, pleasant, durable, or, on the contrary, difficult and fragile. Though, Akrich points out, it is possible that the scenarios mediated by the objects, and thus the worlds "inscribed" in them, are rejected or contested by users, she nevertheless maintains that "it is likely that the script will become a major element for interpreting interaction between the object and its users" (Akrich, 1992, p. 216).

Adopting this perspective, we thus argue that through analyzing descriptions of innovations as written by designers and marketers, we can reconstruct the worlds that these innovations presuppose is existing or should be existing, and by doing that we gain insight in the connections between people, places and things that these innovations deem desirable. Focus on the textual representations of innovations is just one possibility as the "script" can also be reconstructed through engaging with the object and its use, interviewing designers etc. Focus on descriptions of innovations, however, allows us to cover a much broader scope of innovations than any other methods would afford.

3. Methodology

The novelty of the subject and the goal to explore the meanings of smart cycling innovations led us to choose the constructivist grounded theory (Charmaz, 2006) that builds on Strauss and Corbin (1998). Grounded theory methodology, despite some variations, can be broadly defined by an inductive orientation and the goal to develop theory from the data rather than apply theory to the data. Grounded theory is generally considered suitable when exploring new research avenues. The novelty of the subject, our focus on the production of meanings and the aim to develop questions for further research make this approach a

good fit.

We emphasize three features of this approach. First, the constructivist approach to grounded theory methodology emphasizes the constructed nature of knowledge (as opposed to the idea of a pre-existing objective truth to be found in the data[1]). Second, another distinct feature of this approach is that theorisation is seen as a process of interpretation, with an emphasis on "*understanding* rather than explanation" (Charmaz, 2006, p. 126). This implies that the end product of the analysis is an understanding – one of many possible – of a particular phenomenon or process, rather than an explanatory framework (Ibid). Third, pre-existing literatures and theoretical frameworks can be used by researchers both prior to research to help them shape questions, and at the final stage of theory development to see if "the literature can be used to confirm findings" or, on the opposite, if findings extend or correct existing understandings (Strauss and Corbin, 1998, p. 38). These do not have to be the same bodies of literatures, as 'following' the data means that concepts and frameworks not considered at the beginning of the research may become relevant in the concluding phase. Following these considerations, in this paper we first construct a landscape of different meanings of smart cycling futures through inductive analysis of our empirical material. Second, we relate the results to existing frameworks.

For the purposes of our paper, we focused on innovations using ICT or Internet of Things (IoT) solutions in cycling, ranging from ICT-enabled cycling gadgets and connected bikes to digitally enhanced cycling environments. This methodological choice makes us exclude other, potentially relevant cycling innovations, and in particular electrically-assisted cycling (e-bikes). There is extensive academic and societal debate about differences in techniques, the potential changes in the geographical range of cycling (e.g. Plazier et al., 2017a) and in the range of the target population (e.g. Plazier et al., 2017b; de Kruijf et al., 2018). In the Netherlands e-bikes are a mainstream part of the bicycle portfolio (in 2018, 40% of bicycles sold are e-bikes[2]). In our view, excluding this from our analysis on mobility futures is justified because of this already ongoing debate and its manifestation in parts within mainstream cycling presents, typified even as 'the new normal' by some.[3]

Following the distinct approach of grounded theory methodology to sampling as discussed by Charmaz (2006, Ch.5), we began with broad scanning of the landscape of cycling innovation in the initial sampling stage. We 'followed' a variety of cycling-related accounts communities, blogs, organisations and companies on Twitter and Facebook, checking our news feeds every day. In addition, we did a systematic search on social media every other day over the course of one and half year (January 2016–June 2017) using search terms "smart" AND "cycling" and "cycling" AND "innovation". Innovations discussed or promoted on social media often were linked to crowdfunding platforms Indiegogo and Kickstarter, where we also conducted periodic searches using the above search terms. As this research is embedded in a larger transdisciplinary consortium, *Smart Cycling Futures*, we are part of a professional network in the Netherlands through which newsletters and updates on cycling innovation in the Netherlands as well as abroad are circulated. Regular discussions within the above-mentioned network as well as presentations at national and international cycling community events helped cross-check our list. In accordance with the goal of the paper, we aimed to cover a spectrum of ICT and IoT mediated solutions to urban mobility issues that involve cycling and thus achieve some diversity of kinds of innovations.

We used standard coding techniques, such as initial coding and focused coding (Charmaz, 2006), having performed about 3500 coding operations. We inductively created 1045 codes in the initial coding phase, which we aggregated into seven key *themes* in the focused coding. These themes are seven types of changes in how cycling can be experienced, given meaning to and organized, according to innovators. Most themes are aggregations of multiple *categories* – distinct kinds of change within a theme. For an overview see Table 1.

As we began coding the first texts, we also continued the selection which – following the logic of the grounded theory methodology (see Charmaz, 2006, pp. 96–116) – was increasingly guided by theoretical sampling. We started to identify codes that led us to constructing broader, more abstract categories and themes. To give one example, a category "technology mediating human-to-human interaction" and a category "mobile collectivities" as well as other codes related to impact of innovations on social interactions led us to suggest that we were observing possible changes in the *relationship between the cyclist and social environment*. The latter became a theme, within which we then explored further and sought possible new categorial variations through sampling.[4]

When no new codes emerged that significantly altered the developed framework of seven themes (Table 1), we achieved what Dey (1999) calls "theoretical sufficiency" (a concept, in his opinion more fitting to a grounded theory study than "saturation"). As such, we collected and analysed texts by the developers of 86 innovations. For pragmatic reasons, data collection focused on press and social media in English, Dutch and Danish. While this approach has its limitations, it allows us to start reflecting on how smart cycling futures may be articulated and enacted differently across geographies, and particularly start to identify differences between mature cycling environments (the Netherlands and Denmark) and those where cycling represents a minor share of the modal split (for instance, the UK, the USA, France and others)[5]. This paper presents the first and the most comprehensive overview of IoT and ICT cycling innovations to date and, as such, we believe, it provides sufficient data for the goal of articulating a research agenda on smart cycling.

For the purposes of this paper we first focus on the general tendencies and observations across the entire dataset and, to a lesser extent, on the differences between two groups of innovations: those developed in and for "mature" cycling environments and those developed in and for environments where cycling represents only a marginal share of the modal split. Differences were noted early on in the open coding stage and, in a move characteristic of the grounded theory methodology, we decided to pay closer attention to these differences. It was not possible to split the dataset neatly into two subsets of data as some texts were targeting both contexts and some innovations were developed in translocal collaborations. Yet, we recorded the differences and we point to them in the analysis where appropriate.

[1] For the discussion of this and other key distinctions between grounded theory traditions see e.g. Heath and Cowley, 2004.

[2] According to RAI, the Dutch branch organisation of bicycle industry, see RAI Verenigning (2019).

[3] According to Verkeersnet (Dutch online platform for transport knowledge). See Rottier (2019).

[4] Of course, any such suggestion only remains in play insofar it can be grounded in data through coding. The continuous interplay between inductive (dominant) and deductive (supporting) logics is fundamental to theoretical sampling and thus constructivist grounded theory analysis. As it is impossible to communicate the whole process of such interplay even for a single category, we refer the reader to the discussion of the principles of such processes in Charmaz (2006, pp. 104-105).

[5] The Netherlands and Denmark are neither identical nor internally homogeneous in terms of cycling rates, cycling culture and infrastructure provision. Also, there are places with higher rates of cycling in non-cycling countries. Yet, this distinction clearly emerged in our analysis, and it helps illustrate the differences in aspirations of innovators depending on which context they address.

Table 1
Overview of themes, categories and innovations.

Theme	Categories	Innovations
1. The bicycle	Simplicity and connectedness	*Linka, Mobilock, Smart Halo, VanMoof Electrified S, Hexagon, Linkalock, Brightspark, Blubel, Sherlock, Student Bike*
2. The relationship between the cyclist and the bicycle	From owning to using a bicycle	*HonorCycles, Urbee, Student-Bike, Bikeshare 050, Student bike, Mobilock, Urbee, Yobike*
	A deeply personal relationship	*SmartHalo, LINKA, Wink Bar, VanMoof Electrified S, Lyra*
3. The relationship between the cyclist and social environment	Technology mediating or replacing human-to-human interaction	*Smart Jacket, Blinkers, Goledbag, Blinkers Light Up your Mood, Cloudfietsenstalling, Hexagon, Sena X1, Solos glasses, the Social Light*
	Connectedness and mobile collectivities	*SmartHalo, LINX Smart Helmet, Project Jacquard, Blubel, Nachtnet, Sena X1 Helmet, LIVALL, RoadwareZ, XON Ride-1, Electronic Information Boards*
	Empowerment and mobilisation of communities	*BikeBlackspot App, SmartHalo, Blubel, Smart Corridor, Ring-Ring, Lock 8, Brightspark, ICON, RoadwareZ, #endbiketheft, B-Riders*
	Relationships between modes	*Brightspark, Lumos, Hexagon, Livall, Goledbag, Wink Bar, Blinkers, Cyndicate System, VUP Plus Backpack, ICON, Bikescout, Smart Jacket*
4. The relationship between cyclists and spatial environment	Interactive landscape	*Warmtesensor, Groenvoorspeller, Schwung, Spinning Wheels, Flo, Evergreen, Volg Groen, Electronic information boards, P-Route, Bikescout*
	Adaption of cyclists to environment	*Brightspark, Blinkers, WAIR, B-Riders, Groenvoorspeller, Tring-Tring, Sitraffic Sibike, Ring a Bell*
5. Experience and meaning of cycling	Customisation of experiences	*UberEats, P-Route, Sena, Hexagon, SmartHalo, Bikenow, Bicycle Buddy, Flo, Re-Light, Groenvoorspeller, Volg Groen, Evergreen, GoLight Avenue,*
	Non-stop cycling	*Groenvoorspeller, Volg Groen, Evergreen, GoLight Avenue*
	Cycling as a target-driven performance	*SmartHalo, Blubel, Hexagon, Garmin Garla Vision, Livall, Sena, XON-Ride 1*
	Cycling as an experience valuable in itself: exploration and safe adventure	*Fietsy, Smart Corridor, Ring-Ring, Illumilane, Blubel, Gobike, RoadwareZ, LINX Smart Helmet, Garmin Varia Vision, Solos, Wink Bar, Beeline*
6. Governing cycling	Automobilsation of cycling	*Sitraffic SiBike, Volg Groen, GoLight Avenue, Green waves for cyclists, Electronic information boards, P-Route, Cloudfiestenstalling, Mobilock, Blinkers, Brightspark, Livall, Hövding, Hexagon, Lumos*
	Surveillance, data collection and data-driven governance	*Lyra, Sherlock, SmartHalo, VanMoof Electrified S, Lock8, XON Ride-1, RoadwareZ, Green waves for cyclists, Electronic information boards, CyclePRINT, Bikescout, GoLight Avenue, Ring-Ring, Ring a Bell, ICON, BikeLook, LibertyBell, UberEats, Burn Fat not Fuel*
7. Identities and lifestyles	Flexible and smart lifestyles	*Van Moof Electrified S, Livall, Student Bike, TringTring, Beeline, Foodora*
	Elegance, fashion and style	*Brightspark, Van Moof Electrified S, Wink Bar, WAIR, Blubel, Lumos*

4. Results

4.1. Changes in the bicycle: simplicity and connectedness

From the descriptions of “connected” bikes as well as other innovations promising to alter the functions of the bicycle, a composite description of a ‘smartified’ bicycle arises. It is promoted as a combination of the “simplicity” of a “regular” bicycle with promises around the convenience that ICT enhancements offer. The latter often imply a lack of features that supposedly mean extra hassle for the cyclist, such as holding on to one's keys:

> …you no longer have to pull out your keys or fidget with a bulky lock (*LINKA*).

> YoBike is bike-rental made easy. Anytime, anywhere, no docks or fobs. Just tap your phone and go”(Yobike, see also *Urbee*, *Student-Bike*, *Mobilock*).[6]

The connectedness of a bicycle to a smartphone is seen as another key feature that can make any bicycle “smarter” (e.g. *Hexagon*, *SmartHalo*). A smart bicycle encapsulates the negotiation between past and future – retaining the bicycle's traditional simplicity while embracing “simple” and functional smart tech design. Thus, “sleekness”, “simplicity”, “elegance” and “connectedness” are key features of a smartified bicycle (e.g. *VanMoof Electrified S*, *Linkalock*, *Brightspark*, *Blubel*, *Sherlock*). Smart bicycle accessories often offer “seamless” integration into an existing bicycle structure while promising multiplication of functions and possibilities. Thus, the creators of Smart Halo, a device that can be mounted on the steer to provide navigation, lights, anti-theft alarm, fitness goals tracking, call and sms notifications and more, emphasize the minimalist non-obtrusiveness of the design:

> With no visible screws, it is refined yet subtle, as it merges perfectly with any type of bike. This is the smart biking device you've been waiting for. ONE MINIMALIST INTERFACE. INFINITE POSSIBILITIES. SmartHalo's circular interface has been designed to keep you focused on what matters: the road. Simple yet versatile, this luminous halo can guide you around, track your fitness goals and much more. (*SmartHalo*).[7]

4.2. The relationship between the cyclist and the bicycle

Cycling innovations can reconfigure the relationship between the cycling person and the bicycle in subtle or dramatic ways. The

[6] See the Appendix for the alphabetical list of innovations with URLs of webpages from where the texts were retrieved. A number of innovations were in the stage of a pilot or a concept at the moment of coding, and thus the availability of the texts cannot be guaranteed. We have recorded the last valid URL.

[7] Hereinafter the excerpts from the texts are either originally in English or were translated from Dutch or Danish by the authors.

following two categories are particularly prominent in the analysed texts.

4.2.1. From owning to using a bicycle

First, a number of innovations offer a cyclist a relationship with a bicycle in which any issue will be taken care of by a third party, such as a repair service that one can summon using a mobile application (*HonorCycles*) or the provider of the bicycle – a bicycle sharing or a bicycle leasing company (*Urbee*, *Student-Bike*). In the latter case the bicycle can even be replaced by an identical one (*Bikeshare 050*, *Student bike*, *Urbee*). One no longer has to tinker with her bicycle as it becomes an equivalent of Netflix, a *service* rather than a possession (see also Petzer, 2017). A bicycle becomes an interchangeable commodity that somebody else takes care of, whereas an owner is becoming a user or a subscriber, freed from the commitment to take care of the bicycle as "everything is taken care of" (*Urbee,* see also *Yobike*). Furthermore, smart locks expand the fleet of shareable and interchangeable bikes into the realm of owned, personal bicycles: "every bike can be a part of a rental or bike sharing system" (*Mobilock)*. The peculiar materiality of one's personal bicycle ceases to matter.

4.2.2. A deeply personal relationship

Another type of relationship, in particular, but not exclusively, manifested in cycling innovations targeting theft as an issue, presents a contrasting vision of the relationship between the cyclist and the bicycle. It is a deeply *personal* relationship that some innovations promise to mediate and safeguard. The bicycle is "your sacred two-wheeler" (*SmartHalo*) which can "recognize you" as you approach (*LINKA,* see also *Wink Bar*, *VanMoof Electrified S*, *SmartHalo*). The language may presume a special, lived relationship between the cyclist and the bicycle: "Should you become separated, the Lyra's upgradeable GPS system is designed to help reunite you two" (*Lyra*).

4.3. The relationship between the cyclist and social environment

Cycling innovations bear a potential to bring to life, or exclude, particular mobile socialities, encouraging or prohibiting interactions on the move, mediating relations between different modes, challenging or confirming existing hierarchies on the road. While some innovations promise to bring people together or capitalise on already existing or presumably existing communities, others lead to the removal of social transactions.

4.3.1. Technology mediating or replacing human-to-human interaction

A chief goal of a number of innovations is to mediate interaction between traffic participants, either viewed as something functional or as arena of civilised or playful sociality. In the first category we find a variety of devices that help communicate the cyclist's intentions (e.g. to turn, to break) to others (*Smart Jacket, Blinkers, Goledbag, Blinkers*). In the second, we see a number of concepts designed to enhance playfulness and social cohesion, on and beyond the cycle path:

> 'Light Up Your Mood' (LUYM) is a concept that responds to a lack of social contact among foreign students who are living in the Netherlands. It provides the opportunity to feel connected. A part of the bicycle will be lighted with a color. This color communicates a message to its surroundings, depending on the mood of the student. It is a tool to encourage students to travel by bike and interact with others more often. By cycling together, instead of alone, we would like to improve students' experience with cycling. Social connections, trust and fun are the core values of LUYM. (*Light Up your Mood*).

> If you want to say 'thanks' to a driver behind you, you can raise your hand and the jacket shows a 'Thank you' smiley on the back. (*Smart Jacket,* see also *the Social Light*).

Smart cycling technologies also offer possibilities to be in touch with people who are not sharing the road with you. "Ride sharing" – sharing data such as route, photos or videos – are also enabled by some innovations, potentially reconfiguring the sociality and the spatiality of a bike ride that "friends from all parts of the world can view" (*Hexagon*). A ride can be recorded, "re-lived" and shared in improvised social networks:

> For those looking for the complete, all-in-one package, the X1 Pro Helmet option includes a QHD camera on top of the integrated Bluetooth. Equipped with WiFi and built directly into the center of the helmet, the camera allows you to re-live any ride or share your experiences with friends. As long as you are connected to a mobile network you can create private groups, invite your friends to join, and chat with them while using your Sena X1 Helmet. (*Sena X1*, see also *Solos glasses*).

In some cases, technology is supposed to replace human-to-human interaction altogether. One example is through introducing systems of communication that are replacing jobs currently done by humans – which is "costly and time-consuming" – such as the job of a bicycle parking guard (*Cloudfietsenstalling*).

4.3.2. Connectedness and mobile collectivities

A number of texts appeal to the idea of a community that would be created through the use of an innovation. Envisioned communities may be communities of data exchange (*Blubel, RoadwareZ*), but also offline mobile collectivities emerging spontaneously or through collaborative planning (*Nachtnet*):

> I didn't just want to make a slick cycling gadget, I actually wanted to create a community that could engage and communicate together to create safer journeys. And one of the things I kept thinking about is well what if every time someone rang a bell we would be able to use that data to find safer routes. (*Blubel*).

> If cyclists use Nachtnet Fiets [Cycling Night Network] together they increase the feeling of social safety for the users. This increases the chances of meeting a fellow cyclist on Nachtnet Fiets. Moreover, you can arrange to make use of Nachtnet Fiets together. Colleagues, friends, sportsmen that use the same route, can now more easily arrange to bike along. (*Nachtnet*).

Electronic Information Boards in Copenhagen appeal to all cyclists as a mobile collective: "Take care of each other" ("Pas på hinanden").

Being connected while on the move is a promise that a variety of innovations make, yet the supposedly desirable types of connectedness vary. Quite a few innovations offer the possibility to be alerted to and take phone calls while cycling:

> Cyclists often miss important calls because of street noise and vibration. This is the thing of the past with SmartHalo's personal assistant. (*SmartHalo,* see also *LINX Smart Helmet, Project Jacquard*).

Commonly, smart wearables not only offer the possibility to use one's mobile phone with hands on the handlebars but also offer to mediate communication with one's "riding partners" (*Sena X1 Helmet*, see also *LINX Smart Helmet, LIVALL, XON Ride-1)*. As these innovations connected to a smartphone can also stream music, dictate directions and read aloud text messages, they offer a ride that is customized to one's preferences and can keep the cyclist in her own social bubble, connected to her usual contacts, but isolated from her immediate environment.

4.3.3. Empowerment and mobilisation of communities

Some texts explicitly use community rhetoric to mobilise cyclists for broader change in mobility regimes and urban living:

> Together we can build the case for substantial and sustained funding for cycling infrastructure, by reporting potential improvements and

> danger zones in our local areas. (…) Together let's build a better cycle network (*BikeBlackspot App, #endbiketheft)*.

Crowdsourcing knowledge in some cases is framed as more than a pragmatic and cost-efficient solution to data gathering, but as an opportunity to forge community and societal contributions:

> Just by riding your bike, you help designing your city. (*SmartHalo, also* see *Blubel, ICON, B-Riders*).

In two cases, cycling innovation is framed as a way to mobilise community to make a direct monetary contribution to societal goals:

> The app sets regular distance challenges for the community to aim at. Every user's journey along the cycle route contributes to the overall target. If the target is reached a local Isle of Wight charity gets a donation. (*Smart Corridor*, see also *Ring-Ring*).

Especially in the texts from the contexts where cycling is marginal, the idea of a community is evoked in the context of facing a common enemy – usually, the bike thief or a common problem which usually means being or feeling unsafe.

> New in town? Just visiting? It may look OK to park where you are but it may actually be notoriously known for high bike theft. We'll let you know and recommend a safer area for you. (*Lock 8*).

> First and foremost, we are cyclists, just like you. And, just like you, we want to be safer on the road (*Brightspark, see also RoadwareZ)*.

Content focussing on theft and safety plays into a call for community action and cohesion, for building on representative power and perhaps forging one glocal cycling community. In the contexts where cycling is marginal, frustrations with bicycle theft and lack of safety are presented as two major impediments to the "ease" of cycling (an omnipresent term) as an enjoyable social and functional practice and innovation is offered a tool to galvanise and inspire cyclists as a marginalized group.

4.3.4. Relationships between modes

Smart cycling innovations can mediate different types of relationships on the road across the world. In a variety of contexts where cycling is seen as a marginal mode, the major selling point of the innovation is its supposed ability to make one "visible" to others (e.g. *Brightspark*, *Lumos*, *Hexagon*, *Livall*, *Goledbag*). As these solutions are described, what seems to be at stake is not only one's safety, but potentially, empowerment, confidence, and the respect of others: "distinguish yourself" (*Hexagon*); "Even in the darkness you can show up" (*Wink Bar*); "be seen" (*Goledbag*, *Lumos*). The text advertising *Blinkers*, Swiss-developed bike lights that communicate a cyclist's behavior to others, goes as far as to frame this bicycle accessory as *the* solution to cyclists' marginal position on the road:

> Blinkers is the one thing that was missing for cyclists to be safer and to be a natural part of the road. It packs everything you need to be seen, understood and respected by everyone else in the road.
> More respected: A laser semi-circle projected to the ground behind the bicycle makes you even more visible at night and helps other vehicles to understand what is your space on the road. (*Blinkers*).

Such framings place the responsibility for one's safety and empowerment with the cyclists rather than other road users, regulation or empowering infrastructures:

> Brightspark means more than brighter lights – it empowers you to attract the attention of any driver. Even more, car drivers will immediately recognize that there is a vehicle approaching, as the two lights can help them see your width. Brightspark increases your perceived presence and size by projecting laser indicators on your side. This way, pedestrians and drivers are guaranteed to notice you and to be able to better estimate your intentions. (*Brightspark,* see also *Livall*, *Wink Bar, Cyndicate System, VUP Plus Backpack, ICON*).

While we have come across a similar narrative on visibility and safety in the descriptions of Dutch innovations (*Bikescout*, *Smart Jacket*), we have not found the same emphasis on empowerment and respect. Also, the number of innovations targeting this specific problem in the texts coming from "mature" cycling environments is lower. In one case the same issue of the presumed unpredictability of cyclists is proposed to be resolved through informing drivers at crossings about approaching cyclists (*Bikescout*). The responsibility for cyclists' safety in this case lies with the driver, warned by the LED lights in the road surface

4.4. The relationship between cyclists and spatial environment

This theme is particularly prevalent in the set of innovations that target mature cycling contexts, in which cycling infrastructure innovations are more prominent. The scenarios of how interactions with the (usually urban) landscape are unfolding are related to the relationships between modes discussed above.

4.4.1. Interactive landscape

For example, *Warmtesensor* ("*Warmth Sensor*") in Rotterdam is supposed to react to the presence of many cyclists at a crossing and provide green lights to cyclists longer and more frequently. *Groenvoorspeller ("Green Predictor")* and *Schwung ("Dash")* also react to approaching cyclists and extend the green light for them. The *Spinning Wheels* installation in Copenhagen "registers movement" so that "the light 'spins' in the same direction as passing cyclists and pedestrians". The light then "slowly fades out until the next person passes through". Other innovations in contexts where cycling rates are high, such as *Flo*, *Evergreen* and *Volg Groen* in the Netherlands, and green waves in Copenhagen, Denmark, provide a different kind of interaction: the cyclist receives information on how to adjust her speed to catch the green light for one or a number of consecutive traffic lights. *Electronic information boards* in Denmark and *P-Route* in the Netherlands also provide cyclists with information about the traffic situation and the availability of bicycle parking spots, respectively.

4.4.2. Adaption of cyclists to environment

In the texts produced in and for contexts where cycling is marginal, interactions with the landscape often envisage a cyclist trying to temporarily establish her presence in the cityscape, e.g. through using laser projection on the road (*Brightspark, Blinkers*), while the urban landscape hardly reacts to her presence. As discussed above, in the data coming from "mature" cycling environments, the urban landscape is more often interactive, responding to cyclists' movements or presence (e.g. *Warmtesensor*, *Volg Groen*, *Bikescout*).

In both datasets, responses to urban pollution came across as another framing of the relationship between the cyclists and the urban environment. The WAIR scarf, designed in France and meant to protect cyclists from air pollution and gather data on pollution in different parts of the city, is presented as an adaptation to changing urban environment:

> At WAIR, we believe that assisting you, city dwellers, against air pollution is critical. (…)Your environment has changed a lot lately; it is time for your clothes to take the same turn (*WAIR*).

An app designed to accompany the scarf is meant to help cyclists choose cleaner routes: "Discover SUPAIRMAN by WAIR, your best friend in town to ride safely, away from pollution!" (*WAIR*). Similarly, a Dutch innovation *Ring a bell* aims to help cyclists navigate away from polluted areas: the smart bell changes color depending on air quality. Both innovations gather data in order to create more awareness of air pollution, yet they also have a potential to redistribute cyclists in the city, reducing the visibility of cyclists in some areas and increasing it in

others. A number of other texts mention pollution as an important issue, while calling for more cycling as a way to make cities cleaner (*B-Riders, Groenvoorspeller, Tring-Tring, Sitraffic Sibike*). Thus, the cyclist is summoned to become a harbinger of environmental change and to adapt while the change has not yet taken place.

4.5. Experience and meaning of cycling

4.5.1. Customisation of experiences

Smart cycling innovations envisage a variety of supposedly desirable changes in how cycling can be experienced and what it might mean in one's life. The imaginaries of smart cycling vary greatly: from a non-stop commute to an adventure, from a relaxed exploration to a target-focused performance. This sheer diversity underscores another feature of smart cycling that we have identified across different types of innovations and geographical contexts: *customization* of one's cycling experience. Innovations promise to get food delivered from *your* favourite restaurants (*UberEats*), identify spots at *your* favourite parking facility (*P-Route*), play "your favourite music" (*Sena*), "recharge your favourite gadget" (*Hexagon*), and work as "your personal assistant", allowing you to take important calls while cycling (*SmartHalo*). As one is cycling past infrastructure innovations, the ride can be customized to suit one's speed or aesthetic preferences:

> Personal advice. Flo measures your speed and uses it to give you an advice. This way every cyclist receives a personal advice. This improves your chances to catch the green light! (*Flo*, see also *Bikenow)*.

> Every time you cycle through the tunnel, the light turns on. The more often you pass the tunnel, the more colors you can choose! (*Bicycle Buddy*).

> Cyclists can adapt the light level of the adjustable LED lighting alongside the cycle path. Depending on the time of year and weather conditions, cyclists can increase or decrease lighting level as they desire. (*Re-Light*).

We have come across appeals to three major types of cycling as an experience that innovations sought to improve or make possible.

4.5.2. Non-stop cycling

The first type is cycling without stopping or with minimal interruptions. Especially in the Dutch context, cycling without stopping at crossings is presented as a pleasant experience that a cyclist is seeking (*Groenvoorspeller*, *Volg Groen, Evergreen*, *GoLight Avenue*). *Groenvoorspeller* even coins a term for this: "staying in your cycling flow" (in Dutch: "in je 'fietsflow' blijven").

4.5.3. Cycling as a target-driven performance

Another way that cycling is framed is as a form of physical performance, characterised by exertion and challenge:

> Set Goals. Get Fit. Bike Hard. Feel like surpassing yourself? You can set fitness goals in the app and SmartHalo will display your progress in real time, right on your handlebar. (*SmartHalo*).

A number of innovations offer tracking one's "performance" through monitoring health parameters, speed and distance cycled (*Blubel, Hexagon, Garmin Garla Vision, Livall, Sena, XON-Ride 1)*. Cycling here is presented as a focused, target-driven experience while the innovation in question enables maximum information provision on one's performance and minimal distraction from pursuing one's goals.

4.5.4. Cycling as an experience valuable in itself: exploration and safe adventure

The last framing of cycling that we have identified is quite different from the first two: cycling as exploration, adventure and an experience valuable in itself. Thus, some innovations offer cyclists an opportunity to learn more about their natural or cultural environment (*Fietsy, Smart Corridor*) or encourage active exploration made possible by the peculiar pace of cycling (*Ring-Ring*).

While in some texts cycling by itself is presented as pleasant, other innovations suggest improvements to make it even more fun:

> The sensors would activate a series of lights along the path sequentially, following the bicycle, creating a fun and memorable interactive space on a bike lane. (*Illumilane*).

A feature of most of the representations of cycling as an adventure is a certain amount of assistance or guidance. Navigation assistance is a common feature of many innovations (e.g. *Blubel, Gobike, RoadwareZ, LINX Smart Helmet, Garmin Varia Vision, Solos etc*):

> Beeline is a smart compass for your bike. Instead of showing a prescribed route, Beeline strips navigation back to basics by simply showing you the direction to your destination and the distance to go. No rules, no instructions – you're free to pick your own path. (…) Beeline is built for everyday adventuring. After all, where's the fun in being told exactly what to do? Take back control of your ride and explore your city with Beeline. (*Beeline*).

> The Wink is a smart handlebar connected to your smartphone. With the Wink bar you'll never get lost anymore. Thanks to its turn-by-turn navigation system, the Wink bar can guide you through any adventures by the blinking of its lights. (*Wink Bar*).

Adventuring with smartified cycling means being guided while still, presumably, retaining the sense of freedom, autonomy and surprise. Supposedly, unobtrusive navigation assistance removes the last nuisance from the fun and easy ride:

> Inventor/Narrator (female): "Cycling is one of life's joys. It's a fast, free and fun way to get around, and you feel so free…."
> Female cyclist 1 "I just love the way you feel when you're biking, with the wind in your face and you feel so free".
> Narrator: But finding you way from A to B hasn't always been easy.
> Female cyclist: "I remember the first time I went cycling to a new job and just I got lost and, and it was just so embarrassing …I had to get off my bike and check where I was going. (*Blubel*, video transcript).

Smart cycling is a safe, carefully monitored adventure, or an engineered challenge with smart technology amplifying the existing pleasures of cycling, while removing the challenges that are supposedly hindering the experience.

4.6. Governing cycling

In this theme we included categories that represent profound systemic changes in how cycling can be organized and governed as a mobility mode.

4.6.1. Automobilisation of cycling

A key change that smart technology promises to bring to cycling is granting cyclists with the similar possibilities and privileges that drivers already have. This has the potential to profoundly change the nature of cycling as a mode, the rights of cyclists, and possibly their responsibilities. The automobility system may openly be mentioned in such texts or the word choice may allude to the language associated with driving. For example, the German mobile application Sitraffic SiBike offers "green waves" to cyclists and uses the language associated with automobility for cycling infrastructure:

> A "green wave" is what drivers have come to expect (…) To date, "green waves" were aligned exclusively with the speeds of motor traffic. Very soon, however, Sitraffic SiBike will be extending the advantages of a "green wave" to cyclists as well – on cycling *highways*, *fast* cycling *lanes, roads* or cycling paths. [emphasis added] (*Sitraffic Sibike*).

Other examples of offering "green waves" to cyclists, such as *Volg Groen* (*Follow Green*) and *GoLight Avenue* in the Netherlands, and green waves for cyclists in Copenhagen, Denmark, promise to improve the "flow of cycling traffic" (*Volg Groen*), "minimal time losses", "direct city to city connections" and "few stops" (*GoLight Avenue*). A "more efficient journey" thanks to a 17% travel time reduction is promised for cyclists (*Green waves for cyclists*). Thus, the descriptions of innovations emphasize values that can be seen as borrowed from automobility discourses such as unimpeded flow and minimal time losses.

Another solution borrowed directly from the automobility system is information provision. *Electronic information boards* in Denmark and *P-Route* in the Netherlands provide cyclists with information about the traffic situation and available bicycle parking spots, respectively:

> It works similar as the P-route for cars. On entrance routes into the inner city and the station area, digital signs show the number of free parking spots in the nearest bicycle parking facilities. The signs also show the directions to these facilities. When a facility if full, cyclists are directed to a nearby parking facility that still has spots available. (*P-Route*).

> Tables should provide information about travel times and provide alternative route suggestions. The purpose is to utilise the existing infrastructure in the best possible way (*Electronic information boards*).

Bicycle parking innovations sometimes not only transfer solutions from car parking; the very framing of the parking issue is reminiscent of the way car parking problems are presented, particularly in the Dutch context:

> …[L]ots of bikes sit still during the work day, possibly resulting in an overflowing bike parking lot (*Mobilock*).

> Do you also have a hard time finding a good spot to park your bicycle? (*P-Route*).

> An important challenge are bicycles that are parked for a longer duration. Orphan bicycles use over 20% of the total bicycle parking capacity (*Cloudfiestenstalling*).

Other direct transfers from the automobile world include specific safety solutions such as turn indicators (e.g. *Blinkers, Brightspark, Livall*), lights that automatically switch on when a cyclist slows down (e.g. *Hexagon*, *Lumos*) and a 'smart' bicycle helmet with an airbag that inflates in case of an accident (*Hövding*).

4.6.2. Surveillance, data collection and data-driven governance

Cycling at the moment, together with walking, continues to be a largely unsurveilled mobility mode. Of course, in some places cyclists may be seen on surveillance cameras in public spaces, but for privately owned bicycles there are no systematic data collection processes in place, no possibilities to track individual journeys such as for driving, using public transportation, flying etc. As our analysis shows, smart cycling innovations can change this radically. The methods and the purposes of data collection differ.

Safety is one of the common justifications for equipping a bicycle (accessory) with a GPS-tracker. Most frequently this is advertised as solution to bike theft or, rather, retrieval after theft (*Lyra, Sherlock, SmartHalo, VanMoof Electrified S, Lock8*). In a few examples, safety in traffic and social safety are addressed. Thus, LIVALL helmet is equipped with a sensor that would react to the bump in case of an accident and the LIVALL Riding App would send an SOS message to a chosen contact. In some cases, the descriptions of innovations envisage whole (mobile) communities of surveillance keeping an eye on each other:

> If someone in the group gets into trouble or falls from their bike, RIDE-1 will capture the event and alert the other riders. RIDE-1 can also create alert warning areas (areas where bike accidents frequently happen) by using data from other people's sensor logs. (*XON Ride-1*).

> You can track where riders are with the app's GPS. With a built-in emergency response system you can ensure the safety of all riders. If an accident occurs, the app will notify pre-programmed contacts and the emergency services of the riders' exact location. Arrive safely to your destination with the RoadwareZ smart vest. Be smart, be seen, be safe. (*RoadwareZ*).

In some cases, measuring the number or the speed of cyclists and tracking their movements in real time is the crucial part of the functioning of an innovation (e.g. infrastructural innovations at crossings such as *Warmtesensor*, *Flo, Bikescout)*. In other cases, the rationale is different: measurements are framed as necessary for a larger change in cycling policy.

Thus, in Copenhagen, the municipality claims to use data collection in order to create connected infrastructures facilitating cycling with a minimal number of stops and traffic information provision:

> Today, green waves function in isolation without any coordination behind them. For this reason, work is being carried out to link them together. It must be possible for the green waves to be monitored and adjusted by means of a traffic management system based on measurements of the cyclists' real travel time, number of stops etc. (*Green waves for cyclists*).

> [Electronic] boards will communicate with the municipality's new central traffic management system MobiMaestro that collects the necessary traffic information, which is then passed on to the cyclists. Real-time data comes from radar detectors, which counts the passing cyclists. (*Electronic information boards*).

In the Netherlands, the online cycling network performance tool, CyclePRINT, promises to help "you understand how to use the power of cycling as a transport mode to unlock your city" as it is supposed to translate "your GPS data into policy relevant insights and enable its' users to analyse current behaviour, investigate future network enhancements and monitor bicycle network performance in a more detailed way" (*CyclePRINT*).

A number of other applications frame data collection as a secondary function offering the policy-maker data on speeds, routes, numbers of cyclists and carbon dioxide emissions (*Bikescout, GoLight Avenue, Ring-Ring)*. The cyclists and their journeys in these cases are becoming data. They are supposed to make use of the primary function of the innovation while data gathering takes place in the background. Other innovations explicitly frame cyclists as data-gatherers on a mission to improve their habitat. *Ring a Bell*, a bike bell measuring pollution in the Hague not only warns a cyclist when she turns to a more polluted street, but also collects the data and as such is "handy for every inhabitant of the Hague who wishes to be outside and breath clean air but also delivers insights to policy-makers" (*Ring a Bell*). Cyclists become more than moving dots on a screen, they are becoming mobile sensors, pictured by the innovators as responsible citizens conducting data collection and thus saving their cities money on a path to transitions to sustainability:

> Our cities are broken. They are congested, polluted and face serious resource challenges. Getting more people to cycle is a big part of the solution. And the challenge is how to improve our cities encouraging more people to cycle. The key is data. But no one is willing to pay for the deployment and maintenance of the sensor infrastructure to collect it. We've solved that problem. We've created ICON. It's an intelligent and connected bikelight that contains all the senses needed by the city (*ICON,* see also *BikeLook, LibertyBell*).

Finally, surveillance is also offered for non-strategic goals, e.g. for an enhanced accountability as part of the service: thus, one can trace their food moved through the city by the *UberEats* "rider"; an employer using *Burn Fat not Fuel* application stimulating cycling instead of driving "is provided with an overview of the cycled kilometers per employee".

4.7. The cyclist: identities and lifestyles

How are cyclists themselves envisioned in smart cycling promotional material? Texts describing innovations are selling not just smart technology and somehow enhanced experience of mobility, they are also selling lifestyles and constructing a variety of identities to do so.

4.7.1. Flexible and smart lifestyles

While this is not explicitly said, the emphasis on independence, flexibility, ease and customization as well as the presentation of the bicycle as a liberating, personalized mode of transport suggests that smart cycling technology is supposed to be conducive to the inner-city lifestyles of the young middle class and cater to their increasingly complex, "connected" lifestyles where work and life are at the same time balanced and fused. One can be on an adventure and yet track their performance, listen to one's favourite playlist and still be able to take "important calls" (*Livall*), connect to others when one feels like it and disconnect at a click, or remain "always connected" (*Student Bike*). The notions of freedom, flexibility and lack of commitment are presented as the ideal of mobility desired by the imagined user:

> No rules, no instructions – you're free to pick your own path (*Beeline*).

In the case of urban logistics, flexibility is a selling point both for the consumers and the couriers. Thus, *TringTring* offers an image of independence to the prospective "tringer": "Determine your own working hours. No boss. Healthy body. Fresh head" (see also *Foodora*). Consumers of services, in their turn, are offered a sort of understanding of the complicated busy lifestyles they have and are offered speedy indulgence:

> Your work, your friends, your sports. Always busy. TringTring gives you a little bit more time. Stay at home, and have your groceries delivered. (*TringTring*).

Cycling here becomes co-constitutive of an identity of a modern urbanite: agile, adaptable, "smart" and aware of sustainability impact of her actions, too busy to walk to the store or ready to hop on a bicycle for an "easy" money earner.

The envisioned users of 56 out of 86 innovations in the dataset are supposed to have a smartphone, and there are also many indications of smartness and connectivity as important parts of one's lifestyle, such as mentions of tablets and laptops that the cyclist carries, social networks etc. Smart cycling technology supposedly caters to a tech-savvy audience:

> It's also been designed to be as smart as everything else in your life, shipping with its own smartphone app and anti-theft tracking designed to make bike theft a thing of the past. (*Van Moof Electrified S*).

4.7.2. Elegance, fashion and style

Elegance, fashion and good looks represent another set of important codes, especially in the texts coming from contexts where cycling is marginal. The imagined users presumably care about their style:

> And, as we know, that you care about the style of your bike, we've designed two different types of handlebars to meet your expectations!' (*Wink Bar*).

> A LIFESTYLE ACCESSORY. The WAIR scarves are real daily apparel accessories! We wanted to integrate our protection in a lifestyle accessory, available in different colors or prints, so you can match them with your own style, every day…Protect your style and your lungs. (*WAIR*).

> Male cyclist: "I think style is very important, the look of something, the aesthetic, it's very simple it doesn't overcomplicate your bike." (video transcript *Blubel*).

> We made no compromises and cut no corners when we created Brightspark. We used quality aluminium for its sleek look and light feel, tough rubber controls to give you a better grip even on rainy days, and a timeless design that makes it look great on any bike. The result? Great quality and unique style. (*Brightspark*).

> An elegant solution for your safety and visibility. (*Lumos*).

> Meet the first beautiful electric bike - that's connected to the internet (*Van Moof Electrified S*).

4.8. Bringing the themes together: staging smart cycling futures

The seven themes and the categories within them together present an interpretive scheme of possible smart cycling futures. Following recommendations of Strauss and Corbin (1998), we sought a theoretical framework that would advance the interpretive power of our results. We have chosen the "staging mobility" framework by Jensen (2013) which proposes to view mobilities as "staged from above", that is designed, planned and regulated through institutions and "staged from below" as individuals perform mobilities and interact with each other in the process (p.6). It is clear that some of the reviewed texts reflect (potential) changes in cycling as it is planned and regulated, while others have a potential to alter embodied performances of cycling and social interactions. We used Jensen's framework and adapted it (by bundling the embodied performances and social interactions) and charted the landscape of smart cycling innovations as they already are staging or can potentially stage mobilities in new ways (Fig. 1). Just like Jensen (2013, p. 6) does, we emphasize that these are two *analytical* levels that help understanding how mobilities are assembled. Also, important to note that the dashed lines between the boxes do not represent links of causality but show relatedness so that the reader can clearly see which developments belong to which themes.

Adding this theoretical layer in order to organise and advance our findings achieves three goals.

First, distinguishing between the potential impact of cycling innovations on "staging from above" and "staging from below" shows that smart cycling is neither exclusively a matter of individuals using new technological tools to enhance their cycling experience, neither is it a top-down process of monitoring and shaping cycling practices. In one case, with mobilisation and empowerment of communities (dubbed "Communities of Change" in Fig. 1), these processes can be situated at both analytical levels as embodied performances, social interactions and planning may all be involved.

Second, this visualisation makes explicit that on the one hand, there are decision points that are situated at the level of policy and planning, for example, whether to facilitate or restrict bike-sharing services, data-collection practices or infrastructures empowering cyclists. On the other hand, some changes in cycling practices may happen without any interference from "above". Some innovators may aim to help cyclists to adapt to existing environments or to facilitate or ignite bottom-up change through, for instance, mobilising cycling community (e.g. *BikeBlackspot App, #endbiketheft*). Others aim to change individual experiences rather than to change policy, planning or road cultures.

Thirdly, by breaking down the impact of innovations in this way, we draw attention to the possibilities of interaction between different changes within and between the two analytical levels. Indeed, we do not aim to capture casual relationships as the scope and the methods of our study do not allow that. Moreover, our findings point to context-dependency of how smart cycling is staged from above and from below, hence, any interactions between the two levels would also be shaped by context-specific circumstances. Yet, this interpretive scheme can be used by scholars, innovators, planners or policy-makers to ask further questions about the impact of any specific smart cycling innovation:

- What does it aim to change, which of the seven themes are manifested in that change? Which other changes may it trigger?

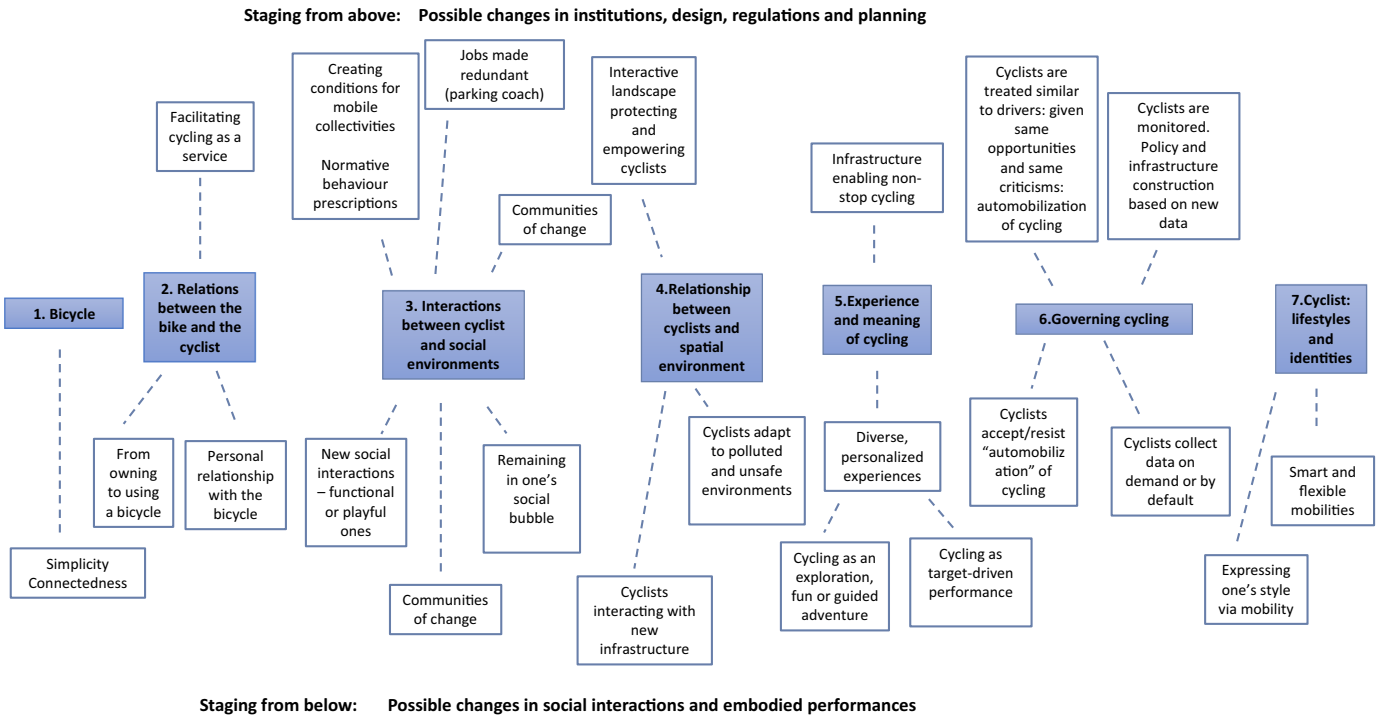

Fig. 1.

- At which level does the change take place? Can it trigger changes at another level?
- Can it be related to other changes already or potentially taking place in the landscape of smart cycling as presented in our scheme?

For instance, a mobile application measuring one's speed and tracking trips, can become a part of top-level change if the innovator partners with the municipality on data collection. At the "bottom" level using the application may be embedded in a particular "smart" lifestyle and lead to particular socialities ("sharing" rides through social media).

The opportunities we presented are far from exhaustive. Rather, they are indicative of paths that smart cycling can create.

5. Conclusions and discussion: towards a research agenda on smart cycling

5.1. Tensions within and between cycling futures

In this paper we have uncovered what the smartification of cycling can bring into the ways cycling is practiced, given meaning to and governed. The aim of the paper was to map the landscape of smart cycling innovation in its diversity, and the grounded theory approach to data analysis has facilitated revealing the variances while identifying seven common themes. Thus, in the analysed texts the changes are envisioned in (1) the bicycle itself, (2) the relationship between the cyclist and the bicycle, (3) the relationships between the cyclist and spatial environments (4) the relationships between the cyclist and social environments, (5) the experience of cycling and its meaning, (6) the governance of cycling as a mobility system and (7) the cyclist's identity and lifestyle. Integrating this into existing theoretical frameworks (the final stage of our methodology) showed how these themes together reveal diverse ways in which cycling is "staged from above and below" (Jensen, 2013).

Within most of the seven themes we found significant differences between the implications of the promises of different innovations for cycling. Smart cycling futures are fraught with internal contradictions and tensions. For example, promotional materials appeal to the idea that cycling offers adventure and freedom, but they propose varying degrees of engineering such "adventurous" rides. Smart technologies offer diverse tools of controlling and customising one's cycling experience, yet the designers and marketers aspire to keep the image of cycling as a free, unpredictable exploration which produces managed, surveilled and often shareable (on social media) "adventures". Likewise, aspirations for and understandings of sociality and connectedness are ambivalent as they are complemented by catering to the desire for individualism and solitude. One can cycle in a bubble of one's own music and incoming calls, yet the same technology may also provide possibility to form (albeit mediated) mobile collectives and interact on the move.

External tensions, i.e. between futures, also exist. Some innovators try to tackle the question of abandoned bicycles or the sheer number of bicycles on streets, others effectively stimulate putting more bicycles on streets. Some facilitate interactions with other cyclists, others – speed and focus. Some aspire to eliminate a need to have one's own bike, others propel bike ownership to a whole new level (high end bicycles), while some make bike ownership a prerequisite for a job. The meanings attached to safety of cyclists proved to be particular contested, with some new technologies 'arming' the cyclist against the presumably hostile environment and others holding drivers to account. This latter difference has a geographic dimension (see Section 5.2).

We thus conclude that just as cycling presents are multiple and contested, so will (smart) cycling futures inevitably be. Recognising the variety of paths that these futures may take and understanding in what kind of movements, meanings, practices and politics of mobility (Cresswell, 2006) in the *present* they are rooted is important – for scholars in order to understand transformations of cycling practices, cultures and policy contexts, and for transport policy-makers and advocates – for informed decision-making. Smart cycling innovations may thus advance and upscale specific new visions of cycling, e.g. fast and focused cycling with minimal time losses, and marginalise others, e.g. slower, interactive practices (see also Popan, 2019). In this proposition we align with the existing body of scholarship. It has been argued that representations of cyclists, cycling accessories and infrastructure are important since they may reinforce certain existing stereotypes,

attitudes and cultural scripts that may form exclusive cycling subcultures and identities (Aldred et al., 2016; Osborne and Grant-Smith, 2017). Imagery and language do not only legitimize and normalize particular practices and identities, while marginalizing others, they also influence public and private investment in the wider cycling system. Contested and place-specific meanings of cycling may "create additional resources and challenges for interventions that seek to make cycling practices grow and/or become more inclusive" (Aldred and Jungnickel, 2014, p. 86).

The key questions that follow from this are: What are you buying when you are buying a smart cycling gadget or a new mobility service? What are you investing in when you invest in certain smart cycling futures? What kind of social relationships will particular solutions facilitate or hinder? What kinds of lifestyle are seen as rational, desirable, trendy? And what lifestyles and mobile subjects are left invisible and ignored? These questions entail profound political choices to be made – choices that are not value free, but that will inevitably leave their mark on our mobilities and public spaces.

According to Docherty et al. (2017), "because mobility is a system, many different potential 'Smart Mobility' futures exist, even for any given package of technological innovations" (p. 3). Such futures, they argue, are already in the making, and thus decisions that currently may seem "trivial and experimental" may lead to irreversible systemic changes (ibid., p.7). We therefore need to ask what is the role of the state, non-state actors and citizens in smart cycling futures? Which innovations receive support of the public and policy-makers? Which choices between those contradictory visions of present and future are made? Who makes these choices? How aware are such players of the potentially contested smart cycling future that they buy into? Who develops the new algorithmically governed infrastructures and defines conditions for automated decisions? Who receives a green wave and to the expense of whom, who is rewarded for cycling and who is excluded by new assemblages of meaning, movement and practice?

5.2. Geographies of smart cycling

We have found significant differences between different geographical contexts. While often presented as universally applicable and sold across the world, smart cycling innovations cannot be detached from their contexts: in a number of geographic contexts, groups of users are enrolled with the use of particular imagery, linking cycling to certain, context-specific aspirations and lifestyles (also see Sengers, 2017).

First, in the analysis of the innovations developed in/for mature cycling contexts, such as the Netherlands or Denmark, there is a prevalence of codes related to the *system* and infrastructure (staging from "above"), while codes coming from the analysis of texts written in/for contexts where cycling is marginal more often are related to *individuals* – their quest for safety, comfort, performance, community (staging from "below"). We also found indications that in the contexts where cycling infrastructure is more developed and cycling is perceived as a "normal" way of moving around, the cyclist is less targeted with the need to equip herself with smart accessories in order to be "respected". In contexts where cycling is marginal and where, presumably, infrastructure, formal regulations and informal norms of behaviour leave cyclists feeling invisible, ignored and endangered, innovators – often on the basis of their own experiences – propose 'solutions' that are supposed to make cyclist feel or be safer without any systemic change on the road. In fact, they thus may implicitly and unintentionally reinforce a contested understanding of responsibility for safety. To put it bluntly, these innovations (i.e. smart jackets, glasses, helmets, lights) help potential victims to not get killed or maimed, but do little (if anything) to prevent others from doing harm. This may be strengthening the notion that the street is a dangerous place in which the responsibility for safety lies with the most vulnerable person ('please make sure not to get hurt/die') and not the person that brings in the danger ('please do not hurt/kill') and perhaps even that imminent danger is an inevitability for cycling as a mode.

Relatedly, our data suggests that there is a trend in the way cycling is framed as a mobility mode in mature cycling contexts – we label it 'automobilisation' of cycling. In the Netherlands and Denmark the bicycle is increasingly treated as a car – a mobility mode that supposedly needs streamlining, more efficient organisation and potentially more regulation, especially when it comes to parking. Through smart cycling innovation cyclists also increasingly receive 'privileges' similar to those that drivers have enjoyed for years: green waves, (occasional) priority at crossings, information on availability of parking places etc. In the contexts where cyclists' share in traffic is marginal, we talk about a different type of automobilisation of cycling: incorporating "safety" features that mimic those of a car and presume that a cyclist needs to invest more effort in ensuring her own safety appears to a be a common theme in innovations.

There are other differences that could be further explored in a larger dataset. E.g. the relations of innovations with everyday-ness of cycling and its mass adoption as a mainstream mode of transport. The presumed possibility of cycling without an intense focus on the dangers of traffic in Denmark and the Netherlands possibly explains the presence of innovations aiming at enhancing or facilitating sociality and playfulness on the bike path. In other contexts, smart cycling technology often appeals to community mobilisation for fighting against common grievances – thieves, potholes, unsafe environment. That focus has not been prominent in Dutch and Danish innovations.

Therefore, smart cycling innovations should be understood and conceptualised within their specific geographical embeddedness, their relation to specific discourses on cycling as an embodied and affective experience and local politics of mobility. Hence, we argue that these innovations are produced by and are producing new cycling geographies as, on the one hand, they are embedded in particular socio-spatial contexts that shape their "scripts", and, on the other, they create new relationships between cyclists and their socio-spatial environments, reorganise their mobilities (e.g. through directing them to particular destinations or routes), mediate faster or slower, solitary or collective mobilities. As such they are also part of wider urban transformations and may be driven by particular imaginaries of urban futures.

A key difference identified in our study is between mature and emerging cycling environments. Future research could build on this finding and explicitly unpack and explain how and why smart cycling futures are spatially diverse. How are these futures entangled with *glocal* cycling cultures and networks? What is their role in and relationships to broader processes of sustainable urban transformation and discourses around smart cities? (How) do innovations strengthen self-reinforcing feedback loops of normalizing cycling in contexts where cycling is already mainstream and de-normalizing it elsewhere? How can such cycles be actively reversed? How and by whom are these processes governed?

5.3. Smart cycling citizens

Our analysis makes it plausible to suggest that smart cycling, through technologies of self-monitoring and accountability, may support the trend towards neoliberalisation of transport planning and assigning the responsibility to the citizen for advancing sustainability transitions through behaviour change and data supply. This in particular concerns the innovations that encourage people to save their carbon emissions and calories or contribute their data to help targeted investment in their cities as large infrastructural projects are supposedly too expensive to accomplish. Such findings resonate with existing research relating discourses on cycling and transport in general to neoliberalism (see Schwanen et al., 2011; Reigner and Brenac, 2019; Spinney, 2016). However, for a large share of innovations in our dataset it is the individual who is appealed to, rather than an urban authority, so the focus on individual contribution is to be expected. Also, following Aldred (2010), and in resonance with the rhetoric of community

and commons in cycling innovation texts (see the examination of *Ring-Ring* application in Nikolaeva et al., 2019) we would refrain from interpreting particular expressions of care for the self and the environment as exclusively neoliberal. Thus, further research is needed to explore the politics of cycling and its relationship to wider changes in urban governance, including neoliberalisation.

Another important question arises from identifying surveillance and data collection as an important feature of innovations. Emerging research on surveillance, Internet of Things and mobility suggests that data collection practices of mobile phone applications and smart devices are non-transparent, and are often driven by commercial motives as user data are sold to third parties without proper informed consent procedures (Leon, 2019; Petersen, 2019; Zuboff, 2019). Spinney and Lin, 2018 discuss how dockless bikesharing instead of "encouraging solidarity" can stimulate mutual surveillance (p.80) and instead of contributing to environmental and civic goals can work towards "harvesting, recording and combining user data with a view to monetising this resource" (ibid) and mediate "the maximisation of private utility (saving time and effort) over collective utility (the ability of other users to easily use the public realm)" (p. 76). Further research is needed to establish if such practices also exist the in smart cycling field and to better understand the rationales, the politics and the effects of data production: Which interests drive the data collection processes? How is the data used? What is the actual impact of mobilising cycling data for the development of cycling infrastructures? Can these processes empower communities and make marginalized voices heard?

5.4. Understanding innovations: limitations of the study and ways forward

Our study was limited only to the analysis of the text as a "script". The worlds that are contained within scripts as 'logical' and presumably attractive socio-spatial contexts of innovations may come true or may be contested. For instance, one may decide to wear a smart helmet but talk to their cycling companion instead of listening to music or taking phone calls. Catching a "green wave" can be an expression of playfulness, a submission to the imperative of saving time, part of a fitness routine or a competition with oneself, tracked by a mobile application. Mobile subjects may perform a few scripts simultaneously or contest them while spaces that they move through may thus become multidimensional, flexible and contested (cf Nikolaeva, 2017). Further research can investigate how scripts are contested or adapted by the designers themselves or by the public.

Yet, the framing role of representations of mobility should not be underestimated. Research on representations of cars and driving in advertising concludes that despite the difficulties of establishing the link between the content of advertising and the behaviour, these representations nevertheless play an important role in "shaping expectations about cars and the experiences they are able to induce" (Redshaw, 2007, p. 125). Given the importance of emotions in sustaining contemporary high carbon mobility cultures (Sheller, 2004), understanding the affective dimensions of cycling experiences and cycling accessories through advertising and its reception, may be necessary to facilitate transitions to low carbon futures.

We have focused on texts accessible to us in Dutch, Danish and English languages, and further research can expand the geographical scope of analysis. Furthermore, the analysis of visual material (videos and images) could help to further understand whether the smart cycling futures are imagined as inclusive and socially diverse, and which identities and lifestyles they cater to (cf policy imagery analysis by Osborne and Grant-Smith, 2017).

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Declaration of Competing Interests

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtrangeo.2019.102486.

References

Adey, P., 2010. Mobility. Routledge, London, the UK.
Akrich, M., 1992. The De-Scription of technical objects. In: Bijker, W., Law, J. (Eds.), Shaping Technology, Building Society: Studies in Sociotechnical Change. MIT Press, Cambridge, Mass, USA, pp. 205–224.
Aldred, R., 2010. 'On the outside': constructing cycling citizenship. Soc. Cult. Geogr. 11 (1), 35–52. https://doi.org/10.1080/14649360903414593.
Aldred, R., Jungnickel, K., 2014. Why culture matters for transport policy: the case of cycling in the UK. J. Transp. Geogr. 34, 78–87. https://doi.org/10.1016/j.jtrangeo.2013.11.004.
Aldred, R., Woodcock, J., Goodman, A., 2016. Does more cycling mean more diversity in cycling? Transp. Rev. 36 (1), 28–44. https://doi.org/10.1080/01441647.2015.1014451.
Banister, D., Stead, D., 2004. Impact of information and communications technology on transport. Transp. Rev. 24 (5), 611–632. https://doi.org/10.1080/0144164042000206060.
Behrendt, F., 2016. Why cycling matters for smart cities. Internet of bicycles for intelligent transport. J. Transp. Geogr. 56, 157–164.
Bulc, V., 2016, June 17. Cycling: Green and Efficient Transport for the Future. Retrieved from. https://ec.europa.eu/commission/commissioners/2014-2019/bulc/blog/cycling-green-and-efficient-transport-future_en.
Charmaz, K., 2006. Constructing Grounded Theory, 2nd ed. SAGE Publications, Sonoma State University, Rohnert Park, USA.
Chen, P., Shen, Q., Childress, S., 2018. A GPS data-based analysis of built environment influences on bicyclist route preferences. Int. J. Sustain. Transp. 12 (3), 218–231. https://doi.org/10.1080/15568318.2017.1349222.
Cox, P., 2017. Bicycle design history and systems of mobility. In: Spinney, J., Reimer, S., Pinch, P. (Eds.), Mobilising Design, Designing Mobilities: Intersections, Affordances, Relations. Routledge, London, United Kingdom, pp. 48–61.
Cresswell, T., 2001. The production of mobilities. New Form. 43 (Spring), 3–25.
Cresswell, T., 2006. On the Move: Mobility in the Modern Western World. Routledge, New York, the US.
Dey, I., 1999. Grounding Grounded Theory: Guidelines for Qualitative Inquiry, 1 edition. Emerald Group Publishing Limited, San Diego.
Docherty, I., Marsden, G., Anable, J., 2017. The governance of smart mobility. In: Transportation Research Part A: Policy and Practice. 115. pp. 114–125. https://doi.org/10.1016/j.tra.2017.09.012.
Fishman, E., 2016. Cycling as transport. Transp. Rev. 36 (1), 1–8. https://doi.org/10.1080/01441647.2015.1114271.
Gössling, S., 2018. ICT and transport behavior: a conceptual review. Int. J. Sustain. Transp. 12 (3), 153–164. https://doi.org/10.1080/15568318.2017.1338318.
Heath, H., Cowley, S., 2004. Developing a grounded theory approach: a comparison of Glaser and Strauss. Int. J. Nurs. Stud. 41 (2), 141–150.
Jensen, A., Richardson, T., 2007. New Region, New Story: Imagining Mobile Subjects in Transnational Space. Space and Polity 11 (2), 137–150. https://doi.org/10.1080/13562570701722014.
Jensen, O.B., 2013. Staging Mobilities. Routledge, Abingdon.
de Kruijf, J., Ettema, D., Kamphuis, C.B., Dijst, M., 2018. Evaluation of an incentive program to stimulate the shift from car commuting to e-cycling in the Netherlands. J. Transp. Health 10, 74–83.
Larsen, J., 2014. (Auto) Ethnography and cycling. Int. J. Soc. Res. Methodol. 17 (1), 59–71. https://doi.org/10.1080/13645579.2014.854015.
Latour, B., 1990. Technology is society made durable. Sociol. Rev. 38 (1), 103–131. https://doi.org/10.1111/j.1467-954X.1990.tb03350.x.
Leon, L.F.A., 2019. Eyes on the road: surveillance logics in the autonomous vehicle economy. Surveill. Soc. 17 (1/2), 198–204. https://doi.org/10.24908/ss.v17i1/2.12932.
Manders, T.N., Wieczorek, A.J., Verbong, G.P.J., 2018. Understanding smart mobility experiments in the Dutch automobility system: who is involved and what do they promise? Futures 96, 90–103. https://doi.org/10.1016/j.futures.2017.12.003.
Nikolaeva, A., 2017. "Spoiled", "bored", "irritated" and "nervous": The transformations of a mobile subject in airport design discourse. In: Spinney, J., Reimer, S., Pinch, P. (Eds.), Mobilising Design. Routledge, Abingdon, pp. 24–34.
Nikolaeva, A., Adey, P., Cresswell, T., Lee, J.Y., Nóvoa, A., Temenos, C., 2019. Commoning mobility: Towards a new politics of mobility transitions. Transactions of the Institute of British Geographers 44 (2), 346–360. https://doi.org/10.1111/tran.12287.
Osborne, N., Grant-Smith, D., 2017. Constructing the cycling citizen: a critical analysis of policy imagery in Brisbane, Australia. J. Transp. Geogr. 64, 44–53. https://doi.org/10.1016/j.jtrangeo.2017.08.015.
Petersen, A.B., 2019. Scoot over smart devices: the invisible costs of rental scooters. Surveill. Soc. 17 (1/2), 191–197. https://doi.org/10.24908/ss.v17i1/2.13112.

Petzer, B., 2017. What is Cycling-as-a-Service? Retrieved from. http://brettpetzer.com/?p=1826.
Plazier, P.A., Weitkamp, G., van den Berg, A.E., 2017a. "Cycling was never so easy!" an analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews. J. Transp. Geogr. 65, 25–34.
Plazier, P.A., Weitkamp, G., van den Berg, A.E., 2017b. The potential for e-biking among the younger population: a study of Dutch students. Travel Behav. Soc. 8, 37–45.
Popan, 2019. Bicycle Utopias: Imagining Fast and Slow Cycling Futures. Routledge, Abingdon.
RAI Verenigning, 2019. Zonnig 2018 stuwt omzet fietsbranche naar record. Retrieved 8 March, 2019 from. https://raivereniging.nl/artikel/persberichten/2019-q1/0301-zonnig-2018-stuwt-omzet-fietsbranche-naar-record.html.
Redshaw, S., 2007. Articulations of the Car: the dominant articulations of racing and rally driving. Mobilities 2 (1), 121–141. https://doi.org/10.1080/17450100601106484.
Reigner, H., Brenac, T., 2019. Safe, sustainable… but depoliticized and uneven – a critical view of urban transport policies in France. Transp. Res. A Policy Pract. 121, 218–234. https://doi.org/10.1016/j.tra.2019.01.023.
Rottier, J.P., 2019. Uitdagingen door fikse groei aantal elektrische fietsen. Retrieved 8 March, 2019 from. https://www.verkeersnet.nl/fiets/28872/uitdagingen-door-fikse-groei-aantal-elektrische-fietsen/?gdpr=accept.
Schwanen, T., 2015. Beyond instrument: smartphone app and sustainable mobility. Eur. J. Transp. Infrastruct. Res. 15 (4), 675–690.
Schwanen, T., Banister, D., Anable, J., 2011. Scientific research about climate change mitigation in transport: a critical review. Transp. Res. A Policy Pract. 45 (10), 993–1006. https://doi.org/10.1016/j.tra.2011.09.005.
Sengers, F., 2017. Cycling the city, re-imagining the city: envisioning urban sustainability transitions in Thailand. Urban Stud. 54 (12), 2763–2779. https://doi.org/10.1177/0042098016652565.
Sheller, M., 2004. Automotive emotions: feeling the car. Theory, Cul. & Soc. 21 (4–5), 221–242. https://doi.org/10.1177/0263276404046068.
Spinney, J., 2016. Fixing Mobility in the Neoliberal City: Cycling Policy and Practice in London as a Mode of Political–Economic and Biopolitical Governance. Annals of the American Association of Geographers 106 (2), 450–458. https://doi.org/10.1080/24694452.2015.1124016.
Spinney, J., Lin, W.-I., 2018. Are you being shared? Mobility, data and social relations in Shanghai's public bike sharing 2.0 sector. Applied Mobilities 3 (1), 66–83. https://doi.org/10.1080/23800127.2018.1437656.
Strauss, Anselm, Corbin, Juliet M., 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Ttheory*, 2nd ed. Sage, London.
Sunio, V., Schmöcker, J.-D., 2017. Can we promote sustainable travel behavior through mobile apps? Evaluation and review of evidence. Int. J. Sustain. Transp. 11 (8), 553–566. https://doi.org/10.1080/15568318.2017.1300716.
Te Brömmelstroet, M.C.G., Nikolaeva, A., Chan, C., Glaser, M.A., Nicolaisen, M., 2017. Traveling together alone and alone together: Mobility and potential exposure to diversity. Applied Mobilities 2 (1), 113–129. https://doi.org/10.1080/23800127.2017.1283122.
Vivanco, L.A., 2013. Reconsidering the Bicycle: An Anthropological Perspective on a New (Old) Thing. Routledge, New York, USA.
Witlox, F., 2015. Beyond the Data Smog? Transport Reviews 35 (3), 245–249. https://doi.org/10.1080/01441647.2015.1036505.
Yaneva, A., 2009. Making the social hold: towards an actor-network theory of design. Des. Cult. 1 (3), 273–288. https://doi.org/10.1080/17547075.2009.11643291.
Zuboff, S., 2019. *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. Profile Books, Kindle edition. .