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Cycling to work and making cycling work: What makes committed utility cyclists despite perceived risks of air pollution and traffic?

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ABSTRACT

Introduction: Cycling as an active mode of transport contributes to an environmentally friendly and healthy system of mobility. An increasing body of research has examined human-centred factors influencing cycling modal share, yet there is still need for more data on perceived risks, mitigation strategies, and their impact on the subjective safety of cyclists. In this study, we analyse cyclists' risk perception concerning air pollution and traffic and how these risks are mitigated. We provide insights into the habitus of committed utility cyclists and draw conclusions for the social and cultural factors influencing a cycling-friendly mobility culture.
Methods: Focusing on one central route through the German city of Aachen, we conducted problem-centred interviews with ten utility cyclists who had cycled the route regularly over a longer period of time. Interviews were analysed with qualitative content analysis method.
Results: The cyclists mitigated their perceived risks of air pollution and traffic by employing strategies that may seem counter-intuitive to non-cyclists or less experienced cyclists. Strategies included speeding up instead of braking or taking up more road space. We hypothesise that experiences of subjective safety are not necessarily due to the absence of risks but are dependent on the perceived efficacy of individual mitigation strategies for perceived risks.
Conclusion: In-depth analysis of risk perception and mitigation strategies of committed cyclists can help planners to design better functioning infrastructure that ultimately can make cycling more diverse and inclusive. Understanding the habitus of committed cyclists contributes to understanding potential cultural and social factors impacting utility mobility behaviour. Advancing cycling research towards a more human-centred and movement-focussed understanding of mobility can ultimately contribute to more sustainable transport planning.

1. Introduction

Germany has often been positively referenced in the cycling context along with other European countries such as the Netherlands (Cox and Koglin, 2021; Pucher and Buehler, 2006, 2008b, 2021). While the share of trips made by bicycle in Germany exceeds that of other highly motorised countries such as the US (Buehler, 2011), cycling modal share remains low (13% in 2019) (Ecke et al., 2021), varies between regions and cities (Nobis, 2019), and between German cities (Lanzendorf and Busch-Geertsema, 2014). Overall, there is

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still much ground to cover to fulfil the requirements of the German "Verkehrswende" [mobility transition] (Umweltbundesamt, 2020) towards a more sustainable system of mobility. Especially for short distances in everyday contexts, Germans use the car more often than their neighbours in Switzerland or the Netherlands (Nobis, 2019), raising the question why utility cycling in urban settings appears to be unpopular in Germany. Transport research has increasingly shown that quantitative and infrastructural data alone do not realistically depict transport systems and that more in-depth research is needed on perceived risks and subjective safety (Schwedes et al., 2021; von Stülpnagel and Lucas, 2020). Research has shown that adverse conditions for cycling are often not documented comprehensively, underreported, or misinterpreted (Aldred and Crosweller, 2015; Gössling et al., 2019; Heinen et al., 2010; Juhra et al., 2012). A combination of adverse conditions can be found in the German city of Aachen, where despite an increasing interest in and civil society advocacy for cycling (Radentscheid Aachen, 2022), the cycling modal share remains stagnantly low (Nobis, 2019).

Our case study focusses on one route through Aachen, combining field research and interview accounts to provide a micro-level insight into the risk perception and mitigation strategies of committed utility cyclists. We seek to find out how cyclists remain committed to cycling as a mode of utilitarian urban transport despite adverse conditions. The paper analyses how cyclists perceive risks, which mitigation strategies have been established over time to deal with perceived risks and unsafety, and how these factors impact on their perception of subjective safety. Understanding how experienced cyclists deal with risks may support planners in improving road infrastructure for all road users, therefore improving safety for all road users, lowering the bar for novice utility cyclists, and making utility cycling culture in Aachen more inclusive and diverse. On a conceptual level, our research aims to contribute to improving the theoretical framing of perceived risk and subjective safety beyond numbers. Through understanding how experienced cyclists frame and construct risks and safety, we work towards closing the research gap around subjective safety and individual risk perception in cycling research and towards advancing cycling research towards the "new mobilities paradigm" (Sheller and Urry, 2006).

2. Background: Utility cycling as social practice

The study's target group are utility cyclists. We use the term utility cycling to describe everyday cycling as a mobility behaviour that mainly includes short distances for purposes such as commuting to and from work, trips to local shops, or visiting friends and family (Buehler and Pucher, 2021a). We acknowledge that a utility framing is not without problems (Aldred, 2015) but we employ it to limit the mitigation strategies we analyse in this paper to behaviour in an utilitarian, everyday context. In line with social practice theory (Bourdieu, 1977; Reckwitz, 2003) we understand utility cycling – and the risks and strategies related to it – as social practices that constitute a habitus (Bourdieu, 1977) and carry cultural and social meaning beyond their function as a form of transport (Nettleton and Green, 2014). Different "cycling identities" (Aldred, 2013a), including those that distinguish between more utility and recreational cycling, have already been identified for local cultures (Aldred, 2013a, 2013b), and the influence of culture on cycling practices and transport policy has been analysed for the UK (Aldred and Jungnickel, 2014). But as traditional transport research has long focussed on motorised transport, there is still a lack of integration of cycling research and theoretical conceptualising in transport planning (Koglin and Rye, 2014). For the German city of Leipzig, Marquart et al. (2020) have shown that transport planning for cycling in Germany could benefit from better integrating cyclist's perceptions in planning. We therefore aim to understand cyclists' risk perceptions and risk mitigation strategies for one route in the German city of Aachen.

2.1. *Background: Cycling risks*

As health, we broadly understand the WHO definition of "physical, mental and social well-being" (World Health Organization, 2020a). Effects of cycling on health are twofold: Cycling affects individual health (Celis-Morales et al., 2017; Dons et al., 2018; Morris and Guerra, 2015) and populational health (Johansson et al., 2017). As risk we understand "a factor that raises the probability of adverse health outcomes" (World Health Organization, 2009) for any individual or population. We focus specifically on air pollution and traffic safety, which have been the focus of research and policy connected to urban cycling and health (World Health Organization Regional Office for Europe, 2017). Under air pollution we broadly subsume "a mixture of substances and particles, which have been associated with various health effects" (World Health Organization Regional Office for Europe, 2017). Consensus amongst most studies is that the health benefits of cycling outweigh the risks (Garrard et al., 2021; Kubesch et al., 2018). Our study focusses on the perception of risks.

2.1.1. *Risk: Traffic safety*

Risks and the perception thereof are a major deterrent to cycling, as cyclists belong to the group of vulnerable road users most exposed to road traffic crashes and injuries (World Health Organization, 2020b). How traffic risks and severity of health impacts are defined, measured, and operationalised has therefore been discussed in a wide range of studies (de Hartog et al., 2010; Eluru et al., 2008; Erdem and Erol, 2021; Olivier and Creighton, 2017; Olivier and Walter, 2013; Walker, 2007; Walker and Robinson, 2019). Separating cyclists and motorists through infrastructure decreases risks of fatal and non-fatal incidents (Elvik, 2021; Pucher and Buehler, 2016) and perception of infrastructure influences cycling behaviour (Gössling et al., 2019; Winters et al., 2011). More nuanced data is needed on the effectiveness of specific cycling infrastructure (Mulvaney et al., 2015; Thomas and DeRobertis, 2013). Cycling crashes and injuries are frequently underrepresented in official reports (Juhra et al., 2012). Perceived risks (Winters et al., 2011), "near misses" (Aldred and Crosweller, 2015), and "emotional barriers" (Horton, 2007) are often not represented in statistics at all, but may influence subjective safety and decrease the success of policy measures (Aldred and Crosweller, 2015; Gössling et al., 2019). Perceived risks may differ from quantitatively measured risks (Sørensen and Mosslemi, 2009). As Schwedes et al. (2021) write, there is a focus on infrastructure in transport research on Germany, defining unsafety in terms of collisions only, which often leads to wrong assessments of the effectiveness of infrastructural measures, risks, and safety. Cycling research still requires more nuanced assessments of perceived risks and subjective safety, and these findings have yet to be fully integrated in transport planning in Germany (Schwedes et al., 2021; von Stülpnagel and Lucas, 2020).

2.1.2. Risk: Air pollution

A growing body of research exists investigating exposition to air pollutants as a risk in dependence on the mode of transport (Rank et al., 2001; Zuurbier et al., 2010) or on the type of route (Adams et al., 2001; Kaur et al., 2007; Park et al., 2017). It has been observed that a high perception of air pollution does not discourage commuters from choosing active modes of transport (Badland and Duncan, 2009), but does influence their route-preference (Anowar et al., 2017; Gössling et al., 2019). Mobility decisions are often influenced by individual perceptions of air pollution. Perceptions of air pollution depend on social and cultural factors, are highly location-dependent (Bickerstaff and Walker, 2001), and can differ significantly from actual measured data (Daniels et al., 2018; Paas et al., 2016). As local conditions differ, considering air pollution data in the specific urban setting is vital (de Nazelle et al., 2017; Umweltbundesamt, 2018). The study presented in this paper was therefore carried out in direct line to a complementary study measuring particulate matter (PM) exposure doses using a mobile, fast response monitoring platform based on a cargo bike, followed by chemical PM analysis at fixed sites (Fuchte et al., 2022). Fuchte et al.'s (2022) data show, that pollutant concentrations vary along our route, with certain sites being more frequently polluted, for instance due to local infrastructural characteristics like narrow street canyons or crossings. Fuchte et al.'s (2022) data thus provides detailed background information for our investigations on cyclists risk perception concerning air pollution.

2.2. Background: Mobility paradigm, inclusion and equity

We specifically include social and equity-related risks such as discrimination in our framing of risks. We prescribe to the understanding that environmental risks and the social construction thereof are linked with power and equity (Olofsson et al., 2016) and that power dynamics play a role in transport planning (Koglin and Rye, 2014). Increasingly, mobility research and policy is including calls for social justice and equity (Buehler and Pucher, 2021b; Umweltbundesamt, 2020), and cycling as active mode of transport has been at the centre of these discussions, proposing that where cycling levels rise, transport equity would increase (Shirmohammadli et al., 2016). However, increasing the cycling modal share alone does not automatically increase equity and inclusion and does not automatically result in more cycling diversity (Aldred et al., 2016). Therefore, more research is needed on the intersections of cycling, inclusion, and diversity. In the context of social justice and "mobility justice" (Sheller, 2018), cycling has been framed as a common good (Scott, 2020), and new sustainable and democratic systems of mobility have been conceptualised under the term "vélomobilities" (Cox, 2019). A paradigm shift away from planning for and around motorised transport towards a cycling paradigm has been suggested as a sustainable way to increase cycling safety and thereby health (Whitelegg, 2021). We prescribe to the paradigm shift in mobility research as developed by Banister (2008), Cresswell (2006), and Sheller and Urry (2006) and adapt an understanding of mobility cultures that considers social and cultural aspects as essential for transforming a mobility system towards more equity and sustainability (Bosen and Leicht-Scholten, 2020). To summarise, our study aims to contribute to closing the research gap concerning perceived risks and mitigation strategies and their effects on subjective safety with an equity and inclusion lens, employing a mobile instead of a "sedentarist" (Sheller and Urry, 2006) perspective and considering cycling a social practice.

3. Materials and method

3.1. Case study Aachen

Infrastructural and policy measures to promote utility cycling have been comparatively analysed for different cities and countries. In global comparison, European cities have repeatedly been identified as positive examples for infrastructure and cycling-friendly mobility cultures (Pucher et al., 2010; Pucher and Buehler, 2008a, 2008b; Tolley, 2003). While the German city of Aachen can be compared to cycling-culture cities like Münster in size and student population, and historically even in infrastructural planning in favour of cycling (Meyer, 2016), its mobility culture today has to be classified as an "auto-oriented city" (Klinger et al., 2013). Recent years have seen an increase in civil society initiatives such as the "Radentscheid" (Radentscheid Aachen, 2022), campaigning to change Aachen's mobility culture through improving cycling conditions, and transport planning for cycling has become an issue of public discourse.

3.2. Route

We defined one route featuring as many factors potentially influencing perceived risks and subjective safety as possible. The route includes sections of one of the major ring roads with high traffic volume and inconsistent cycling infrastructure, as well as Aachen's typical topography with changes in elevation and urban green, and infrastructural elements such as an underpass and large crossings. The route runs from the main train station to the western parts of the university campus. It is a central, multiple lane road featuring cycling infrastructure that changes frequently along the road and includes main intersections publicly known for multiple fatal and non-fatal cycling collisions as well as an air-quality monitoring station (see Table 1, appendix for detailed description). Focusing on one route allowed for better comparisons between interviewees' statements and for executing extensive field research on the route. It also allowed for documenting the infrastructure and measuring air pollutants. In Fuchte et al.'s (2022) study on the same route, several trips were conducted using a cargo bike featuring installed particulate measurement technology. We treated the cargo bike trips and following fixed-site measuring as sociological field research for the present study. Our observations included traffic situations, motorised and non-motorised traffic participants' behaviour, weather and climate conditions, route conditions, construction sites or temporary changes on the route, as well as our own experiences in cycling the route. The rides were partly documented in pictures. The participatory observations and pictures were combined with a content analysis of local news sources for cycling-related incidents, as summarised in Table 1 (appendix).

3.3. Recruitment and interview sample

Cyclists were recruited via flyers through personal networks, university networks, the local branch of the German Cyclist Association (ADFC Aachen), and local bicycle shops. As incentives two vouchers for a local bicycle supply shop were raffled. We specifically recruited people who habitually cycled in the city of Aachen and who had regularly cycled the route or significant parts of the route for a longer period of time (two to three times a week over at least two different seasons). Prospective interviewees were asked to confirm this beforehand during the recruiting process. Our flyer introduced the topic air pollution, the route, and the complementary study by Fuchte et al. (2022).

We were able to recruit ten interviewees. Interviewees either cycled the route to work or for work-related appointments ($n = 7$ cyclists) or to university ($n = 3$) mostly in combination with occasionally cycling parts of the route in their free time. Interviewees had cycled the same route at about the same time each day for a longer period of time, over different seasons, in different traffic situations. Four interviewees identified as female, six as male. Most interviewees were between 26 and 30 years old ($n = 5$), two interviewees were between 18 and 25 years old, two interviewees were between 31 and 40 years old, and one interviewee was between 41 and 50 years old. As the route connects Aachen's main train station and the university campus, most interviewees had a connection to the university: Most had at least one university degree ($n = 9$) and/or were currently enrolled as Bachelor's or Master's students ($n = 3$). Some were employees of the university ($n = 4$) and were completing a doctorate ($n = 3$) (for an overview, see Table 2, appendix). Most of the interviewees ($n = 7$) explicitly mentioned as motivation for their participation that they had a previous interest or expertise in the topics urban utility cycling or specifically air pollution ($n = 3$).

3.4. Qualitative content analysis

We use qualitative interviews to understand what cyclists sense and feel when they are on the move, how they post-hoc explain and contextualise how they perceive risks, and which mitigation strategies they have developed over time. We decided to conduct qualitative interviews, participatory observations, and air pollution measurements separately. This way, we were able to gain the most in-depth insights without compromising on traffic safety on the busy route or interfering with the mobility routines of our participants. We conducted semi-structured problem-centred qualitative interviews in person. We also elicited a short questionnaire for socio-demographic data, and had interviewees trace their usual route on a map of our route. Interviews were conducted, transcribed, and analysed in German and thematically analysed using the seven-step content-structuring qualitative content analysis framework provided by Kuckartz (2018). During these interviews, broad topics were deductively set through the questionnaire but interviewees could also set their own focus. The qualitative content-structuring method was selected as it allows for a deductive-inductive evaluation. The first categories were deducted from literature, the authors' participant observations on the route, and the questionnaire. Then thematic categories and subcategories were built and refined inductively from the transcripts. In order to reach greater reliability and validity of the inductively built categories, a team of coders from different disciplines ($n = 4$) coded segments to reach inter-coder validity. The codes were then compared and discussed until consensus was reached. This process of communicative validation was repeated to achieve intersubjective validation of all codes and to achieve inter-rater reliability (Flick, 2007).

3.5. Limitations of the study

As we were focused on a specific route through Aachen, we were only able to recruit a small group of interviewees. As described above, the interviewees were a very non-diverse group referring to diversity categories such as nationality, race, age, educational, and social status. Our results do thus not represent all strata of utility cyclists and they do not include non-cyclists. Our research would benefit from further qualitative studies among utility cyclists with more diverse backgrounds as well as quantitative validation with representative samples.

4. Cycling to work: Experiences of risk and unsafety

4.1. Risk: Air pollution

Although we originally envisaged air pollution as a topic of relevance and some interviewees mentioned that an interest in the topic was a reason to participate in our study, our group of cyclists considered air pollution "not a primary issue" but rather a long-term risk. As all interviewees had previous knowledge about air pollution, some even specialised knowledge, their risk perception ranged from the immediate perception of air pollution to perception informed by knowledge. Cyclists perceived air as polluted when they smelled presumably polluted air, saw exhaust fumes from cars or experienced trouble breathing. When we asked the cyclists how they experienced their perceptions of air pollution, one interviewee responded:

> "You notice when it smells of exhaust fumes when you cycle. That is also an unpleasant feeling breathing." (our translation, as henceforth)

Another interviewee referred to the physical exercise and increased minute ventilation while cycling, stating:

> "It's not that I feel physically restricted. This route is simply not a sports route. But I do find it unpleasant, and because I know that what you are breathing is not only unpleasant but also harmful to your health I find that no pleasant thought."

One interviewee referred to knowledge about emissions at one specific traffic junction on the route called "Kaiserplatz" (cf. Table 1, nbr 4, appendix) and combined this knowledge with daily observations of the traffic situation:

> "In terms of traffic, it's also well known. In terms of emissions, it's the most critical corner of Aachen. And I think it's also noticeable, […], there's often a traffic jam. That's also where the nitrogen oxides measuring station is and so on."

The interviewee referred to this knowledge to then describe the air pollution perception:

> "So it's exactly this corner that I feel is the most critical in terms of air pollution."

Most interviewees perceived the risk of air pollution as too intangible to warrant mitigation, with one interviewee commenting:

> "I can't really assess how harmful the stuff I'm breathing is. That's why it's so difficult for me to judge that in the respective situation. Okay, so, I know it's harmful but I can't rank it on a scale. It is then also difficult for me to think about it in everyday life."

The lack of information on air pollution and related effective mitigation strategies caused the cyclists to stress about their commitment to utility cycling, with one cyclist stating:

> "It is not clear to me what I can do exactly, to be honest. If there was a protective mask available, the question is, would it be effective at all? I don't know that. I don't know how to deal with that at all".

Consequently, the cyclist resigned to accepting air pollution and its potential harmful impact on health:

> "So currently […] you have to accept it. And that's in fact the main problem".

Evaluating how air pollution is framed as a perceived risk highlights subtle nuances in risk-perception and safety concerns, showing how cyclists' knowledge on air pollution is combined with their sensory perceptions. Interviewees shared the conviction that their subjective perception of air pollution is not a reliable point of reference to develop successful mitigation strategies.

For our cyclists, air pollution contributes to an overall burden of risks that decreases subjective safety in the long-term. They all assumed that air pollution is detrimental to their health in the long term but that the positive health impacts of cycling outweigh the potential health risks air pollution poses. Air pollution exposure was not perceived as an immediate risk to health and therefore it was perceived as a secondary, rather than acute, risk and safety concern for our group of cyclists.

This finding is in line with the findings of Fuchte et al. (2022) who found pollutant levels (i.e. particulate matter and associated pollutants) on the route to be generally below the limit values set by the European Commission but in some cases above the annual mean recently recommended by the WHO. Fuchte et al.'s (2022) identification of sites with elevated levels, however, did not always match our cyclists' statements on perceived elevated levels. For our cyclists, the perceived levels of air pollution were mostly described as dependent on the presence of motorised road users.

4.2. Risk: Traffic and infrastructure

In contrast to air pollution, traffic and road safety were mentioned by all participants as the most acute risk factors. As traffic risks were perceived as severe enough to cause concern, interviewees described them in great detail. They gave detailed descriptions of dangerous or stressful traffic situations along the route, described safety concerns, and attributed them to specific points on the route. Interviewees factually described the route and traffic infrastructure, mentioned their experiences, and their knowledge about others' experiences and described their immediate emotional responses to these stressful situations, as well as how these experiences contributed to their overall emotional mindset when cycling.

In terms of traffic safety, our cyclists showed a high level of reflectiveness and awareness. It became clear that interviewees were experienced speaking about these traffic situations in great detail. Many potentially unsafe spots on the route have become common knowledge amongst utility cyclists in Aachen and cyclists often have a shared experience about these spots. This common knowledge is connected to discourses on the dangers of cycling on this specific route and in Aachen in general (Table 1, appendix lists descriptions and pictures of potentially unsafe spots on our route). One interviewee described an experience of cycling on the advisory cycle lane[1] on the right side of right-turning cars at a specific intersection called "Krefelderstraße":

> "Basically, every time I stop at a traffic light and there is the right-turning lane for cars on my left. Every time it's 'Oh god, do they see me?' Especially at the intersection at Krefelderstraße. I often get cut off there." (cf. Table 1, nbr 7, appendix).

Interviewees referred to infrastructure and how effective they perceive infrastructure in improving subjective safety. Not all infrastructural measures that are supposed to improve cycling safety were perceived as functional by the interviewees. The main example of this are the advisory cycle lanes featured on the greater part of the route (cf. Table 1, appendix). The advisory cycle lanes run along parked cars and are not separated from the road by a physical barrier, as such, they are part of the car lane and are legally considered a carriageway. At constrictions such as zebra crossings, advisory cycle lanes typically end without indication, merging bicycle and motorised traffic.

> "I am thinking of Wilhelmstraße, there are these Schutzstreifen [advisory cycle lanes] painted on. They used to be standard. Nowadays they rather encourage close overtaking, and especially this form of too close overtaking is what I find very, very exhausting."

The interviewee described the repeated experience of close overtaking by motorists as "exhausting", as it is a regular experience that decreases the interviewee's subjective feeling of safety. Incidents of close overtaking on advisory cycle lanes cause an increase in stress because the infrastructure that is supposed to serve as protection is not functional. Advisory cycle lanes are not wide enough for motorists to overtake while maintaining the overtaking distance of 1.5 m minimum between cyclist and car, but they suggest otherwise. In our cyclists' experience, the road marking suggests to the motorists that overtaking is safe if the road marking is not crossed, even when there is not enough distance between bicycle and car.[2] On our route, this problem is amplified because the lane runs along parked cars, increasing the risk of dooring incidents when cyclists are overlooked by drivers exiting their parked cars. Cars also frequently illegally park on the advisory cycle lanes (Table 1, nbr 4, appendix). Talking about dooring-incidents, one interviewee shared:

> "As I said, I'm still a bit afraid of these dooring-crashes, so I don't cycle close to parked cars. […] It happened to me the other day that someone just pulled out and opened the door in front of me. I slammed on the brakes and dismounted. Ultimately nothing really happened but it was completely unnecessary."

The repeated negative experiences lead to a lower level of subjective safety for our cyclists and a higher level of risk for all road users. As such, the infrastructure meant to facilitate cycling and improve safety through reducing risks is not fulfilling its purpose. On the contrary, in the experience of our interviewed cyclists, it even increases risks and therefore decreases safety levels, as it suggests a false sense of safety for both cyclists and motorists. It may therefore be an even higher risk factor for novel cyclists lacking this knowledge through experience.

Other infrastructural measures that our cyclists had experienced on other routes were mentioned as positive examples for increasing subjective safety. Measures included "mirrors installed at traffic lights", "protected bike lanes", or even bans of bigger vehicles such as trucks because they evoke a "feeling of unsafety since they have a bigger blind spot".

Concerning all infrastructural measures, even if they were perceived as improving subjective safety momentarily in specific situations, the increase of subjective safety was mainly attributed to the behaviour of other road users and not to the infrastructure alone. There was a general frustration about infrastructural measures, both from having experienced that they decreased subjective safety (e.g. advisory cycle lanes) but also from having experienced a lack of respect from other road users. As one cyclist summarised:

> "Wide bike lanes are of no use to me if cars use half of them."

4.3. *Risk: Monetary and cultural barriers*

There is a regularity in the negative day-to-day experiences shared by our interviewees, expressed through words such as "every time" or "exhausting". Our cyclists described how their risk perception and definition of subjective safety had been shaped through accumulated everyday experiences. These experiences are a constant stressor when cycling for the individual cyclist. They also have become common knowledge amongst Aachen's cyclists. The low subjective perception of cycling safety and high risk is perceived as status quo for many. This generates a cycling discourse that is often cynical in tone and requires social capital to be understood in its nuances. This potentially reduces inclusion and makes utility cycling more elitist and less diverse, not from an economic point of view,

[1] They are called "Schutzstreifen" in German which would translate to "protection lane". In the English translation of the German traffic regulations, they are translated as "advisory cycle lane". We use this term, also to prevent any confusion with "protected bike lanes". However, the difference in meaning is striking, concerning the implied function (protecting versus advising) of the lane. To further complicate matters, in the Netherlands, "advisory cycle lanes" mean more roadspace for cyclists and stricter regulations for motorists than in Germany. A detailed description of the route cycling infrastructure with pictures can be found in Table 1 in the appendix.

[2] We also experienced this when we cycled the route with our cargo bike, which was bigger than normal bicycles (cf. appendix, Table 1).

but from a social and cultural point of view. Mobility-cultural discourses are factors contributing to the social sphere of sustainable mobility. There are initiatives in Aachen aiming to lower the barrier for novel cyclists and vulnerable-to-exclusion citizens, one of our interviewees shared the experience of working with these groups:

> "The […] long-term unemployed who really have nothing at all. They also cannot participate in this 'I participate in environmental protection, because I am a cyclist' because bicycles are expensive as hell."

And:

> "Also, I'd say the appropriate environmentally friendly maintenance. So, for example, I use mostly oil which is biodegradable. […] But these products are so incredibly expensive. People with little money simply cannot afford to participate, as much as they wanted to."

Environmentally friendly bicycle maintenance products are often more expensive, and access is therefore limited. While cycling is often communicated as a highly accessible and low-cost means of transportation, it is not costless, especially when long-term usage, climate and topography require sturdy equipment and frequent bicycle maintenance. Negative discourse around perceived risks and subjective safety in connection with a trivialisation of economic costs of long-term utility cycling may create a vicious circle, furthering the notion of utility cycling as elitist and difficult to pick up, potentially reducing cycling diversity, equality and inclusion, and delaying a sustainable mobility transition. We therefore consider it a risk to establishing cycling as a utilitarian mode of transport.

5. Making cycling work: Mitigation strategies

After having established how certain risks are perceived, we are now looking more closely at the mitigation strategies cyclists employ to deal with perceived risks.

5.1. *Strategy: Avoiding risks*

To deal with the risks of air pollution and traffic, interviewees described avoidance strategies. Some were immediate reactions, such as spontaneously changing lanes or overtaking cars to evade exhaust fumes. Other immediate strategies included behaviours, such as trying to hold the breath or trying to breathe less deeply. Some interviewees had considered wearing a filtering facemask before but had decided against it because they were not convinced about its effectiveness. Longer-term strategies to avoid air pollution and traffic included adapting the everyday route to one with less cars. This strategy was employed even if it came at the expense of cycling comfort, for example through cobblestone roads, but not if it would have increased commuting time significantly. Similar results on factors influencing route choice have been found by Gössling et al. (2019). One interviewee commented that the decision for cycling and against using motorised traffic counts as a long-term mitigation strategy. Through deciding against driving, the cyclist contributes to improving the overall air quality in the city and thereby reduces individual risk exposure, summarising:

> "I cycle, I am not part of the polluting group".

5.2. *Strategy: Controlling risks*

Our cyclists had developed most of their mitigation strategies to improve their levels of subjective safety despite a high level of perceived traffic risks.

5.2.1. *Increasing visibility*

To prevent risky traffic situations arising from confrontations with motorised traffic, interviewees shared that they had increased their visibility on the road over time. Wearing highly visible attire and having strong lights at their bicycles was a strategy adapted by most over time. However, interviewees also mentioned reluctance to buying high-vis attire in hopes of being recognised and respected by motorists. Even though they all agreed that high-vis attire "just makes sense", criticism was voiced at the same time on how passive this strategy felt by some. Investing in high-vis attire attributes the power to the motorists and leaves the cyclist in hopes of "being seen". It therefore reinforces a feeling of being at the mercy of motorists without having much agency. As it reinforces that unequal power dynamic, high-vis attire becomes a mitigation strategy that reduces the specific risk of being overlooked, but at the same time increases the feeling of being constantly at risk in traffic. It thereby contributes to a general decreased feeling of subjective safety on the road for our cyclists.

5.2.2. Taking up space

Our cyclists had adapted their cycling behaviour over time towards occupying more road space. This strategy was specifically developed dealing with the risk of cars overtaking without legally required distance. Many had started cycling in the city trying to occupy as little road space as possible to avoid collisions with motorists, they had stuck to the above-mentioned advisory cycle lanes for example. Over time, they had experienced dangerous situations such as dooring incidents or close overtaking. Consequently, they had gradually started to occupy more space, to make it impossible for cars to overtake at all and avoid dooring incidents:

> "Positively speaking [my cycling style is being, authors] very present on the street. I am taking up space. I think that is what someone else might call exaggeratingly Kampfradler ['combat cyclist'], who just does not ride nicely on the right in his mini-lane. I also sometimes place myself, when the advisory cycle lane is there, to the left of the marking, so that I know, here I do not come into danger from opening car doors and overtaking motorists. It is something I have noticed. The further you cycle away from the curb, the less you get overtaken. Making yourself small is more dangerous than making yourself big."

Two cyclists reported that they had become more outspoken and sometimes even confronted drivers that had overtaken them too closely at the next traffic stop:

> "Well, sometimes I'm really scared when cycling, so I would say that I cycle quite defensively. But I don't put up with everything either. Especially drivers who overtake me with too little distance and who then stop at the traffic lights in front of me afterwards. I then knock on the window and ask if they have not noticed that they have just overtaken much too close. I'm a bit confrontational there."

These mitigation strategies had been developed over time by our cyclists to minimise the risk from unsafe infrastructure and unsafe behaviours of other road users.

5.2.3. Diverting on the sidewalk and maintaining speed

Another strategy mentioned was diverting from the road onto the sidewalk when no pedestrians were present. This strategy was mentioned by multiple interviewees, but it was framed differently. One group of cyclists framed this strategy as defensive, because in relation to the car, they were forced to give up road space. They understood their behaviour as reluctantly giving way to the car, both practically and figuratively:

> "[…] I think that if it were to get really dangerous, I would also divert onto the sidewalk, if that was foreseeable. If that is not foreseeable, I have no chance, of course. Then you have to brake. And it doesn't help if you cycle recklessly into a situation, I think you have to be smart enough to back off. Because anything else would be nonsense."

In this framing, the behaviour is understood as a last-resort mitigation strategy, it essentially describes being run off the road by motorists. As such, it contributes to a long-term decrease of subjective safety, as it reinforces the unfair power dynamic of being put at risk by motorists and being forced to break traffic laws to protect one's health.

Others, in contrast, described cycling on the sidewalk as an example for their cycling behaviour becoming more confrontative with increased stress levels. They used this strategy to avoid braking and thereby "giving up speed" in flowing traffic which they did want to avoid as it would have been seen as giving way to and thereby losing against car drivers. They thus understood this as standing their ground against motorists.

> "So, if I have the opportunity to, then [I] just quickly jump somewhere on the sidewalk or a parking bay, I do that. In that sense, you can call that, or people would call that, rowdyism. But of course, I don't do that when there are pedestrians around. I don't put anyone in danger or bother anyone with it, I only do that when [the sidewalk] is empty."

No matter the framing, maintaining speed was another acquired mitigation strategy from repeated experiences where losing speed had been experienced as dangerous and had increased traffic risks because it impeded flowing with traffic. A correlation between cycling speed and risks of incidents has also been found by Aldred and Crosweller (2015), supporting the hypothesis of our cyclists that through maintaining speed, they avoid conflicts and experience a smoother ride with less risks. Where cyclists are forced to break traffic laws to maintain speed and avoid collisions however, the strategy contributes to a decrease in subjective safety overall, as it makes obvious the unjust power dynamic between motorists and cyclists on shared roads in mixed traffic.

6. Discussion and conclusion

We spoke to a group of committed utility cyclists about their experiences with cycling on a route through Aachen known for its higher levels of pollution and dangerous traffic situations. We assumed as they cycled this route regularly, the cyclists would showcase an elevated awareness of risks and subjective safety along the route. This was confirmed and we received very detailed accounts. As such, our research contributes to the "mobility turn" through moving away from "sedentarist theories" (Sheller and Urry, 2006) towards movement-focussed theorising and understanding peoples mobile (social) practices.

6.1. Abstract and concrete risks

Our initial focus on air pollution was not that prominent in the foci set by the interviewees. We conclude this phenomenon occurred because air pollution is an abstract risk, whereas dangerous traffic situations are acute risks. Acute perception of air pollution is only possible through momentary sensorial perceptions such as smelling, tasting, or seeing exhaust fumes, but those perceptions then need to be categorised as air pollution applying acquired knowledge, whereas dangerous traffic situations are immediately categorisable as such. Talking about traffic situations also gave interviewees the chance to report on mitigation strategies they had established, whereas most had not taken as much concrete action concerning risks from air pollution exposure.

Apart from situations in which interviewees experienced immediate sensorial perceptions of pollution, air pollution was not perceived consciously. We conclude that air pollution contributes to the overall burden of perceived risks but is not as influential as traffic and infrastructure on subjective safety in our local setting, where pollutant levels did not exceed limit values as confirmed by the complementing study by Fuchte et al. (2022). In contrast, traffic and infrastructure were described as more acute risks, contributing more strongly to the overall burden of perceived risks and to the feeling of subjective safety. Concerning traffic risks, more mitigation strategies had been established over time by the cyclists. We conclude that this is because traffic risks are less predictable and have immediate consequences warranting immediate reactions.

6.2. Mitigation strategies and subjective safety

A central finding is that the accumulated experiences of perceived risks of our cyclists lead to mitigation strategies that may seem counter-intuitive at first (limiting high-vis attire, taking up more instead of less road space, maintaining speed instead of braking, breaking traffic regulations to avoid collisions). Accounts of experiences of risks include combinations of risk perception and perceived efficacy of mitigation strategies. This leads to our hypothesis that experiences of subjective safety are not necessarily due to the absence of risks but are dependent on the perceived efficacy of individual mitigation strategies for perceived risks.

6.3. Cycling habitus

However, and importantly, the mitigation strategies are only necessary because the conditions are this adverse for cyclists in Aachen. The unsafe traffic situation in the city has become a common experience to the extent that it has become part of the local mobility culture. It constitutes common knowledge and “implicit” knowledge (Reckwitz, 2003) among experienced utility cyclists and is part of the habitus of utility cyclists in Aachen. While this may have encouraged our cyclists to share their individual strategies, the cycling-adverse mobility culture and the habitus connected to it are risks to diversity, equity and inclusion, raising the barriers for novice cyclists, impeding “mobility justice” (Sheller, 2018), and significantly slowing down a sustainable mobility transition.

6.4. Fearful cycling culture

The habitus and surrounding cultural discourse on cycling in Aachen contributes to the construction of a culture fearful of cycling, as analysed in detail before for other cities by Horton (2007), and may thus raise the barriers for people less experienced with cycling. That acquiring the habitus of urban utility cycling requires cultural and social capital has also been shown by Nettleton and Green (2014) for novice cyclists. If the social practice of utility cycling includes being able to confidently navigate the risks associated with it, and mitigation strategies seem counter-intuitive to novel cyclists, this creates a barrier for those with less social and cultural capital available to learn such behaviour.

6.5. Risking equity and inclusion

Our study finds that utility cycling may not be as inclusive and accessible as it is often painted as. The interlinkage of utility cycling to a sustainable lifestyle is a form of privilege that is in practice not accessible for all. This is a blind spot in public and scientific discourse, often concealed by the framing of cycling as a cheap and accessible mode of transport. Through the interlinkage of cycling with the normativity of a sustainable lifestyle, utility cycling becomes a social practice that may reinforce social stigma surrounding low- or no-income people, when these blind spots are not proactively addressed. Consequently, both the financial and cultural means necessary for sustainable and long-term utility cycling should not be excluded from the discourse surrounding the benefits of utility cycling. Further research focusing on the intersections of social and cultural barriers to cycling, along with further explorations of perceived risks and their impacts on subjective safety, is necessary.

7. Policy recommendations

Our study is a case study of a specific group of cyclists, and we acknowledge that translation from our results on habitus and social practices into policy recommendations is not without methodological challenges and normative connotations. The following policy recommendations are thus formulated in answer to the question 'what makes committed utility cyclists despite adverse conditions?'. Through this framing, we are able to provide planners and policy makers who would like to plan for utility cycling to become a mode of transport in cities where infrastructure, traffic planning, air quality, and topography are not ideal with concrete recommendations, without concealing that our policy recommendations are deduced secondarily from the results of our case study. So, what makes committed utility cyclists despite adverse conditions?

1. A perceived level of high traffic safety, which does not necessarily have to correspond with the actual level of safety and is highly subjective and adaptive. Therefore, availability of robust data on and transparent communication of fatal and non-fatal cycling incidents, their prosecution and clearance are necessary, to make individual risk assessments easier, risks more understandable for non-cyclists, and to reduce hearsay in public discourse.
2. Perceived and ascribed respect from other traffic participants, especially motorists
3. Feeling of belonging to an equitable and diverse cycling-friendly mobility culture
   a. Feeling of integration into civil society, local politics, and public discourse
      i. Representation and visibility of cycling-related issues, especially risks, in local politics and public discourse
      ii. Transparent city planning with understandable infrastructural interventions and accountability of planners and politicians
   b. As many safe cycling infrastructural measures as possible to reduce the less predictable risks, such as air pollution, to a minimum and thereby reduce stress levels of utility cycling
   c. Infrastructural measures to increase speed and efficiency of utility cycling, especially in relation to motorised traffic
   d. Infrastructural measures to make cycling easier to execute with less social and cultural capital, thereby increasing equity
   e. Infrastructural measures to make slower cycling possible, thereby increasing diversity

We argue that to transform the mobility culture of a city towards a more environmentally friendly and healthy one, the barriers to participating in active modes of transport need to be lowered. Mobility behaviour is a cultural and social practice inextricably linked with infrastructure. A micro-level analysis of perceived risks and mitigation strategies of utility cyclists can help to understand the mobility habitus beyond quantitative and infrastructural factors. While infrastructure can motivate people to change their mobility behaviour, cultural and social factors are relevant for establishing mobility habits such as committing to utility cycling long-term.

Author statement

Jennifer Bosen: Conceptualisation, Methodology, Formal Analysis, Investigation, Data Curation, Writing: Original Draft, Writing: Review & Editing, Visualisation; Hanna E. Fuchte: Conceptualisation, Validation, Review & Editing; Carmen Leicht-Scholten: Supervision, Funding Acquisition, Review & Editing.

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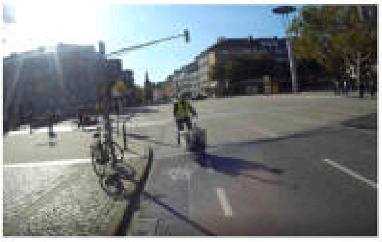
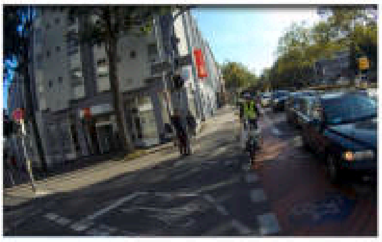
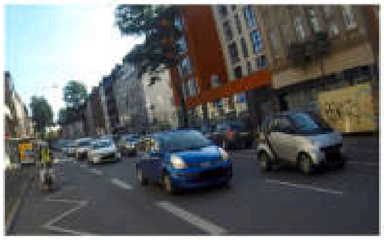
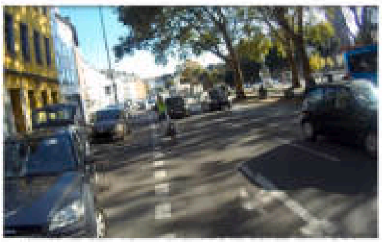
Appendix

Table 1
References: Fuchte et al. (2022), Deutsche Umwelthilfe (2019), Polizei Nordrhein-Westfalen Aachen (2017).

Typical Cycling Scenario	Location and Field Description of Route
	0. Complete Cycling Route Start: 50.768656, 6.090822 End: 50.778977, 6.047224 The route "crossed the city center of Aachen in a three-quarter circle through the valley basin from South counterclockwise to West. The cycling route started close to the main station, proceeded along the inner city ring road, crossed the peripheral areas in the West of the city with residential development, and eventually led to the university campus close to the Dutch border (5.2 km)" (Fuchte et al., 2022).
	1. Central Train Station Four-lane street, two lanes per direction, with advisory cycle lanes [A] and bus stops. Advisory cycle lane runs between bus stop and motorised traffic lanes, buses have to cross cycle lanes to reach bus stop.
	2. Normaluhr Four-lane street, two per direction, large intersection with multi-lane streets crossing and advisory cycle lanes, right-turning motorists crossing the advisory cycle lane.
	3. Wilhelmstraße and Air-Quality Monitoring Station Four-lane street, two per direction, with advisory cycle lanes and bus stops. Advisory cycle lane runs between bus stop and motorised traffic lanes, buses have to cross cycle lanes to reach bus stop. High levels of traffic, lanes for motorised vehicles and advisory cycle lanes are narrow, minimum distances are often not maintained. Air-quality monitoring station "Wilhelmstraße" (VACW) next to the road. This site is known for higher levels of air pollutants (Deutsche Umwelthilfe, 2019).
	4. Kaiserplatz Intersection with advisory cycle lanes. Parked cars frequently blocking the advisory cycle lane, forcing cyclist to merge with motorised traffic.

[A] To facilitate matters, we use the term "advisory cycle lane" for all cycling infrastructure that is not separated through a physical barrier from the road, part of the car lane and legally considered a carriageway. However, the route actually features two different cycling lanes: "Schutzstreifen" (direct translation: "protection lane") which are non-mandatory and "Radfahrstreifen", which would be mandatory, but are not on our route because they are not indicated correctly through traffic signs. Therefore, even though the road marking is different, all cycling lanes on the route are non-mandatory.

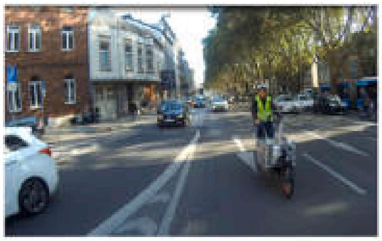
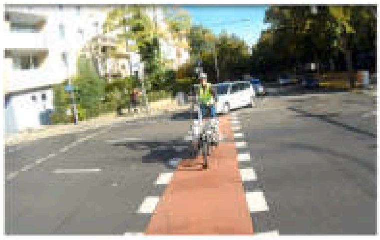
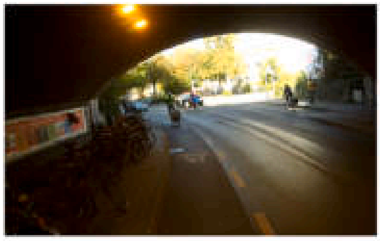
Typical Cycling Scenario	Location and Field Description of Route
	5. Hansemannplatz Large intersection, advisory cycle lane ends shortly before the intersection, forcing cyclists to merge with motorised traffic. Right-turning lane appears shortly after the advisory cycle lane disappears, forcing cars turning right to cross cyclists going straight ahead. No cycling lane on intersection, intersection known for multiple non-fatal and fatal collisions (Polizei Nordrhein-Westfalen Aachen, 2017).
	6. Mohnheimsallee and Ludwigsallee Four-lane street, two lanes per direction are separated by park strip with trees. Road partly with advisory cycle lanes, partly without cycling lanes, mixed traffic and urban green. Several turn-offs where motorists have to cross the advisory cycle lane. Incline of road, especially on Ludwigsallee, making cycling at speed more exhausting and increasing minute ventilation.
	7. Intersection Krefelderstraße Intersection with advisory cycle lanes. Motorists turning right are forced to cross advisory cycle lanes of cyclists going straight ahead.
	8. Westbahnhof Train station underpass with advisory cycle lanes. Advisory cycle lane merges with sidewalk in the underpass. Stairs to a train station above generate high flows of pedestrians and crowded sidewalks with pedestrians walking on cycling lanes. Cycle racks on the sidewalk.
	9. Mies-van-der-Rohe-Straße to 10. Computer Science Centre Road with incline, without cycle lanes, mixed traffic, frequent car and bus traffic on a single lane, cars parking on the side of the road, allowing only for one car or bus to pass through and cars accelerating while overtaking to avoid oncoming traffic. Incline makes cycling at speed more exhausting and increases minute ventilation.

Table 2
Socio-demographic characteristics of the interviewees.

Socio-demographic categories	Number of interviewees
Age	
18–25	2
26–30	5
31–40	2
41–50	1
Gender	
Female	4
Male	6
Highest Educational Level	
Master's Degree or equivalent	6
Bachelor's Degree	2
PhD or German Doctorate	1
Abitur (German Secondary School Diploma)	1
Employment Status	
Employed	7
Student	3

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