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Practitioners' perspective on user experience and design of cycle highways

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ABSTRACT

Cycle highways, also known as “fast cycle routes”, are an emerging concept in urban planning that describes long distance, high quality bicycle routes built for commuter use. In Northern European countries, large sums of money are invested into cycle highways promising to induce a mode shift with little critical assessment as to how cyclists experience these infrastructures. Through eleven interviews of practitioners from five European countries – the Netherlands, Belgium, Germany, United Kingdom and Denmark – this paper explores how practitioners define cycle highways and how their conceptualizations of cycling experience shape the physical design of cycle highways. Results show that while practitioners are guided by infrastructural standards for cycle highways such as width, design speed, and intersection treatments, it is less clear how these infrastructure elements fit within the surrounding environment to create desirable cycling experiences. In addition to commuters, cycle highways are also used by recreational and sport cyclists, so policy makers and designers should consider a wide variety of user groups and their aesthetic and social experiences in the planning and design of cycle highways. Future research should investigate cycle highway experiences from the perspective of various user types.

1. Introduction

Cities around the world are building cycle highways to encourage sustainable inter-urban transport using bicycles, e-bikes, and other forms of small wheeled vehicles (Pucher and Buehler, 2017). To further reduce automobile use and to promote physical activity, environmental sustainability, economic growth, and accessibility, cities in Europe have invested in a variety of infrastructure and policies to improve the attractiveness of cycling (Buekers et al., 2015). Cycle highways are often framed within a package of interventions, along with improvements to public transport, with the intent of changing commuting behavior by substituting investments in road infrastructure to cope with expected commuter traffic growth (Skov-Petersen et al., 2017). From general cycling research, we know that cycling becomes relatively less attractive compared to other modes as trip distances increase (Heinen et al., 2010; Scheepers et al., 2013). Cycle highways seek to encourage cycling for longer distance commuting trips, and survey data from governments seem to suggest that users of cycle highways do indeed tend to take longer trips (“Cycling Report for the Capital Region”, 2016; “FIETS-GEN studie Eindrapport”, 2012; Faber). On a policy level, Rayaprolu et al. (2018) attribute cycle highways to a Dutch concept in response to “rising environmental and health consciousness, and the growing popularity of electric bicycles”. At the time of writing this paper, there are major cycle highway routes and networks being

planned and constructed in northern and western Europe (Rayaprolu et al., 2018). The Netherlands was the first to experiment with the cycle highway concept with demonstration routes in Tilburg and The Hague in the 1970s, yet modern designs have only been implemented since 2004 (ter Avest, 2015; Kristjansdóttir and Sjöo, 2017). More recently, the concept of “Cycle Superhighways” has been popularized in the English media with London opening its first routes in 2010 and having eight completed as of 2018 (“Cycle Superhighways”, 2018). Copenhagen opened their first cycle highway in 2012, with fifteen planned for 2021 (“Cycle Superhighways Capital Region of Denmark”, 2018). More recently, Germany began executing their first plans for cycle highways with three pilot projects in 2012, following examples of cycle highways from the Netherlands, Copenhagen, Belgium, and London (Thiemann-Linden and Van Boeckhout, 2012). Similarly, the Netherlands is planning a nation-wide network of bicycle highways that connect urban cores.

As more attention, funding and projects utilize the language of cycle highways to improve cycling numbers, there does not appear to be a clear understanding among design and planning professionals and policymakers of what cycle highways *are* and what they *should be*, with evolving conceptualization of its design and purpose. For example, the first generation of cycle superhighways in London, built in 2010, was little more than blue paint on high traffic roads. London's new cycle superhighways have since evolved towards more “continental” design, incorporating elements such as traffic separation and protected intersections (“Evolution of cycle superhighways in London”, 2018). The European Cyclists' Federation CHIPS project defines cycle highways as, “... a mobility product that provides a high quality functional cycling connection. As

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backbone of a cycle network, it connects cities and or suburbs, residential areas and major (work)places and it satisfies its (potential) users" (Faber). However, there are multiple terms that could be used almost interchangeably to describe similar typologies, such as "cycle super-highways", "greenways", "high quality cycle paths", "through cycle routes", and "fast cycle routes" to name a few. Without a clear definition and especially given the variety of languages used to describe the cycle highway concept, it is difficult to assess the performance of cycle highways as an intervention and to transfer knowledge about successes and failures, especially across countries. It also blinds us to underlying, and contested, assumptions of what cycling is, or ought to be.

Currently, using the terminology of "cycle highway" might be strengthening an underlying vehicular approach to bicycle infrastructure design. In relation to this, Dutch practitioners Sargentini and Valenta (2015) warn that bicycle paths should not be built with the same logic as automobile highways and instead should take cyclists' embodied experiences and a variety of individual motives into account. They urge practitioners to stay away from car-oriented thinking, moving beyond A-to-B logic, and proclaim "do not make cycle highways into car highways!" (Sargentini and Valenta, 2015). This plea for the unpacking of the black box of travel by developing a more nuanced understanding of the journey is echoed by mobilities researchers who have conceptualized travel in terms of meanings and experiences (Sheller and Urry, 2006; Spinney, 2011; Jensen et al., 2016; te Brömmelstroet et al., 2017). There is also tension within the concept "cycle highway" itself. On the one hand, cycling has an experiential element that scholars have attempted to conceptualize in relation to aesthetics, emotions, and spatial design (Stefánsdóttir, 2014; Forsyth and Krizek, 2011; Spinney, 2009; Krizek, 2019; Liu et al., 2018). Yet, the term highway seems to place this type of infrastructure more in common with the logic of automobile highways; focused only on the fast and efficient transport of people and goods (Koglin and Rye, 2014). Hamilton-Baillie (2004) conceptualized traffic zones versus social zones as realms of competing logic, both physically and conceptually. Hamilton-Baillie defines the traffic zone as "single purpose, uniform, regulated, impersonal, and predictable", whereas the social zone is characterized as "multi-functional, diverse, culturally defined, personal, unpredictable". On a street, these zones are demarcated by the sidewalk for pedestrians and the roadway for motorized vehicles. Where do cycle highways belong on this scheme, and what design logic do cycle highways currently follow? To what extent do practitioners pay attention to each aspect of Hamilton-Baillie's logic, and do cycle highways seek to create a unique zone for the cyclist, taking into account Forsyth and Krizek's unique perspective of the cyclist (Forsyth and Krizek, 2011)?

In academic literature, cycle highways have been analyzed from a few perspectives. From bicycle counter data and three questionnaire campaigns, Skov-Petersen et al. (2017) analyses Copenhagen cycle highways in the framework of induced travel demand, cyclist satisfaction and competition for funding. From the a public health perspective, Buekers et al. (2015) estimates health impact of modal shift due to two cycle highways in Flanders, Belgium. From the physical design perspective, Kristjansdóttir and Sjöo (2017) provides a technical review of European cycle highway standards in the Netherlands, Denmark, United Kingdom, Germany, Norway, and Sweden, focusing on engineering criteria such as infrastructure type, intersections, markings, lighting, width, curve radii, etc. This paper seeks to develop an understanding of how practitioners define cycle highways and how they conceptualize users, experiences, and design in relation to cycle highways. Cycle highways incorporate many of the elements known to improve the attractiveness of cycling, such as priority crossings, rest areas, lighting and effective wayfinding (Thiemann-Linden and Van Boeckhout, 2012). While these measures have been shown to improve the attractiveness of cycling routes (Heinen et al., 2010), there is a relatively little academic research on how these elements impact the experience of cycling and none to date that explore practitioners' conceptualization of cycling experience. Thus, our research questions are:

1. What are the main concepts used to describe and define cycle highways by practitioners?
2. How do practitioners articulate cyclist types and cyclists' motives within the conceptualization of cycle highways?
3. How is cycling experience conceptualized by cycle highway practitioners?
4. How is the perspective of the cyclist reflected in the design of cycle highways?

2. Methodology

2.1. Selection of practitioners

We interviewed practitioners from five European countries that are actively working on developing cycle highway networks – the Netherlands, Denmark, Germany, United Kingdom, and Denmark. To select interview participants, an initial search was conducted of internet and media reports of cycle highway projects that are either recently constructed, under construction, or being planned in the near future. Particular attention was paid to northern and western European countries in which cycling is relatively matured (Pucher and Buehler, 2008; Vandenbulcke et al., 2009). London, although with lower cycling rates, has been actively building a cycle highway system.

From the list of projects based on geographic location, expert government practitioners were selected for interview based on their associated project, their position in the organization, and their work portfolio having contained cycle highways. Interviewees for this research hold, or have previously held, positions in regional or provincial governments working on cycle highway projects for at least two years; the time in their position is used as an indicator of their familiarity with the subject area. Given the relative novelty of cycle highways as a concept, none of the interviewees had a formal education in cycle highway planning and design, and perhaps due to the novelty of the cycle highway concept, none spent more than ten years working on cycle highways. All interviews were conducted in English (Table 1).

2.2. Interview structure

We followed a semi-structured interview format, consisting of four sections. These sections ask practitioners about 1) the general concept of cycle highways, including their typology, differentiation, and best practices 2) the cycle highways they have currently worked on, including design priorities, good and bad aspects of design and target users 3) describing the ideal cycling experience, and relating this ideal experience to any considerations of cycling experience in the design of the case study cycle highway and 4) the professional role and knowledge sources of the interviewee, including the focus of their work, extent and type of their professional network, experience with cycle highways, and use of professional and academic sources on cycle highway design.

Each interview lasted between 45 min to 1 h, and participants were encouraged to share personal anecdotes where relevant to the question. Interviews were recorded in person or through recorded telephone or internet voice call. Interview data was transcribed then coded inductively focusing on the following themes: 1) definition of cycle highways, 2) design of cycle highways, 3) user types and trip purposes, and 4) experience of cycling. (See Appendix A for interview script). After transcription of the interview and coding for themes in the interview answers. These themes then formed the basis for the findings of this paper.

3. Findings

3.1. Competing logics

The interviews begin by establishing how cycle highways are defined. Participants were asked, "what is a cycle highway?" and "what makes cycle highways distinct from other types of infrastructure?" Participants

Table 1
Interview participants, affiliations, and their cycle highway projects.

Interviewee	Project	Affiliation	Role	Department
UK1	Cycle Superhighway	Transport for London	Design Manager	Engineering Directorate, Highways and Traffic
UK2	Cycle Quietways	Transport for London	Senior Engineer	Engineering
BE1	F1	Province of Antwerp	Policy Member	Dienst Mobiliteit
BE2	F1	Province of Antwerp	Policy Officer	Dienst Mobiliteit
BE3	F3	Provincie Vlaams-Brabant	Policy Officer	Dienst Mobiliteit
GR1	Radschnellweg Mannheim-Heidelberg	City of Mannheim	Traffic Planner	Department of Urban Planning
NL1	RijnWaalpad	Province of Gelderland	Coordinator	Cycling Team
NL2	RijnWaalpad	Royal Haskoning DHV	Bicycle Mobility Advisor	Transport and Planning
GR2	RS1	Ruhr Regional Associations	Project Manager	Regional Development Department
DK1	Cycle Superhighway	City of Copenhagen	Project Leader	Office for Cycle Superhighways
DK2	Cycle Superhighway	Rødovre Municipality	Road Engineer	Road and Traffic Department

responded with reference to three general themes, representing competing logics that are implicit in the discourse surrounding cycle highways. These logics contextualize the extent to which cycling experience plays a role in current discourse among practitioners. Broadly, these categories are:

1. Political context, jurisdiction, and funding
2. Infrastructure and environmental quality
3. Directness, efficiency, and competition with other modes

Cycle highways are defined differently among the practitioners interviewed, varying among responses coming from the perspective of policy makers, designers, and engineers. Some respondents feel there is no clear definition at this point. NL2 states, “I’ve got no clue. I’ve been working for 10 years in it, I’ve got no clue, but it really depends on who you ask. I think that’s a proper answer.” Policy makers have also framed the concept of cycle highways differently depending on the state of political priorities. In reference to the Netherlands, “Probably the answer in the coming four years is that it will help us reduce our carbon dioxide emissions, and maybe in the four years after that it might contribute to a healthier city. . . . By strategic positioning of projects as a cycling highway you see that it gets us more attention and gets us more political attention and thus you can get more funding, and then suddenly you can also become more ambitious as a matter of fact, and you can invest more” (NL2).

Cycle highways should also distinguish itself from other cycling infrastructure by having a distinct character achieved through signage, infrastructure design, and environmental quality. GR2 states, “at the first glimpse, you should see it’s more than an ordinary bike path, meaning there should be a special design, a special color scheme, and unique signage of the cycle highway, so you see that it is not just an ordinary bike path, but that you have really a special way for cycling.” When asked about taking cyclists’ experiences into account, BE2 says there is a growing realization of the importance of the surrounding environment adjacent to the bike path, stating, “we are struggling with that question because, our main goal, what our politicians asked from us, is that we build a clean, smooth, and wide infrastructure, and there is not really a real vision about how a cycle highway feels and what it has to offer alongside this infrastructure.” Definitions of cycle highways tend to require high quality cycling infrastructure, yet quality is defined in terms of minimum physical design standards and lacks a vision for how physical design relates to improving the cycling experience.

Some practitioners choose to define cycle highways primarily through a political lens in relation to jurisdiction and funding. UK1 emphasized the importance of allocating cyclists’ own space on the street and distinctive branding, yet jurisdiction boundaries can limit the types of infrastructure that can be built. UK1 gives the example that Transport for London only has jurisdiction over major arterial roads, so London’s Cycle Superhighway infrastructure is built on heavy traffic corridors. Given this limitation, London’s Cycle Superhighways focus on creating an easy to follow route from the suburbs to central London. In the context of Copenhagen, cycle highways must go through many municipalities with different objectives and political agendas, so compromises are made in the quality

of routing and design elements where political boundaries are crossed. In practical terms, “it means some municipalities are not very ambitious. They must do what they need to do in order to get it approved” (DK1). Thus, cycle highways are also distinguished from other cycling infrastructure through their strategic relevance on a regional and national level, in many cases requiring cooperation from many municipalities in order to realize a continuous cycle highway route.

In addition to physical design and political context, a third logic is revealed through the language used to describe geographic connections and relative efficiencies over a larger scale. These descriptions place cycle highways in relation to traffic network and urban planning goals. Interviewees conceptualize cycle highways as providing the fastest, most direct, and most efficient route between two places over relatively longer commuting distances, directly connecting suburbs to urban centers. “To bring them (cyclists) from A to B, without lots of interference with other traffic and giving them their own space is crucial. But that’s the dream. In reality, we do not always achieve the high level that we want.” (BE2). Another goal of cycle highway is to encourage people to switch from cars to cycling, especially for commuting trips, where convenience is a key factor in accomplishing this goal. The German RS1 case reveals that the literal translation of the term “radschnellweg”, or “bicycle highway” is taken seriously in the marketing of the route. The RS1 logo is one of a bicycle imposed on a recognizable blue sign used to represent the German Autobahn network ([Radschnellwege in NRW, 2014](#)). UK2 also relates cycle highways to the design of motorways, “I would say it is a dedicated cycle facility. And one that is a pretty fast and direct. If I was thinking what a highway is and then applying it to cycling, that’s what I come up with.”

These definitions of cycle highways by practitioners illustrate that the existing logic of cycle highways seeks to implement an engineering-based criteria of cycle highway design that is limited by funding, ambitions, and cooperation among bordering political entities. It is clear that conceptualizations of cycling experiences are missing from initial definitions given by practitioners, even though interviewees have an intuitive sense that the experiential elements play a role in improving the attractiveness of cycling trips.

3.2. User differentiation by motives, demographics, and vehicle types

After defining cycle highways, practitioners were then asked about their conceptualization of relationships between the various users of cycle highways and to their cycling experiences. In general, practitioners prioritize commuter cyclists’ needs and design cycle highways with home-to-work journeys in mind. “The question is, for what do we design it for? We do it for the commuters etc., and they want to spend the least time on mobility and transportation, so that means they want to get A to B in the shortest time” (GR2). There are other cyclist needs, but the primary target group of cycle highways is commuters who want to minimize their travel time. “If you are doing it via greenways etc., it may be the case that it takes much longer and that is okay if it is about leisure activities on the weekend, but I think most of the people just want to get to their destination quite quickly” (GR2).

Cycle highways should also be inclusive for users of all ages and abilities. BE2 says, “when we design or a cycle highways we try to design them for eight year olds so they can cycle independently from A to B.” But problems may also arise from the mix of users on the cycle highways, and how they interact with each other. “We have a problem from certain cyclists. . . the more soft kindergarten children, elderly. And when we used the words FAST as a term to define a cycle highway. . . , then you refer to what people see when they think about the highway and, and they think SPEED. It’s a real discussion. Some people are afraid because of the high speeds.” BE1’s response considers how the faster speeds of speed-pedelets (fast e-bikes) and sport cyclists creates potential conflict with the needs of more leisurely commuters, “There are also people who bike more at ease and they say, ‘I don’t want to hurry.’ These people also want to use the cycle highways. Cycle highways are also for them.” BE2 then mentions the problem of understanding and accommodating cycling experiences of different people, “We have some colleagues who are older. They like something else compared to the younger ones. Men, women, and children may also like different things, so you try to make something one fits all or, or, at least appreciated by different target groups.”

Like in more famous cycling contexts Copenhagen and Amsterdam, urban tourists on bikes are a category that is being recognized in London as well. “. . . there’s now at least three, probably four companies who do cycle tours around central London, and they all use the super highways more or less to get round the tourist sites and obviously with the London cycle hire, you see a lot more people cycling along the inner superhighways, whereas before they would have kept themselves to the parks instead of the road” (UK1). Hence, UK1 sees different users for each part of the cycle highway network, “[We want to] to get commuters in from the outside to central limit and then get them out of the cars. I would say the central part of the behind is we’re much more than designed with recreational use in mind as well, so we don’t just design something for the morning rush and the evening rush”.

While it is clear that cycle highways are primarily designed for commuters, practitioners are well aware of different experiences as perceived through different people. In addition to commuters, users are differentiated by their trip purpose (sport cyclists, leisurely recreation cyclists, commuters, etc.), their vehicle (e-bike, normal bike, etc.), and age (children, elderly, etc.), and gender. Although the primary target audience of “commuters” is clear, cycle highways should also be designed with different users in mind.

3.3. Elements of experience

Safety is the most frequently mentioned topic in relation to cycling experience, and traffic safety is the main concern for practitioners in Germany and the United Kingdom where cycling rates are lowest. There is a perceived tradeoff between traffic safety and expediency, especially when handling cyclists at intersections. UK2 states, “I think in the Quietways, [as opposed to Superhighways], there’s perhaps a perception that cyclists emphasize safely. So the idea is that when you get to an intersection, you may not have an advantage over traffic, but. . . you will be able to cross safely.” UK2 emphasizes social safety in addition to traffic safety, saying, “[In] isolated areas like parks or down under, under railways or through subways, we seek to enhance or improve security conditions. I suppose the word is social safety. . . under the healthy streets approach now that is even more important”.

It is also a variety of experiences along a route that seems to be important. There may not be one ideal cycling environment, but a combination of environments with transitions to give variety to the cycling journey may be more ideal. GR2 states, “you are also passing through greenbelts and then you have the rural experience of just being in the countryside, so it is a mixture of both urban areas and rural parts. So that makes it quite attractive because you have both experiences being on the cycle highway” Design considerations change when designing for long distance versus short distance journeys, and DK1 emphasizes both the social and sensory aspects of cycling, and how these relate to a sense of time. “Longer

distance, especially commuting and in that sense if time is important for you, but also the experience as a cyclist you just like dealing with pedestrians, you like to have something to look [at]. You like to have other people around you, so I think to that extent it’s possible, you should definitely try to have the cycle highways away from car traffic with the noise. And have it in places where it’s either really beautiful or there’s other people around that you can look at it because it’ll make time fly by. And also, that’s what you can do on a bike. You interact with your surroundings.” Practitioners from Flemish Belgium reflects on the similarity of their cycling culture compared to the Netherlands in that cycling is seen as a social experience, highlighting the importance of being able to cycle side by side, especially over long distances on cycle highways.

GR1 gives a vivid account of the journey experience, from a spatial perspective alluding to many of Kevin Lynch’s (1960) ideas about navigating and experiencing the city. GR1 describes, “For example, when you go on the cycle highway, you see the biggest inner-city tower or something that you want to reach. Like when I go. . . I live in Heidelberg, it’s 20km from Mannheim, when go cycling to the office, I always see the Television Tower of Mannheim, so you see it getting closer and closer and you think, ‘I’ll get there.’ It’s not hard stuff, but the soft topics should not be ignored and there should be no feeling like ‘How much longer will it still take?’ . . . You should say, ‘Ah, how fast that my ride is over now!’ so when you reach your office, it should be like ‘Ah, I want to continue cycling. . . the weather was so nice, etc.’” UK2 mentions wayfinding as an important aspect of experience, “I think having that certainty of where you’re going, where you’re going or what’s close to you is a big deal. There’s nothing like going out on a bike and like kind of embarking on a journey through a network and then you get lost and your confidence will just drop and you need to use your phone.” DK2 remarks cyclists should feel like they are part of the traffic picture. “People should have a good time while using cycle highways. . . and feel like they are contributing by taking the bicycle instead of the car.”

Overall, visual aspects of experience were mentioned, including greenery, nature, and landscape. Landmarks are an interesting case that represents both an element of aesthetic pleasantries as well as wayfinding reference points. Participants also made the distinction between urban and rural environments, and mentioned the importance of these transitions and variations as important to creating an interesting cycling experience. Non-visual experience includes noise, weather, and comfort in relation to the quality of the infrastructure. In terms of comfort, surfacing is an aspect that was deemed an important factor, with overall quality determined by materials, construction quality, and maintenance. There are also differing views on cycling together with other people. Some pictured a solitary cyclist on the highway in the countryside, while others talked about the pleasure of being able to interact with others. Others mentioned the ideal cycling experience as one that provides opportunities for “serendipity”, or “being able to ride hands free”, and perhaps good design is one that enables these experiences as well.

3.4. Design considerations

Width, quality standards, and intersections are the main concepts mentioned in relation to design. Practitioners say they refer to design standards to guide their work but many cite difficulties when the ideal physical requirements of cycle highway design conflict with other uses of space in urban settings. For example, GR2 refers to the design standard for cycle highways in Germany, which is ideally a 4 m, bi-direction cycle path with a 2 m path for pedestrians ([“Feasibility Study Radschnellweg Ruhr RS1”, 2014](#)). However, participants recognize that segregated cycling infrastructure is not possible on streets where space is limited in the central city, so mixing or separation of bicycle traffic from motorized traffic seems to be a recurring design consideration in urban environments. Even though high quality is frequently mentioned in describing the design of cycle highways, it is unclear what exactly high quality entails.

We don't say what this high-quality means in the definition. It's more a functional definition, but it means that you have higher quality than just normal cycle infrastructure... The problem with qualities, you could say we need, for instance, four meters wide and not too much pedestrians, or if there are a lot of pedestrians, you have space for the pedestrians like in the RS1 in Germany. In the practice, you could also have sometimes just a quiet road where you have a little bit mixed with cars.

(BE3)

Where cycling infrastructure is relatively new, for example in the context of London, cycle highway designers have started recognizing cyclists as road users with their own needs, distinct from the needs of pedestrians or automobiles. UK1 states,

Instead of being either treated as pedestrians, you put them on the foot way or, and treat them as a traffic and put them in with general traffic... you design specifically for the cyclists, at the start of your scheme instead of trying to put a cycle facility almost as an after-thought to your designs. Yeah, I would say that's probably the biggest change is that cyclists are now thought of right to the start of a project instead of as a, Oh yeah, we just need to do something. Let's put a little bit of wide lane in or bit of paint for them.

(UK1)

Some practitioners also emphasize the perspective of cyclists in the design process. BE2 explains that cycling infrastructure is best understood by those who have experience using them. "In cycle infrastructure it is the Flemish road agency that designed a lots of cycle paths, but they are engineers who don't cycle and then you see the difference" (BE2). DK2 uses the example of traffic lights to illustrate a counterintuitive example that highlights the behavior of people in response to unreasonable infrastructure. DK2 says, "the worse thing is always, of course, is when you have a good speed on the bicycle then you have to stop for a red light." DK2 continues, "we must be aware that if they feel annoyed by stopping, they will actually try to break the red lights and that could lead a situation where they actually have some accidents which you could perhaps have avoided because they get impatient." So, it seems that not losing momentum, especially on a human powered vehicle, is an important part of the cycling experience, and designing around this experience can also help cyclists negotiate traffic safely. Cycling experience also depends not only on design, but on the behavior of others. BE2 remarks, "we have to be respectful to each other. It's a soft mode of transport."

Practitioners agree that the design of cycle highways cannot be wholly copied from automobile infrastructure, "It's not my aim to make a copy of highways now to cycle highways because it's different. Cyclists are not motorists. They have other needs. You can't just copy paste. It's not possible. It's not a good idea." (BE2). Yet BE3 suggests the aesthetic considerations of scenic parkways in the United States can serve as inspiration for some aspects of cycle highway design, "even motorways are sometimes designed from the point of view of pleasure in a way. You could find some interesting examples where you add a slight bend where you look at the landscape and the scenery. I think in the United States, sometimes they have beautiful examples." This sentiment resonates with ideas from Appleyard, Lynch, and Myer's *The View from the Road* on how to design landscapes and environments to be enjoyed on the move (Appleyard et al., 1965). However, BE3 cautions, "of course you have to be careful with comparing with motorways, but I think for cycling, and that's really important point... one of the motivations to cycle is also the pleasure of cycling, and doing something healthy, and working on your condition, and enjoying the environment, and nature, and the weather, et cetera. And if we want people to commute more, we want to, we have to think about their motivation to commute".

Traffic logic is also implied in wayfinding signage, directing cyclists to go the fastest route, not necessarily the most scenic, "Cycle highways are directed at commuters who go to work, and serves a wayfinding function to signal the most direct route to follow." (DK2). DK1 mentions the

importance of providing alternatives to fit cyclists' desires for directness and experience, especially through built up areas. "We have these route that runs along an old railway line and it actually goes right through Copenhagen. But it will never be the fastest route, because it curves a lot. But it's just so much more fun to take it. The infrastructure's good but you go through parks and squares and there's something happening along the entire route, so I think that would be a case of if you want to go really direct you would take one of the main roads along with people cars. Or, if you want to experience something, you would take the other route. It's also just a trade-off what can actually be done here because there's already a city." The conceptualization of design varied in scales of analysis, from detail design such as smoothness of pavement to cycle path width, to more network level characteristics such as route connectivity and directness. Experiential elements such as enjoyability, convenience, safety, and attractiveness are often mentioned in relation to physical design, along with concrete ideas such as design speed, traffic separation, curves, traffic volume, and other measurable variables. Although designing for good cycling experiences is not prescribed by design standards, practitioners try to incorporate their own intuition of good design with the goal of making journeys more pleasant for cyclists.

4. Discussion

4.1. Defining cycle highways

Practitioners gave two types of cycle highway definitions, with one relating to goals and another relating to execution. Policies set out visions and goals that cycle highways should fulfil, while design manuals attempt to translate these visions and goals into physical design. Bridging policy and design manuals are funding requirements that define what types of infrastructure qualify for regional and national funding schemes. A definition in terms of goals refers to matters of policy, such as sustainability, traffic congestion, and the desirability of a fast, efficient, and equitable transport system. A second type of definition focuses on the design of cycling infrastructure to meet these goals, such as speed, directness, width, quality standards, and signage. The two types of definitions can be linked by examining how good design can serve policy goals. Practitioners believe that good design of cycle highways can induce commuters to cycle instead of travelling by car for commuting, and the main mechanism for this modes shift is better comfort and travel time and cost savings. This logic of using cycle highways to induce mode shift is tested by the research of Skov-Petersen et al. (Skov-Petersen et al., 2017), on a Copenhagen case study, yet they found that most of the increased cycling along the new cycle highways is the result of cyclists switching from alternative routes, with "only a modest share (4–6%) of the bicyclists on the renewed routes switched to cycling from other transport modes" (Skov-Petersen et al., 2017). At the same time, their surveys showed improved cycling experience along the new route in terms of surface quality, lighting conditions, traffic safety, and personal safety (Skov-Petersen et al., 2017). These research findings suggest that cycle highways may not be meeting their desired policy goals for shifting commuter traffic towards cycling, but higher quality cycling infrastructure still impart benefits for existing cycle commuters and recreational cyclists. Thus, defining cycle highways in relation to the policy goal of achieving mode shift may not fully capture the intrinsic benefits of higher quality design that makes cycling a more comfortable mode of travel for existing users.

4.2. Non-commuting uses of cycle highways

Cycle highways are a challenge for practitioners because it is unclear how related concepts such as "high quality", "functional", and "attractive" should be interpreted and how these criteria can be translated into physical design. On a policy level, cycle highways are conceptualized as functional infrastructures to reduce automobile congestion by encouraging commuting by bicycle (CHIPS, 2016). Yet, even with measures to improve directness and flow, the slower speed of cycling over longer

distances cannot compete directly motorized modes in terms of minimizing travel time. Attention to the quality of the surrounding environment can make cycle highways more attractive not just on the basis of time savings, but also for creating a pleasant experience for cyclists (Forsyth and Krizek, 2011). Practitioners are aware that the same cycle highways built to attract commuters also draw other uses such as recreation, sport, and tourism. For urban designers, these uses are considered optional activities that highlight the intrinsic attractiveness of cycling in relation to the environment, and a high level of optional activities are indicative of good quality physical environments. In reference to pedestrians, Gehl (2011) defines optional activities as, "... taking a walk to get a breath of fresh air, standing around enjoying life, or sitting and sunbathing. These activities take place only when exterior conditions are favorable, when weather and place invite them" Gehl (2011). For cycling, a high proportion of non-commuting activity is an indication of good spatial quality, which also benefit commuter cyclists through intrinsic benefits such as better familiarity with one's surroundings, connection with other people, freedom and cognitive stimulation (Krizek, 2019). It is likely that commuter cyclists enjoy the positive intrinsic benefits of those gained by non-commuting cyclists, plus the quantified health, cost and travel time benefits of cycling (Buekers et al., 2015; Rayaprolu et al., 2018).

4.3. User experience from a cyclists' perspective

Practitioners recognize the importance of designing for a good cycling experience. When asked about what makes for an ideal cycling experience, interviewees engaged in broader concepts such as greenery, noise, weather, landscape and moving scenery. Practitioners benefit from being able to view a design in relationship to the potential experiences of people that their infrastructure seek to serve, and we found that practitioners draw extensively on their own experiences to talk about cycle highway design. A recent Dutch study by Goudappel Coffeng found that large enough differences between respondents that there is no average cycling experience and that it is more informative to understand cycle routes from the perspective of different cyclists. They identified five different user types and found that many people cycle for both commuting and leisure, so there is not always a clear relationship between individual trip purpose and the characteristic of the cyclist (Kalter and Groenendijk, 2018). A diversity of speeds on the cycle path also leads to a social problem of interaction between various users of the space (te Brömmelstroet et al., 2017).

It seems that the challenge with cycle highways, in the model of Hamilton-Baillie, is the quest to provide a uniform, regulated, and

predictable environment for faster cyclists while also providing enough variety to satisfy the desire for a diverse, personal, and serendipitous environments for more relaxed, leisure cycling. Public transport research shows that the subjective feeling of waiting for a bus feels twice as long as being underway, and waiting time can be subjectively reduced by giving passengers an indication of expected arrival time (Fan et al., 2016). The same logic can be applied to traffic lights or to the design of wayfinding elements. Wayfinding is generally focused on quality signage and readability at higher speeds, but some practitioners also conceptualize wayfinding in terms of reference points and notable changes in physical environments. Lynch (1960) discusses a multisensorial, albeit primarily visual, approach to wayfinding and ethnographic research by van Duppen and Spierings (2013) shows that journeys experienced on a bike is also composed of transitory experiences such as smells, traffic, sounds and the weather. As cyclists experience each journey differently, these observations highlight the opportunity for a multisensory and inclusive approach to cycle highway design.

4.4. Flexibility in design

Practitioners tend to conceptualize and high quality standards in terms of wide paths, direct connections, quality of paving, and wayfinding, yet it is unclear to what degree positive experiences arise from well-designed infrastructure and traffic regulation devices versus aesthetic elements and social activity along a cycle highway. Some cycle highway designs include pedestrian paths and others do not. Some cycle highways include sections of shared streets with automobiles while other routes are completely separated from motor traffic (Figs. 1 and 2). Cycle highways in the Netherlands permit heavy vehicles such as mopeds travelling up to 45 km/h while cycle highways in Germany only permit lighter e-bikes with a maximum of 25 km/h. There are opportunities to take advantage the mix of typologies seen on existing cycle highways like the RijnWaalpad in the Netherlands, and in plans for future cycle highways as illustrated in a feasibility study for Mannheim to Heidelberg connection (Albrecht et al., 2018). We know that design concepts carry different meanings when applied to automobile landscapes (Appleyard et al., 1965) versus pedestrian environments (Gehl, 2011), and the term "cycle highway" is taken more literally in some contexts than others. For example, the German RS1 stands in clear relationship with automotive highways through both the design of its logo as well as an image of a bicycle in the middle of an empty motorway (Radschnellwege in NRW, 2014). As an alternative to "highway", the Dutch also uses the term "fast bicycle routes" to describe their system of long-distance bicycle infrastructure in



Fig. 1. Example cycle highway, mixed with automobiles. RijnWaalpad, Arnhem-Nijmegen area, Netherlands. (Photo credit: George Liu)



Fig. 2. Example rural cycle highway. RS1, Essen, Germany (Photo credit: George Liu)

order to move the discourse away associations with automobile highways, but as revealed in the interviews, even the word “fast” is a point of contention (Appleyard et al., 1965).

In terms of design logic, cycle highway practitioners struggle with how the uniform, predictable, and regulated engineering of highway environments can be balanced with the diverse, vibrant, and human-scale design of pedestrian environments (Hamilton-Baillie, 2004). However, all participants recognize to varying degrees that the idea of a “highway” means something different for bicycles than for automobiles. “There needs to be a middle ground, but I do feel that in the current debate we sometimes tend to move too much to the engineering part,” says NL2 recounting the construction of the RijnWaalpad between Arnhem and Nijmegen in the Netherlands, “It’s something we, at that point, discuss it from a traffic engineering point of view, but during the process, we quickly discovered that this wasn’t enough.” As meeting minimum cycle highway standards is necessary for many projects to receive subsidies from the national and regional government, these funding criteria standards determine the basic physical form of cycle highways in terms of width, intersection frequency, lighting, and grading in various street and spatial typologies. Whereas these design requirements form the building blocks for the cycle highway typology, practitioners are still left with flexibility in terms of route choice and designing cycle highways to fit their surrounding context.

4.5. Limitations and future research

There are four limitations to this study that provide opportunities for future research. First, as there is growing awareness of the cycle highway concept outside of Europe, the views of European practitioners may not translate directly to other contexts. It would be interesting to explore how the cycle highway concept can be adapted to contexts with different planning agendas and a wider diversity of land use patterns and to work towards a framework for evaluation. Second, cycle highways have not been researched in relation to the perspective of cyclists themselves. It is clear that practitioners draw extensively from their personal experiences of cycling, but the exact meaning of experiences should be properly explored and defined from the perspective of various user groups in the context of cycle highways. From Jensen’s (2013) Staging Mobilities perspective, this paper explored staging from above in how planning, design, regulations, and institutions shape bicycle highways from the perspective of practitioners. In addition, a nuanced understanding of experiences should be obtained from users themselves and how cycle highways are staged from below by the activity of its users. Third, written knowledge, in the form of design manuals and policy documents have not been extensively reviewed in this paper. Practitioners derive

their knowledge and framework of discussion from policy documents and design guidelines, so research focusing on those documents extensively would add depth to understanding how the process of designing cycle highways and other cycling infrastructure takes place. Fourth, practitioners have repeatedly mentioned that cycle highways can facilitate the use of e-bikes, and studies do show that e-bike users perform more trips and cycle longer distances than conventional cyclists (Fishman and Cherry, 2016; Fyhri and Fearnley, 2015). The discussion of user experience and behavior becomes increasingly important as we see an increasing heterogeneity of speeds and vehicle types such as e-bikes, scooters, and other personal electric vehicles sharing cycling infrastructure with human-powered transport.

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Appendix A. Interview questions

1. Concept of cycle highways in general:

- What is a cycle highway?
- What makes cycle highways distinct from other types of cycling routes?
- What do you think are the best examples of cycle highways?
- Do you think of cycle highways more like car highways, designed for moving people quickly or more for the enjoyment of people’s commute? A mix? How?

2. Case study cycle highway:

- Can you me about the design priorities for the [case study] cycle highway?
- What are the expected people and uses for this [case study] cycle highway? For example, commuters, sport cyclists, children, people walking.
- Are people using this [case study] cycle highway in unexpected ways?

3. Concept of the ideal cycling experience:

- How would you describe the ideal cycling experience?
- To what extent is/was the quality of the cycling experience an important consideration of the [case study] cycle highway design?
- Which aspects and types of people's experience were considered in the design of the [case study] cycle highway?

4. Professional role and knowledge sources:

- What project are you currently working on, and what is the main focus of your work in relation to [case study] cycle highway?
- How long have you been involved in cycle highways?
- Can you describe your professional network? Is it international? Which fields do they work in?
- What professional or academic sources do you consult to help in your work?

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