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Nikolaeva, A.

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Smart Cities and (Smart) Cycling: Exploring the Synergies in Copenhagen and Amsterdam

Anna Nikolaeva 

Amsterdam Institute for Social Science Research, University of Amsterdam, The Netherlands

ABSTRACT

In cities worldwide, cycling is increasingly upgraded with smart technology and is included in smart cities' visions and projects. This process has not been problematized in public discourse, as smart innovation is seen as a potential booster of the known benefits of cycling. Drawing on critical literatures on smart cities, smart mobility, and degrowth and using the case studies of Copenhagen and Amsterdam, the article opens up a more critical conversation on the subject, discussing the role of "techno-solutionism," technology push, and pro-innovation bias in the process of "smartification" of cycling.

KEYWORDS

cycling innovation; smart cities; smart mobility; techno-solutionism; technology push

Interviewer: Often, smart city visions do not include cycling.

Interviewee: Then it's not very smart, in my opinion. (laughs)¹

Introduction

"Smart" cycling innovations, from dockless bike-sharing to smart helmets and data-collecting devices mounted on bikes, have recently become a subject covered not only by specialized journals and blogs but also by mainstream media, including *Guardian*, *CNN*, *Wired*, and *Forbes*, as well as numerous blogs and Internet magazines. This attention peaked around 2016–2017 as the "boom" and "bust" of dockless bike-share schemes facilitated by "smart" locks and smartphone applications unfolded, first in China and then worldwide (Campbell, 2018). The broader process of bringing Information and Communication Technologies (ICT) and Internet of Things (IoT) technologies into bicycles and cycling infrastructure continues, often as part of projects associated with the "smart city" concept. Thus, urban authorities across Europe launch cycling innovation competitions under the direction of smart city offices (for instance, Dublin in 2016 and Amsterdam in 2019) and participate in smart cities projects in which cycling is part of the portfolio (Helsinki, Manchester, and Eindhoven to name a few). A virtual reality cycling simulator was nominated for a World Smart City Award in

CONTACT Anna Nikolaeva  a.nikolaeva@uva.nl  Amsterdam Institute for Social Science Research, University of Amsterdam, Postbus 15629, 1001 NC Amsterdam, The Netherlands

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2017. Bike IT, an interactive platform for bike-sharing services, won the main prize of the first large-scale Smart City Hackathon in Pakistan in 2018. Not only do smart city projects increasingly include cycling but also cycling itself becomes “smarter” in cities where cycling is the mainstream mode of transportation. These cities implement various innovations, from green waves to bike parking solutions using sensors and interactive message boards (Nikolaeva et al., 2019; Nikolaeva and Nello-Deakin, 2020). Also, cities aspiring to increase cycling rates run trials with cycling data collection facilitated by IoT and ICT (Lee and Sener, 2020).

The starting point of this article is the observation that these processes of incorporating cycling into smart city visions, on the one hand, and of bringing smart technology into urban cycling projects, on the other, are often discussed in unequivocally favorable terms by media and cycling advocates. ICT and IoT-facilitated innovation is often seen as helping the momentum for urban cycling—an allegedly benevolent transportation mode that positively impacts sustainability, public health, and accessibility. Thus, the world’s largest bike-share operator, Mobike, was awarded the Champions of the Earth award by the UN “for exploring market-driven solutions to air pollution and climate change” in 2017 (UNEP, n.d.). In 2016, the European Commissioner for Transport, Violetta Bulc, maintained that cycling needs to be incorporated into smart transport networks in smart cities of the future that “will be driven by technology” (Bulc, 2016). The leading cycling advocacy organization in Europe, European Cyclists Federation, has been writing for years about the “opportunities” offered by smart cycling innovation to make cycling more accessible, safer, and more popular (Malovrh, 2018). This suggests that, at least in Europe, the process of the “smartification” of cycling under the umbrella of smart city visions has not been problematized; quite the opposite. Behrendt (2018) even concludes her review of the EU policy documents with the call for including cycling “more consistently and centrally in policy documents concerning the Internet of Things, smart cities, connected vehicles and (smart) transport” as this would ensure that this “sustainable” mode of transport would keep challenging the dominance of the car (17).

Drawing on the literature on smart cities, smart mobility, and cycling innovation, this article aims to open up a more critical conversation around incorporating cycling into smart city projects and planning that centers on the smartification of urban cycling. Scholars have problematized smart city and smart mobility visions as manifestations of technological solutionism and technology push—the growing power of tech companies in defining urban problems and imposing solutions not grounded in the local context (see Literature Review for more detail). The process of smartification of cycling may be related to these trends and, in addition, may even be at odds with the very promises of cycling that make it so popular among scholars and activists in the mobility transition debate. For instance, dockless bike-sharing schemes, perhaps the most researched smart cycling innovation thus far, have been criticized for not delivering sustainability benefits, being exclusive, and capitalizing on personal data (Médard de Chardon, 2019; Spinney and Lin, 2018). While environmentalists and degrowth scholars praised cycling for being a low-tech, energy-efficient mobility means, for its autonomous and self-limiting nature (in stark contrast to driving), the logic of smart city, centered on interconnectedness and doing “more with less” (Shelton et al., 2015) may compromise those qualities. As cycling gets enrolled in smart cities discourse and as smart innovation enters cycling policy and planning, we thus need to ask what the rationales and drivers of

these processes are, what the roles of different actors are, and what choices about urban mobility futures they are making (see also Nikolaeva et al., 2019).

Thus, focusing on the cities of Copenhagen and Amsterdam as case studies, the article answers the following questions: What is the role of cycling in envisioning smart cities? What are the rationales for cycling planners and advocates to engage in the smartification of urban cycling? What is the relationship between “smartness,” understood as incorporating ICT/IoT technology and the low-tech nature of cycling?

The next section provides the literature review and grounds the article in debates on smart cities, innovation, and cycling. After that, we present the research design and methodology. The next two sections answer the three questions posed above. In the penultimate section, just before the Conclusion, I bring the insights from the analysis together, using critiques from the debates on smart cities, innovation, and mobility.

Literature Review

So why problematize the convergence of smart city visions and the momentum for urban cycling? In this section, I offer reasoning and conceptual tools for investigating this process based on the literature of smart cities, innovation in urban planning and degrowth, smart mobility, and cycling innovation.

The smart city discourse—discourse on the crucial role of technology in solving urban problems from crime and pollution to accessibility and lack of participation—still forms one of the dominant visions of the urban future (Cardullo and Kitchin, 2019; Hollands, 2015; Joss et al., 2019). The debate on the shortcomings of smart city visions has been quite prolific, and it is beyond the scope of this article to touch upon all critiques (for an overview, see Luque-Ayala, 2018; March, 2018; Martin et al., 2018). However, it is pertinent to highlight a few recurrent (and related) concerns that resonate with the concerns expressed by scholars writing on smart mobility: technological solutionism, technology push, and a lack of embedding of smart city visions in the respective urban contexts.

Drawing on the exploration of *technological solutionism* by Morozov (2013), scholars have argued that in the smart city approach to urban governance, the way urban problems are constructed and framed “necessitates” solving them with the help of technology (Cardullo and Kitchin, 2019; León and Rosen, 2019; Luque-Ayala, 2018). As a result, technological “solutions” in various fields, including mobility, are often established before proper deliberation on an issue takes place. Such deliberation may have led to a solution that does not involve smart technology or even to a conclusion that the issue does not present a problem that needs solving (Docherty et al., 2017; Sadowski and Bendor, 2019).

A related critique of smart city approaches problematizes *technology push* which “implies that a new solution/product is ushered into the market as a result of quickly advancing science and technology, i.e., it is driven by supply, regardless of the expressed needs of society.” (Angelidou, 2015: 99). The sheer availability of the product and the potential financial gain to be made leads to pressure on policymakers by interested actors, primarily technology companies. Thus, while technological solutionism relates to *how* urban problems are seen and dealt with, technology push relates to *who* is trying to shape and steer that problem-solving.

This dynamic generates another dimension of smart city approach that has been criticized in urban studies—due to the technology push, the “solutions” are often generic and are *disconnected from the local context*—the political, socio-spatial, and cultural fabric of the city (Aurigo and Odendaal, 2021; Shelton et al., 2015).

These three critiques imply that within the smart city approach to urban planning, “solutions” are often not driven by local understandings of urban problems and policy-making priorities and are not underpinned by an open approach to identifying solutions. The increasing introduction of smart innovation into the cycling field appears to be related to the growing power of tech companies and thus may be subject to similar critiques.

The debate on a *pro-innovation bias* in urban planning and degrowth thinking offers another critical perspective relevant to considering smart cycling innovation. Thus, Ferreira et al. (2020) posit that innovation is increasingly seen as an “intrinsically positive value” in approaching challenges in urban planning. Instead of solving “wicked” problems, urban planners pursue “change for the sake of changing,” which is easier short-term but eventually leads to the “proliferation of pointless novelties” with very little progress made toward key policy goals (Ferreira et al., 2020). They argue that best solutions do not have to be innovative and frame cycling as a case in point—“a means to achieve sustainable and active mobility” already available (3; also see Shove, 2012). Indeed, cycling is an activity that can be pursued without any IoT or ICT devices, and successful cycling cities, from Amsterdam to Copenhagen, have seen rising cycling rates without the wide use of smart technology. This observation also suggests that we need to question the rationales for “smartifying” cycling: who is driving it, and for what reasons if it is not intrinsically necessary for cycling to be supported by smart innovation to become a mainstream mobility mode?

Furthermore, in the literature on degrowth and environmentalism, the “humble” bicycle is often seen as a “simple,” “low-tech,”² “convivial” tool that exemplifies the perfect autonomy of an individual, understood in a broad sense as the “the power to control the use of resources in order to satisfy human needs” (Bradley, 2018: 1677). Thus, cycling has the potential to help people fulfill their mobility needs largely without depending on the knowledge of experts, commercial relations, extensive infrastructures, and fuel consumption. To quote the philosopher Ivan Illich (1974), unlike driving a car, “the use of the bicycle is self-limiting.” It allows people to “become masters of their own movements without blocking those of their fellows” (74). According to him, the problem with driving is not only in that it is energy-intensive but in that it is inherently dependent on massive infrastructures (roads, parking) that rob everyone of walkable and cyclable space and thus limit everyone’s autonomy and produce a scarcity of space. Cycling is seen as part and parcel of “simple” living, a prefigurative practice on a path towards degrowth and decarbonization—“moving away from energy-intensive, consumerist lifestyles and adapting to an energy descent pathway of planned economic contraction” (Alexander and Yacoumis, 2018: 1840; see also Bradley, 2018; Furness, 2005; Horton, 2006; Zoellick and Bisht, 2018). Notably, the “simplicity” of tools such as a bicycle (or using washing lines instead of a dryer) for degrowth thinkers is not only about diminishing one’s carbon footprint: “low-tech living” has cultural significance as it can help create “the cultural conditions needed for the fundamental structural transformation of our economies to take place” (Alexander and Yacoumis, 2018: 1843).

Smartification of the bicycle, one may thus argue, may threaten *the autonomy and simplicity* offered by cycling, the features that, according to many, make the bicycle a solution to “wicked” urban problems. Smart bikes or smart cycling infrastructure in a smart city are part of larger systems; interconnectedness is, after all, one of the hallmarks of smart mobility solutions and smart city discourses. Furthermore, dominant visions of a smart city support the pro-growth ideology and consumerist lifestyles, with technology put to service to enable both (March, 2018; Martin et al., 2018; Smigiel, 2019). These literatures thus suggest that there may be a tension between the simplicity and autonomy of cycling and the smart city visions that somehow gets obscured in celebrating smart cycling innovation. We thus should investigate the interrelationship between “smartness,” understood as incorporating ICT or IoT technology and the low-tech nature of cycling.

Finally, within mobility studies, scholars have been critical of some of the claimed benefits of specific cycling innovations, such as bike-sharing and smart cycling in general. Some have argued that the effects of smartifying cycling may vary greatly depending on its ideological underpinnings and that the benefits may be distributed unequally (Nikolaeva and Nello-Deakin, 2020; Gironés and Vrščaj, 2018; Popan, 2019). Bike-sharing schemes, in particular, have been criticized for not fulfilling their modal shift promises, for being exclusive, and for questionable data collection practices (Duarte, 2016; Médard de Chardon, 2019; Spinney and Lin, 2018). Smart cycling innovation, it has been argued, can be utilized to advance very different urban futures and politics of mobility, and it is pertinent to investigate the roles of state and non-state actors in smartifying cycling and their rationales for pursuing particular projects (Nikolaeva et al., 2019; te Brömmelstroet et al., 2020).

This literature review demonstrates that the ongoing process of smartification of cycling, often under the auspices of smart city visions, should not be taken for granted as a mere booster to the benefits of the humble bicycle. Instead, it should be problematized, and its drivers should be investigated. This process may be related to technological solutionism, technology push, smart city visions divorced from the local context, and a manifestation of pro-innovation bias in urban planning. Moreover, smart innovation may even undermine the core benefits for which cycling has been lauded by environmentalists and cycling activists—simplicity and autonomy. Informed by these arguments, this article explores the drivers and rationales behind the alignment between smart cities and cycling in Amsterdam and Copenhagen. The following section discusses case selection and methodology.

Case Studies and Methodology

This article presents an exploratory study, drawing on two cases that can be considered “extreme cases” (Flyvbjerg, 2006). Amsterdam and Copenhagen are often seen as “models of successful cycling cities” (Koglin et al., 2021: 347). Both cities have been investing in cycling infrastructure for a few decades, generating unique cycling cultures maintained through the daily cycling practices of thousands of inhabitants (Koglin et al., 2021; Nello-Deakin and Nikolaeva, 2021). Taking up 35 percent of the modal split in Amsterdam and 41 percent in Copenhagen in 2017, cycling in both cities has become a normalized, pragmatic mode choice rather than a sign of pro-environmental attitudes (Haustein et al., 2020; Nello-Deakin and Nikolaeva, 2021; O’Sullivan, 2017). Both cities

also play an important symbolic function in cycling activism worldwide and a key role in the transfer of the knowledge of cycling policy (Bruntlett and Bruntlett, 2018).

Both Copenhagen and Amsterdam are also prominent players in the European and global smart city field, receiving awards and delegations from different parts of the world eager to learn about their smart technology, cycling planning, and culture. In 2014 Copenhagen received the World Smart Cities Award for its Copenhagen Connecting Project, which includes smart cycling solutions around data collection. According to the study by Joss et al. (2019), Amsterdam and Copenhagen belong to the cities that shape the global smart cities discourse. Copenhagen is often praised for centering sustainability (Joss et al., 2019), while Amsterdam “presents itself to the world as a citizen-driven smart city” (Raven et al., 2019: 264). The prominent role of both cities in knowledge transfer on both cycling and smart urbanism makes these two cases particularly interesting and important for understanding the current and possibly future relationships between cycling and smart urbanism. Also, the chosen approach allows focusing on “actually existing smart cities” and understanding policies and projects in their local context rather than pursuing a more speculative mode of reflection on smart urbanism (Shelton et al., 2015).

The professionals working on smart city projects and stakeholders involved in cycling policy, planning, and advocacy were identified using Internet search and a snowballing technique. In total, 22 professionals were interviewed for the Copenhagen case study, and 33 were interviewed for the Amsterdam case study in 2018–2019 (See Appendix 1).³ The interviews typically lasted between one and two hours, averaging around 75 minutes. The interview guide consisted of open questions that aimed to elicit a detailed narrative on how projects and processes relevant to the study unfolded: when they began, why, who was the initiator, what parties were involved, what happened next, and how the interviewees evaluate ideas, innovations, and visions that developed in their city in the sphere of smart cycling. The goal was to uncover drivers and rationales behind the smartification of urban cycling in an open, non-steering way. The transcribed interviews were analyzed using a two-stage approach. During the first stage, a straightforward coding framework was applied based on the research questions: actors, motivations, priorities, understanding of smartness, and the relationship between smartness and cycling. During the second stage, the data were further analyzed using the operationalization of the concepts from the literature review as the coding guide (See Table 1).

Table 1. Operationalization of concepts based on the literature review

Concept	Operationalization
Techno-solutionism	Urban problems are not approached with an open mindset but are framed in a way that necessitates “smart” solutions; Technological solutions “precede” definition and proper deliberation of problems.
Technology push	Local authorities are not proactive in choosing solutions but adopt innovations under the influence of technology companies; supply-driven smartification.
Lack of connection to the local context	The application of smart innovation is not driven by local policy priorities and knowledge.
Pro-innovation bias	“Change for change’s” sake, unnecessary and superficial application of innovations.
Breaking away from the simplicity and low-tech nature of cycling	Making cycling practice or governance more complicated than is sufficient for it to fulfill its positive social and environmental potential.

Thus, only after looking at the data in an open way, trying to reconstruct what has been happening from the point of view of different actors in the process of smartification of cycling, I investigated if and how the issues identified in the literature play a role in the chosen context. The presentation of the results reflects this two-stage process: first, the questions posed in the introduction are answered for each city, discussing how and why various stakeholders participate in the smartification of cycling; second, the results of applying perspectives from the literature are brought together.

Finally, a number of policy documents, visions, and reports were analyzed with the research questions in mind next to the interview research; however, the main focus was on the actual experiences and views of players in the field, and the analysis of documents played only a supporting role.

Smartification of Cycling in Copenhagen

The Role of Cycling in Copenhagen's Smart City and Smart Mobility Initiatives

In Copenhagen, smart cycling innovations such as green waves, cycling counters, messaging boards for cyclists, and smart data collection projects are frequently highlighted both by the smart city-related actors and by cycling ambassadors in various publicly available texts (Colville-Andersen, 2014; Weinreich, n.d.). The report “Mapping Smart Cities in the EU,” commissioned by the European Parliament (Manville et al., 2014), provides a detailed discussion of cycling in Copenhagen as an essential “solution” in the context of smart cities and extensively discusses cycling policy and planning in the city. However, the interview analysis has shown that what may look like a coordinated set of interventions aligned with a smart city vision from the coverage in media and in grey literature is an assemblage of projects not linked to a single actor or a vision.

According to most interviewees, one of the key drivers behind the investment into smart traffic management in Copenhagen, including testing and introducing various ICT solutions for cycling, was the CPH 2025 Climate Plan, which has set the goal for the city to become “the world’s first carbon-neutral capital city by 2025” (The City of Copenhagen, 2012). Cycling is given considerable attention in the document; of the four areas of action within the mobility theme, the “City of Cyclists” initiative receives the largest share of funding (The City of Copenhagen, 2018, 57). The document prescribes that by 2025 “at least 50 percent of all journeys to the place of work or study must be by bicycle” (The City of Copenhagen, 2018). Making cycling more attractive is presented as one of the means of achieving such a modal split. According to the interviewee involved in developing Copenhagen’s first Traffic Management System, this “attractiveness” often translated into travel time savings as a key objective (C1). Also, next to the goals set in the Climate Plan, the sheer presence of cyclists in the city in such large numbers necessitated considering them during the development of the traffic management system:

[According to the Climate Plan] we should have reduced the number of stops for cyclists. We should have improved the travel time for them and so on ... You cannot ignore 50 percent of your travelers. It was necessary for us to collect data from bicycles and also integrate it somehow into the traffic management as a whole. (C1, similar point made by C6, C19, C20)

Political prioritization of the travel time reduction goal resulted in various projects, both incorporating technology and not, and thus being initiated by different departments within the city administration (for an overview, see van Vlerken, 2018). According to the majority of interviewees, most applications of smart cycling innovations in Copenhagen have not originated within the smart city-related initiatives.

To understand this relationship between smart city visions and cycling innovation in Copenhagen, one needs to understand the character of smart city projects in the Danish capital. In 2014, the city set up a cross-departmental team, “Copenhagen Solutions Lab,” working on smart city projects, described as follows by the former employee:

We identify and coordinate smart city-needs in the municipality’s departments and match them with existing knowledge and solutions on the market. In this way, Copenhagen Solutions Lab acts as a bridge between external partners and Copenhagen Municipality’s initiatives concerning smart city. (C5)

Of the five themes and six laboratories listed on the website of the Copenhagen Solutions Lab, there is only one initiative linked to cycling: a market dialogue with companies that could offer data on pedestrians and cyclists in relation to opening new metro stations in 2019 (Copenhagen Solutions Lab, 2018). Cycling is not mentioned in the short overview of Copenhagen’s Smart City approach. However, smart mobility is listed as one of the five focus areas, with an IT-based traffic management system highlighted as a key example (Copenhagen Solutions Lab, 2016). As an interviewee from “Copenhagen Solutions Lab” puts it: “A lot of what you could call ‘smart solutions’ is actually done by our traffic management team ... I think the smart solutions for bikes come out of the need to manage traffic” (C5). In response to the question of why (despite appearances) cycling is not a strategic part of the smart city vision in Copenhagen, many interviewees have pointed out that there is no coherent smart city vision in Copenhagen in the first place:

We don’t have a smart city strategy ... In Copenhagen we are focusing on ... improving conditions for cyclists and for pedestrians and making sure there’s a nice proper public infrastructure and good public spaces and all of these things. Then in some of the projects we use technology as enabler, but we just don’t have the strategy of putting smart city as a goal in itself. (C5, similar point made by C13 and C19)

Nevertheless, despite this emphasis on using smart technology as an “enabler” and an outright lack of support for techno-solutionism, interviewees acknowledge that this approach runs counter to a default way of thinking about technology use in smart cities. According to them, techno-solutionist logic and technology push did play a role at the beginning of Copenhagen’s engagement with the smart city concept. However, gradually the city has developed a proactive stance:

I use the term [smart city] even though I don’t like it. I think first of all, it was probably invented by tech companies that wanted to sell devices. Then for a while, we maybe joined the hype ... Now we’re a bit more mature ... Back then you had this idea that you’ll just need a lot of sensors that collect data about this and that and as long as we have sensors and data then the city would just become smart. I think now we’ve *flipped* the perspective and started looking at problems and areas where we could either save money or improve service and then see what technology can enable that. (C5, emphasis added; similar point made by C19 and C2)

While companies such as Strava have approached the municipality offering their services, according to the interviewees, the technology push has been minimal, most likely due to cycling not representing a particularly lucrative business case:

This whole smart city area, it's driven by technology companies and they are looking at areas where there's potential for large investments and where you need some kind of technology. I think you're right when you say that cycling is a low-tech solution already. Perhaps that's not the first area to look in. I think that's probably why we don't see so many solutions for bikes. (C5)

Bicycle is very cheap. It's cheap to run and maintain. It's all good but it means that there's not a lot of money in the industry as the car industry. (C19, similar point made by C20)

However, this low-tech nature of cycling is even seen by some as an obstacle for it to becoming more visible and be taken seriously:

There are not so many commercial interests in cycling ... For the car industry there are also huge commercial interests from the industry [side] If you go to the ITS [Intelligent Transportation Systems] congress, you could see the money involved, it's not bicycle companies. It's too cheap. It's too low-tech. There is an issue to get cycling up and level with the other modes of transportation. (C6, similar point made by C22)

At the same time, several interviewees believed that cycling *should* be a part of smart city-related projects (also see the epigraph). According to one of the major ITS companies involved in smart mobility projects in Copenhagen:

[Cycling] should have its place. It should be part of the vision of Smart City. We see that it's becoming part of that Smart City vision more and more. I think we can be happy that that's the change that's happening because without cycling I don't think you'll have an effective Smart City. (C21, also C22)

Cycling is thus not that prominent in smart city initiatives in Copenhagen, and according to actors involved or driving such projects, there is an unfulfilled potential there. The following section discusses how actors in the field of cycling look at this issue.

The Rationales for Cycling Planners and Advocates to Engage in Smart Tech Projects

The interviewed professionals responsible for cycling policy and planning in Copenhagen have been involved in consultations around smart innovations in traffic management and in the research and market consultation processes set up by Copenhagen Solutions Lab. Their attitude could be described as being wary and critical of techno-solutionism and yet being open to solutions that could help them with their key priorities. They seem to be critical of adopting innovation for the sake of innovation, yet ready to set aside their skepticism. Thus, one of the key persons defining cycling policy in Copenhagen admits some personal resistance to high-tech solutions for problems that, in their opinion, could be resolved by traditional means, for instance, a "good old communication campaign." However, openness prevails:

But all these sorts of "I'm a little bit skeptical" I have to combine that with the curiosity ... In innovation, you never really know what the final outcome is. I have this double approach. On one hand, why should we have a high-tech solution if it really a low-tech solution that is

more cost-effective and can do the same job but then again, I also need to maintain an open mind for some added benefits that maybe I did not see because I'm used to thinking in a certain way. (C6)

An example of such openness has led that officer to spot an opportunity in a situation in which initially they felt they had to accept a pre-defined solution, a typical manifestation of technology push and technological solutionism:

I was a little bit critical, I must confess, because I felt that the private companies that were chosen for the project in some way already had defined the solution. Then, it was my job to apply a need on the pre-existing solution. The company that was originally part of the variable message size they wanted to develop a whole new signage concept inspired by the tube in London but for cyclists with different colors of different routes. We chose not to develop that further because we already have pre-existing bicycle infrastructure route schemes, we have green cycle highways, we have supercycle highways. To me, it did not bring added value but one of the minor elements were these dynamic message boards that was then developed as a prototype and throughout the process, we do have a need to enhance traffic flow for cyclists. That is a real need. (C6)

The interview with the municipality office working on super cycling highways provided another example of resisting the pro-innovation bias and looking for solutions grounded in the local context. Even though one of the goals of their project was to explicitly search for “innovative solutions” that could be later applied elsewhere, they did not feel forced to use smart technology (C16). Instead, they first defined a specific need of their target group based on surveys and then looked for solutions across the spectrum of possibilities.

Another officer working on cycling in Copenhagen mentioned that they have several needs—or instance, a better understanding of route choice and planning bicycle parking—with which smart technology, perhaps, could help. In such a case, they would be very interested in smart solutions (C11).

Next to the main reason—the possibility that technology will help to achieve policy goals—there are two other closely related reasons to partake in the smartification of cycling for cycling planners and advocates: the perception of the inevitability of the smartification of urban mobility in general and the desire to keep the central role of cycling in the modal split, also in relation to the emergence of AVs:

Technology is what is driving cities and the future in mobility right now. What we hear is that detection of cyclists is one of the big challenges for autonomous vehicles. Cyclists are the hardest to actually detect and for the car to judge what is the person trying to do. There is a challenge there to making sure that these manufacturers actually take the bicycle seriously and into consideration so that we don't end up with streets where it's necessary to fence off the streets to make sure that these cars can go without being stopped all the time. (C22)

This commentary suggests a complex dynamic at play: on the one hand, cycling may be forced to become “smarter” just as everything else—a form of indirect technology push, yet, on another, this also may represent a potential moment for empowerment. Thus, an officer from the municipality working on cycling and Intelligent Transportation Systems suggests that even though currently smart technology may be used to support the system in which car traffic is prioritized, it can also be used to prioritize cyclists, for example, by reducing waiting times (C19). Relatedly, one of the key officers in cycling planning in

Copenhagen argues that the lack of cycling data keeps cycling behind developments in other modes and that technology may help:

The technology is already in place for motorized transport and has been for a long time ... Cycling is just invisible because we don't have the data to bring them up in the screen to see the bicycle traffic. In a city like Copenhagen where 48 percent of all trips are done by foot or by bike, it's quite a large proportion of traffic that is just completely invisible. (C6)

One of the interviewees takes this idea even further and argues that smart technology can be a tool of reconfiguring mobility politics towards a system in which people will have more priority than vehicles:

I think it's very important to keep talking about the human element of mobility ... Now we have, hopefully, in most of the places, stopped talking about transport of vehicles and how to get those through but about how can we get as many people safe and fast through a city. I think that's where smart technology can really play a role as an enabler for us to make better and more sustainable mobility choices as the users. We can use technology to also make sure that it's safe to be a cyclist. This should benefit people. (C22)

This is an interesting aspiration in dealing with the indirect technology push: to use it towards a mobility future that centers people, not smart technology. The following section will examine more closely what "smartness" means in this context and its relationship to the low-tech nature of cycling.

What is the Relationship between "Smartness," Understood as Incorporating ICT/IoT Technology and the Low-Tech Nature of Cycling?

The enthusiasm for smart cycling innovation in Copenhagen is moderate. One interviewee juxtaposed smart technology to the "basic common sense" and maintained that Copenhagen already has "not technologies but techniques, and they work" (C2). Another interviewee refers to "boring" and "low-tech" solutions that are indispensable for a city that wants to have high cycling rates, such as separated infrastructure (C6). This point is supported by a specialist on cycling safety working at the Danish Road Directorate, who admits that cycling innovation can improve the cycling experience. However, other, already known measures may be more effective.

One thing we tried was this right-turn thing, where we had lights in here and close to the curbstone that would blink, because there were some loops here for turning cyclists. That was a trial project we initiated because it's really popular among politicians to have things that blink ... Really what we have known all the time is that you just need safer vehicles, you just need better vision, you need lower windows, everything has to be better. It's really bad the way car trucks are designed for urban traffic. This is what is being worked on in EU, but it's just not as sexy as putting lights. (C14)

Another cycling expert at the Danish Road Directorate talks about "the basis" and "gimmicks" that need to be used "cleverly," like automatic cycling counters:

What we've come to realize, what I've heard more and more is like none of the technology in itself can fix everything, it is the way we use the technology. (C10)

A municipality officer working on the project on cycling highways juxtaposes "good" solutions and "smart" solutions:

We have all this kind of smart solutions, but sometimes it's not the smartest solution that's the best solution. (C16)

This attitude resonates with how the bicycle is framed in degrowth literature and the discussion on pro-innovation bias in urban planning: cycling planning is “boring” and, while there can be some improvements, it demands no exciting “smart” novelties to work.

Smartification of Cycling in Amsterdam

The Role of Cycling in Smart City and Smart Mobility Initiatives in Amsterdam

Compared to Copenhagen, smart cycling innovation in Amsterdam plays a somewhat less significant role in branding Amsterdam as a smart city. Similarly to Copenhagen, one would not be able to find a coherent narrative on the role of cycling in smart city initiatives. This absence can be partially explained by the decentralized nature of smart city initiatives and the loose links of these initiatives to other roadmap and policy documents produced by the municipality (Raven et al., 2019). Amsterdam Smart City platform bears a distinctly decentralized character as citizens, entrepreneurs, and civil servants register their initiatives on the website without much top-down steering (for a detailed analysis, see Raven et al., 2018). Chief Technology Office (CTO) is an innovation team at the municipality of Amsterdam that collaborates with other departments and external parties in the sphere of innovation and smart technology. While they (co-)author and contribute to visions on smart mobility, they play a mediating and coordinating role in the field of collaborative smart initiatives and do not have an overarching vision of the smart city that drives their actions.

Cycling is relatively underrepresented in official documents and platforms dedicated to smart mobility and smart city: for instance, the Metropolitan Region of Amsterdam plan for smart mobility 2018–2022 (MRA, 2018) includes 11 references to cycling, 34 references to cars and driving and 14 references to self-driving vehicles. While the difference between these numbers is insignificant, one must remember that cycling makes for 48 percent of all trips in the city, whereas the use of driverless vehicles is still hypothetical. In 2020 only two out of 39 projects in the Mobility sector on the Amsterdam Smart City Platform focused on cycling; in 2021, no cycling projects were mentioned on the website (Amsterdam Smart City, n.d.). In the Smart Mobility Action Plan 2016–2018 (City of Amsterdam, 2016), there is some attention to the bicycle, with two out of 24 projects explicitly focusing on cycling. In the more recent Programme Smart Mobility 2019–2025 (City of Amsterdam, 2019), only one out of 29 projects specifically focuses on cycling innovation. Both documents include mobility projects that may include cycling and mention cycling as a mobility mode that is already prioritized and should be prioritized more. Smart innovation, according to the two documents, should help create more space for cycling and walking in the city and also solve issues resulting from massive bike ownership rates, such as crowded bike parking spots and difficulty finding one's bike in the city depot after the city moved it for breaching parking regulations.

According to two interviewees from the CTO office, the main reason for cycling is not very prominent in the smart mobility policy and smart city projects is that it is taken for granted:

Maybe one of the reasons that it's not very prominent is that it's such an automatism for us to cycle ... It's a great way of getting from A to B, and it's stuck in our culture. It's the natural thing to do. (A8, similar point made by A11)

Also, some interviewees mention insufficient coordination between teams working on smart mobility and smart cities and teams busy with cycling policy and planning, both at the municipal and national level: "Those discussions are held in different conference centers. They still have to meet up" (A20, similar point made by A11, A24).

When cycling *is* mentioned on the Smart City Amsterdam platform and in the visions (co-)produced by CTO, similarly to Copenhagen, smart cycling innovation is mobilized to serve the existing priorities in mobility policy, such as the perceived scarcity of space in the city center, especially in the context of bike parking as well as congestion, especially at the regional level. Thus, for instance, one of the key reasons to bring together smart technology and cycling is that the city is "increasingly under pressure." Since the "space will not grow," the city needs to use the existing space and the existing infrastructure "smarter" (A3, similar point made by A6, A7, A8). According to the former manager of the Smart Mobility program, while one of the means to do that is "discouraging cars," one can also consider how cycling could be differently organized, for example, through more bike-sharing, and how the city can manage increasingly crowded bike lanes (A8). Interestingly, the interviewee repeatedly compares bicycles to cars in that respect: how it is increasingly more accepted to share a car or not to own more than one car, whereas it is still normal to have more than one bike, and also that car parking is much more regulated than bike parking (A8). Those norms are probably hard to change as a bike "represents so much more" than a car: owning a bike is a strong element of Dutch cycling, and having a few bikes and having the freedom to park them almost anywhere have thus far been very important (A8). So, for the former manager of the Smart Mobility program, this remains an open question of whether smart technology can change that cultural norm in the service of "smarter" use of infrastructure (A8). A somewhat similar doubt about the possibilities of technology is shared by another city official involved in smart city projects as part of the CTO team:

The most obvious possibility is the decreasing space used by bikes through sharing, which is a mainstay of the smart narrative. It's a bit like the holy grail. What if we could all share our bikes then we would need fewer. There are an awful lot of bikes. At the end, if it still hasn't happened yet maybe it's not that important after all. (A11, similar point made by A6)

Thus, like in Copenhagen, local policy priorities shape engagement with technology. However, unlike in Copenhagen, there is some friction between the aspiration to optimize the use of space with the help of smart technology and the local mobility culture. What is peculiar about the role of cycling in smart city visions in Amsterdam, compared to Copenhagen, is that cycling is framed as a source of problems to solve *and* a solution. A quote from the Smart Mobility Action Programme 2016–2018 sums it up:

The objective of encouraging cycling innovation is greater use of bicycles, fewer abandoned bicycles, less but smarter use of space (by parked bicycles, for example) and assisting with cycling traffic flows. (City of Amsterdam, 2016: 33, translated from Dutch by the author)

Similar to Copenhagen, actors across the board, both involved in smart city projects from the side of the CTO office and cycling policy and planning, brought up techno-

solutionism and technology push in the discussion as trends that they observed and that, they believe, did not take hold in their city, at least not in the field of mobility they are involved in:

It's not ... because IBM says it's a good idea then we just need to implement it. It needs to work for us. (A11)

This CTO official compares this approach to past experiences:

Two years ago, a report was made in which a consulting firm actually advised the city of Amsterdam, "Self-driving vehicles are coming ... You need to really think hard about it. You need extra policemen and extra fences at crossings to educate the Amsterdammers that they should behave." Okay, this is the most ridiculous advice, this is turning the world around ... Two years ago, this was perfectly feasible. I don't think any consulting firm would now consult in a way like that. (A11)

The former manager of the Smart Mobility program makes a similar observation that also echoes the idea of "flipping" the techno-solutionist perspective articulated by the interviewees in Copenhagen:

We discovered that when we started that sometimes, for example, autonomous vehicles were regarded as a cool thing, and as a goal in itself, instead of a means through which to solve a problem. That's our new way of thinking: We have to look at area development What does certain area need in the broadest sense? How can we accommodate that, other than giving people parking spaces in the streets? (A8)

We thus see in Amsterdam a process very similar to Copenhagen of growing reflexivity and proactive approach in dealing with techno-solutionism and technology push.

The Rationales for Cycling Planners and Advocates to Engage in Smart Tech Projects

The analysis of the interviews with cycling advocates and officials involved in cycling planning in Amsterdam suggests that, similar to their colleagues in Copenhagen, they engage with technology, smart mobility discourse, and smart city agenda when it suits their goals. The "Long-term cycling plan 2017–2022" (City of Amsterdam, 2017) mentions cycling innovation in the context of bike parking issues and shows interest in "cycling-friendly" innovations that aim to make cycling more comfortable, such as rain sensors at junctions that invoke a longer green signal for cyclists when it rains.

Bike parking, especially around train stations, is high on the national transport policy agenda and very much so in Amsterdam. A representative of Transport Authority Amsterdam, a collaboration of 15 municipalities in the sphere of mobility, explains why they began investigating the possibilities of innovative solutions:

The most important thing was, we're going to work on innovations to optimize these parking facilities. And that can be putting more racks in the same space, but we thought, why not try to use one bicycle that is standing for 24 or 36 hours doing nothing, letting these bicycles fly in, fly out more often ... So, for us that maybe [is] the golden egg, the holy grail. (A2, similar point made by A6)

This priority stems directly from the Administrative Agreement on Bike Parking at train stations, signed by the national government, local bodies, including Transport Authority

Amsterdam, and interest organizations such as Cyclists' Union in 2016. The goal of the Agreement and thus of this search for the "holy grail" is combatting the challenge of scarcity of bike parking at train stations and the high costs of continuing to build extra facilities by, for instance, more efficient use of the existing infrastructure.

Investigating a "smarter" way of using parking space at and around train stations is also related to broader goals of maintaining the accessibility of the city and a modal shift—encouraging the switch from driving to using a bike-train combination (A6, A2). Apart from this central policy goal, the interviewees also mention crowdedness on bike lanes, the stress of cycling, and improving cycling comfort as essential policy objectives that innovation can support (A3, A6). At the regional level, the issue of congestion and modal switch to an e-bike plays a role: the initiative Bike Coalition Smart-City (in Dutch: Fietscoalitie SmartCity), which is the only cycling initiative in Amsterdam that by its very name establishes a connection to the smart city discourse, was co-financed by the national anti-congestion policy "Optimising Use" ("Beter Benutten" in Dutch) and investigated how to improve the experience of (e-)biking between the municipality of Zaanstad and Amsterdam (A7). We thus see again, much like in Copenhagen, the close connection between policy goals and the interest in innovation. While that does not exclude the possibility of pro-innovation bias and technology push, it does show that the interest in smart innovation takes very different paths in terms of areas of application in the two cities and is thus very much context specific.

We see some indication of a pro-innovation bias and technology push in how less prominent reasons to engage in smart cycling innovation are articulated. They include the momentum for smart technology in the mobility discussion, positive public attitudes towards technology, and financial stimuli to use innovation by their top managers (A2, A7, A22). Also, similarly to Copenhagen, there is a feeling of mild concern about techno-solutionism and possible dangers of smart mobility discourse centered on (self-driving) cars:

We should in any case be careful that we do not consider everything from the perspective of a self-driving car. The city is more than traffic ... It should keep being about interaction between people and not between machines. (A22, also A20)

Cycling doesn't need to be smarter, but if it doesn't become part of the picture, it will be forgotten ... Car will prevail. (A19)

What is the Relationship between "Smartness," Understood as Incorporating ICT/IoT Technology and the Low-Tech Nature of Cycling?

Most interviewees emphasize that the innovation does not need to be tech-heavy or "smart," understood as including ICT or IoT technologies (A2, A3, A6). Smart innovation can be helpful if it aligns with the policy goals and can make cycling more accessible and safer, but it is not essential (A18, also A22). Interviewees questioned the very notion of smartness and the notion of innovation, pointing out that some solutions that are not driven or facilitated by new technology can be necessary, such as a bicycle street, new designs for intersections, bike sharing and bike leasing (A2, A3, A4). Much like in Copenhagen, there is an attachment to the bike's simplicity, its "low-tech

nature, freedom, and autonomy that it offers, resonating with the celebration of the bicycle by the degrowth literature.

What is nice about cycling is that it is so accessible ... All the apps et cetera—I don't really see it happening, and I think that's also not what we [the city of Amsterdam] want. The bike is so free and easy. You don't want to sit with a phone on your bike ... You have to keep that freedom a bit like it is. (A6)

It's important to hold down a bit on the idea of innovations solving everything for biking. Because the bike is a really basic thing. It's just iron with a little chain on it. And that's also the strength of this ... If you make it less simple, it might be even people don't use the bike, because it's not easy and simple anymore. So, I think the strength is that it's so simple, but still, you can experiment and do innovations with it. (A2)

Also like in Copenhagen, the bicycle itself (and cycling planning perhaps, by extension) came up in the interviews as the embodiment of smartness: “Bicycle is the smartest thing that we have in Amsterdam and we should not lose it” (A4). All these quotes suggest not just the pride in the local cycling culture but also the resistance to the tech-driven visions of the urban mobility future and the relentless search for novelty.

Smartification of Cycling in Amsterdam and Copenhagen: An Overview

Having examined the views of various stakeholders on smart cycling and their motivations for engaging with smart technology, in this section, I am bringing the insights from the analysis together using critiques from the debates on smart cities, innovation, and mobility.

In both cities, *techno-solutionism* does not drive the smartification of cycling (though it manifests in a few projects in Copenhagen), and policy priorities are leading. In Copenhagen, the priority is travel time reduction, and in Amsterdam—a more efficient use of existing space and infrastructure and enabling more cycling and walking. In both cities, problems are framed independently from (and prior to) ideas for smart technology applications. In Copenhagen, some degree of *technology push* appears to be present, more so than in Amsterdam. However, the interviewed actors recognize and try to resist it. In both cities, there is *an indirect form of technological push*—a fear that cycling will “fall behind” and lose its place in the increasingly “smartified” mobility of the future. Interviewees in Amsterdam also discussed a related form of indirect technology push—a perceived momentum for smart technology among policymakers and the public. In both cities, *local policy priorities* are a clear driving force behind projects, and *local knowledge* informs policy and planning. In both Amsterdam and Copenhagen, *pro-innovation bias* is present to varying degrees, but innovation is not equated with “smart” solutions. Interviewees claim that they recognize and resist pro-innovation bias. Finally, in both cities, *the simplicity and low-tech nature of cycling* and cycling infrastructure are appreciated. Nevertheless, in Copenhagen, due to an indirect technology push, some perceive the low-tech nature of cycling as an obstacle for cycling to be strongly present in the smart mobility landscape of the future. In Amsterdam, the interviewees showed more attachment to the low-tech nature of cycling and discussed simplicity as a strength that may be under threat in the process of the smartification of mobility.

To sum up, the critiques of smart cities and smart mobility apply to the smartification of cycling only to a minimal degree in both contexts. Global tech industry interests do not

drive smart cycling innovation in these two cities, and the technology push does not override local policy goals and knowledge. Nevertheless, the results also show an interesting dynamic developing around what I have labeled an “indirect” technology push—the expectation that all mobility will become “smarter.” Some actors fear cycling will be “left behind” and believe it needs to catch up. In contrast, others frame cycling with its radical simplicity and reliability as a counterbalance to “shiny new toys” that have not yet proven useful.

Conclusion

Smart Cycling and Smart Cities: Toward a Proactive Approach to Technology?

In Copenhagen and Amsterdam, cycling does not play a prominent role in smart city initiatives. When smart technology is incorporated into cycling projects, this is usually not a result of techno-solutionism or technology push. The smartification of cycling is driven by specific local policy priorities in these two cities. Copenhagen focuses on increasing time savings as part of its climate change mitigation policy, and Amsterdam grapples with the pressures on existing space and infrastructure. Techno-solutionism and technology push, according to the interviewed stakeholders, have lost ground in urban policy and planning in recent years. Technology appears to be a complementary tool even for city officers whose mandate is to work on “smart” solutions. They acknowledge that there has been a period of “hype” around smart technology but claim that they have become more critical and proactive in dealing with it. Why have they been able to “flip” the perspective and resist techno-solutionist logic and technology push? First, it might be the case that technology push and techno-solutionism have never been very strong in the sphere of cycling as it has not been seen as a lucrative business case by the global tech industry. Second, it might have been easier for these successful, almost iconic cycling cities to pursue a proactive approach and mobilize local, grounded knowledge in solving challenges with confidence than it would be for aspiring cycling cities.

Smartification of cycling thus presents an interesting case for understanding how the logics of smart city approaches, closely connected to the tech industry’s interests, operate and are contested. Further research could investigate these dynamics in other cities and policy contexts to understand the impact of techno-solutionism and technology push on urban policymaking and how it has evolved over the last couple of decades.

Does the Bicycle Need to Become Smarter? The Indirect Technology Push and the Futures of Urban Mobility

There is some hesitation in Copenhagen and Amsterdam about the necessity to smartify cycling, at least beyond what the pressing policy goals may demand. It seems relatively easy for relevant stakeholders in both cities to discount the direct technology push (technology companies offering their services). However, this research has identified the presence of an indirect technology push—an idea that smart technology will be central to the future of mobility. Cycling officers and advocates in the two cities are uncertain about what it may mean for cycling. The simplicity and low-tech nature of cycling are paradoxically seen as both the reason for its resiliency in ever-changing urban conditions—its own brand of “smartness”—and its potential vulnerability to the pervasiveness of smart technology.

Some stakeholders believe that the bicycle might need to catch up in order to survive and thrive in the “smart” future of mobility. Actively embracing smart technology, they think, can help make cycling even more central and, perhaps, even advance a vision of a people-centric smart city. Others emphasize the need to protect the simplicity of cycling, which might have been critical for its accessibility and success. The process of smartification of cycling thus exposes the dilemmas of urban policymakers in engaging with smart technology. The questions for future research are: What choices will policymakers worldwide be making facing these tensions? Will they embrace the “inevitable” smartification and adapt to it, use the momentum for smart technology and mobilize it to create more room for cycling and “people-centric” cities, or will they question the inevitability and necessity of all our mobility having ICT or IoT element? Future research could examine what shapes the conditions of decision-making around these choices.

Notes

1. From the interview with an official from the City of Copenhagen, Intelligent Transport Systems team.
2. Here, I draw on a definition from Alexander and Yacoumis (2018): “a technology can be considered ‘low-tech’ if it does not require electricity or fossil fuels to operate, or if it relies on passive or direct (non-electric) solar, wind, or human-powered energy” (1841).
3. The number is slightly higher for the Amsterdam case as I included interviews from a parallel research project on smart cycling technology in which I added a block of relevant questions.

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Note on Contributor

Anna Nikolaeva, Amsterdam Institute for Social Science Research, University of Amsterdam, Postbus 15629, 1001 NC Amsterdam, The Netherlands

ORCID

Anna Nikolaeva  <http://orcid.org/0000-0001-8507-2772>

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