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Exploring the potential of fNIRS in capturing subjective cycling experiences

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Challenge Addressed / Research Problem Investigated

We need a robust way to understand people's subjective experiences while they cycle to increase cycling participation, which has remained low in many developed countries despite proven benefits.

Abstract

INTRODUCTION

Despite proven environmental, economical, and health benefits, cycling participation remains low in many developed countries. Subjective experiences have been identified as a key deterrents to cycling participation; unpleasant weather conditions and sense of unease from exposure to motorised traffic are commonly reported factors (Sanders & Judelman, 2018; Useche et al., 2019). This study investigated the potential of functional near-infrared spectroscopy (fNIRS) to capture and enable understanding of subjective experiences while cycling, and discussed its implications for enhancing cycling participation.

fNIRS is a type of non-invasive neural imaging sensor that measures changes in blood oxygenation levels in the brain to infer neural activity. Its portability and relative ease of setup make it particularly suitable for studying cycling in real-world conditions. This study stands out in its novelty as it is the first to employ fNIRS to explore subjective experiences within the context of cycling. Acknowledging the complex nature of experience, the present study employed a mixed methods approach, combining quantitative fNIRS data with subjective on-ride self-reports. Sensor data is neccessary as self-reports are prone to biases.

For simplicity, subjective experiences were simplified to positive and negative emotions, commonly referred to as *valence* in psychology. Existing literature on the neural correlates of valence highlights the significance of the prefrontal cortex (PFC) (Lindquist & Barrett, 2012; Machado & Cantilino, 2016), which leads to the following hypotheses: Both positive and negative valence are associated with heightened activity throughout the PFC; positive valence in particular corresponds to further increased activity in the left PFC and reduced activity in the right PFC.

EXPERIMENT DESIGN

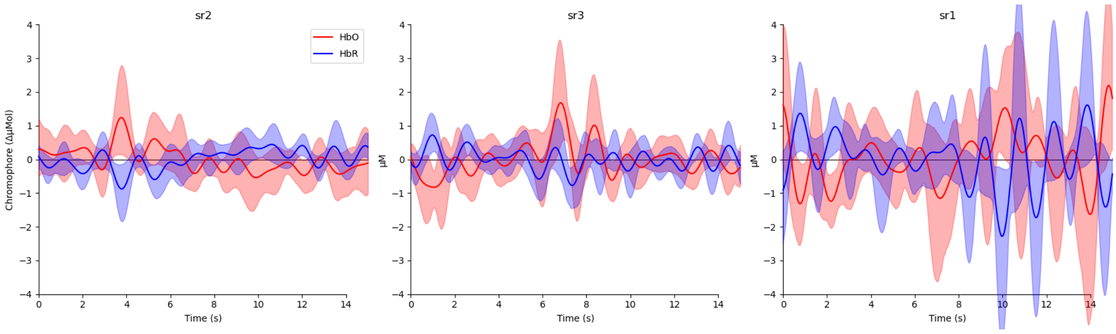
17 healthy participants were involved in the experiment, with each trial conducted individually during non-rush hours to minimise bias from varying traffic conditions. Participants were

equipped with an Artinis Brite MKII, a two-wavelength continuous wave fNIRS system placed over the prefrontal cortex (PFC). The fNIRS device measured oxygenated (HbO) and deoxygenated (HbR) blood levels, collecting data at a rate of 50 Hz. Once equipped with the fNIRS device, participants were taken outside to their bikes. An action camera and a mobile phone were attached to the participant's bike near the center of the steering bar. The camera faced forward, while the mobile phone, preloaded with the PIEL Survey experience sampling app (pielsurvey.org) configured for the experiment, was positioned for visibility to the rider.

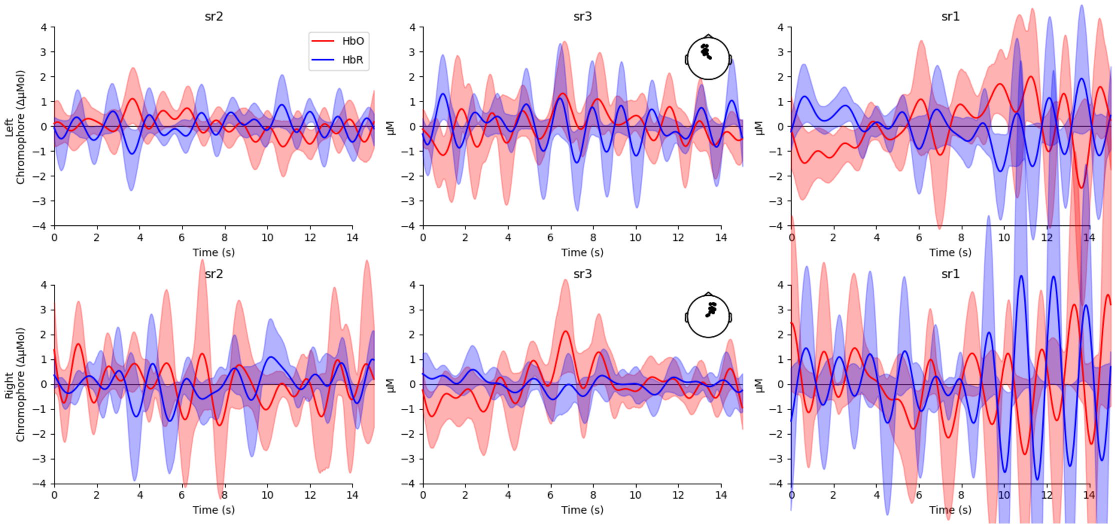
Camera recording and fNIRS measurement began as each participant cycled a 7.5 km looped route. The route was designed to include both a 'busy route' along a main road with motorised traffic, stops, and intersections, and a 'peaceful route' consisting of a dedicated bicycle highway with natural surroundings. The intention was for the busy route to elicit more negative valence, while the peaceful route was expected to evoke more positive valence. To prevent bias, the direction in which participants cycled was randomly determined. Throughout the cycling session, the PIEL Survey app on the mobile phone emitted a notification sound every 3 minutes, prompting participants to rate their current feelings as positive, neutral, or negative. After completing the ride, participants were guided indoors for a brief video-stimulated interview to gather contextual information that could help explain the observed results.

RESULTS

For each participant's data, 15-second windows were extracted, excluding noisy channels and corrupted portions. These windows were then averaged by rating based on the on-ride ratings. Analysis of the average window responses across all participants and channels revealed higher levels of variability and uncertainty in both HbO and HbR signals in response to rating 1 (negative) compared to ratings 2 (neutral) and 3 (positive). No other patterns were identified by visual inspection.



Grand average window responses: The average window responses specific to each hemisphere (left vs right PFC) demonstrated similar findings. Rating 1 exhibited signals with higher variability and uncertainty compared to ratings 2 and 3. Visual inspection suggested that the signals from the right PFC during rating 1 appeared slightly more erratic than those from the left PFC.



Hemisphere-specific average window responses: The quantitative analysis, conducted using a mixed-effects linear model, did not yield significant results, thereby failing to support the hypotheses. Furthermore, as part of an exploratory analysis, a Pearson correlation coefficient test revealed that the busy route did not evoke the expected negative valence, nor did the peaceful route evoke the expected positive valence.

DISCUSSION

The fact that the quantitative analysis did not yield statistically significant findings could be explained by several factors. Based on the post-ride interviews, the broad definition of positive and negative valence might have resulted in neurologically distinct experiences being grouped together, making it challenging to identify specific features accurately. The naturalistic approach of the experiment, combined with the inherent physicality of cycling, likely introduced various confounding factors that were not fully mitigated or accounted for in the experiment design, data preprocessing, and analysis. Additionally, the quality of the connection between the sensor and the scalp could have influenced data quality and led to insignificant results. Nonetheless, the visual correlation between negative ratings and higher variability in HbO and HbR should not be disregarded. This pattern suggests a potential relationship between subjective experiences and physiological measures, notably cerebral oxygen consumption, which warrants investigation in future research.

It became evident that the type of surroundings was insufficient to consistently evoke positive or negative valence. Participants commonly associated negative valence with headwind, which occasionally occurred on both the busy route and the peaceful route (an uncontrolled factor). Manipulating valence by altering the physical surrounding alone is not a reliable solution for a naturalistic cycling study.

This study contributes to the groundwork for future research to develop more effective and robust frameworks for conducting naturalistic fNIRS experiments involving physical activities. The study also faced considerable challenges due to the relatively immature supporting ecosystem of data analysis tools and sparse information on best practices, underscoring the need for improving toolkits and documentation. In the long run, being able to capture nuanced differences between pleasure and arousal in subjective cycling experiences could provide insights for creating people-centric urban spaces and cities.

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This study was conducted as interdisciplinary collaboration between University College Twente, Transport Engineering & Management research group from the Faculty of Engineering Technology, and Pervasive Systems research group from the faculty of Electrical Engineering, Mathematics, and Computer Science, all at the University of Twente.

References

Lindquist, K. A., & Barrett, L. F. (2012). A functional architecture of the human brain: Emerging insights from the science of emotion. *Trends in Cognitive Sciences*, *16*(11), 533–540. https://doi.org/10.1016/j.tics.2012.09.005.

Machado, L., & Cantilino, A. (2016). A systematic review of the neural correlates of positive emotions. *Brazilian Journal of Psychiatry*, *39*, 172–179. https://doi.org/10.1590/1516-4446-2016-1988.

Sanders, R. L., & Judelman, B. (2018). Perceived Safety and Separated Bike Lanes in the Midwest: Results from a Roadway Design Survey in Michigan. *Transportation Research Record*, *2672*(36), 1–11. https://doi.org/10.1177/0361198118758395.

Useche, S. A., Montoro, L., Sanmartin, J., & Alonso, F. (2019). Healthy but risky: A descriptive study on cyclists' encouraging and discouraging factors for using bicycles, habits and safety outcomes. *Transportation Research Part F: Traffic Psychology and Behaviour*, *62*, 587–598. https://doi.org/10.1016/j.trf.2019.02.014.

Planning for cycling: Exploring a flow-based framework for placemaking and urban vitality

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Challenge Addressed / Research Problem Investigated

Investigating the interplay of flow, place-making, and urban vitality to enhance recreational cycling planning in Zwolle, the Netherlands.

Abstract

This abstract presents research conducted in Zwolle, the Netherlands, aimed at improving planning for recreational cycling by investigating the interplay of psychological flow, place-making, and urban vitality. The study was based out of the Mobycon office in Zwolle, the Netherlands and contributed to my Urban Ecological Planning (UEP) master's thesis at NTNU. The study employed a mixed methods approach, incorporating expert interviews, participatory trials, and data analysis from a physiological sensors and camera data.

The trials involved a route that took approximately 15-20 minutes to complete, encompassing four distinct sections. The first section traversed a modern urban area just south of Zwolle station. The second section passed through a semi-urban neighbourhood. The third section led through a rural area and up onto a dike, offering views of the river IJssel. Finally, the fourth section followed a cycling highway that ran parallel to rail tracks.

Drawing inspiration from the work of Marco te Brömmelstroet and colleagues, who have postulated incorporating Flow Theory into transportation planning, Mobycon embarked on this project as part of a larger effort to develop a National Recreational Cycling Network in Denmark. Future trials may take place in Denmark, emphasizing the importance of considering context-specific differences between locations.

Expert interviews conducted during the research highlighted the importance of visually appealing and diverse cycling routes that blend architectural elements with natural surroundings, reflecting the principles of place-making. These features were found to enhance the cycling experience, fostering flow and a stronger connection with the environment. The inclusion of rest stops and points-of-interest along the route emerged as vital for facilitating social interaction and contributing to urban vitality.

During the participatory trials, sensor data such as electrodermal activity (EDA), was collected to gain insights into participants' emotional states. While EDA data was the primary focus, future research should explore the potential of utilizing other sensor data types, like heart rate, heart rate variability, skin temperature, and EEG, to obtain a more comprehensive understanding of emotional experiences during cycling. To enhance data analysis and location-specific correlations, the integration of GPS tracking devices apps, or alternatively a cyclocomputer is recommended. This will provide seamless connection between emotional

data and specific locations on the cycling routes, facilitating accurate analysis and interpretation.

The study also identified the need for improved routing techniques in cycling research. Clear wayfinding and route guidance were identified as essential to minimize participant uncertainty and potential disruptions to the flow experience. Future trials should consider employing ride-alongs with researchers or utilizing mounted devices displaying route maps to ensure participants can focus solely on the ride experience.

Camera placement was also highlighted as an area for optimization. Multiple cameras, including higher-angle and front-facing lenses, or adopting a 360-degree camera lens, can capture participants' interactions, facial expressions, and the surrounding environment. The choice of camera placement should prioritize ease of data analysis and accessibility.

In conclusion, this study conducted in Zwolle, the Netherlands, underscores the importance of understanding the interplay between psychological flow, place-making, and urban vitality to enhance recreational cycling planning. By creating cycling environments that promote flow experiences, offer aesthetic diversity, and facilitate social interaction, planners can contribute to high-quality cycling spaces and foster urban vitality.

The findings presented in this abstract provide valuable insights for the field of recreational cycling planning. I look forward to sharing and discussing these findings at the 7th Annual Meeting of the Cycling Research Board in Wuppertal, Germany, to facilitate knowledge exchange and advancements in the field of recreational cycling planning.

Incomparable Results: Exploring the Challenges of Measuring Lateral Passing Distance

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Keywords
instrumented bicycle, sensors, bicycle safety, urban mobility

Challenge Addressed / Research Problem Investigated
Different methodologies coupled with recent technological advancements lead to a variety of methodological issues regarding measuring of lateral passing distance, thus limiting comparability of obtained results.

Abstract
Lateral passing distance (LPD) between cyclists and vehicles has been researched as of the 1970s (Watts, 1979), but has only recently gained prominence as a safety issue. This was partly influenced by technical developments and the availability of affordable sensors and measurement methods. Instrumented bikes, equipped with a variety of sensors, have been used in a number of studies (see Gadsby and Watkins, 2020).

Rubie et al., (2020) listed 12 different ways in which lateral passing distance was previously defined, ranging from “bicycle tire to outside edge of motor vehicle tire” to “outermost part of the cyclist to the outermost part of the motor vehicle or something sticking out of the motor vehicle, i.e. side mirror”. The difference in distance between those two extreme definitions can be more than 50 cm.

Another methodological issue arises from the technological advancement of instrumented bikes. Modern sensors with high frequency of data recording produce a number of measurements for each passing event. The minimal distance recorded by sensors can often differ from the distance measured at any point during a passing event – a method extensively used in the past (Watts, 1979; Walker, 1997).

In this paper, we aim to explore if different definitions of LPD produce comparable results and if LPD measured as a single measurement during a passing event is representative compared to continuous measurement by sensors with a high frequency of data capture.

METHODS
Traffic camera footage was collected in the town of Brandýs nad Labem, Czechia, in March 2019. 59 passing events were extracted from a video recording. For each passing event, a lateral passing distance was measured using three definitions: (a) tire to tire, (b) edge of bicycle handlebar to body of car, (c) from outermost point of cyclist to outermost point of car. The proportion of passes under 100 cm and 150 cm was calculated for each definition of LPD. A logit model for the probability of the close pass depending on the distance of the cyclist from the edge of the road was calculated for each definition of LPD.

We used an instrumented bicycle equipped with two TFmini-S LiDAR sensors with a frame rate 50 FPS to measure passing events in real traffic in the city of Olomouc, Czechia in March 2023. An instrumented bicycle was also equipped with a button for manual recording of the passing event. 34 passing events were recorded (excluding overtaking maneuvers by buses). The minimal distance during the passing event measured by both sensors and the distance measured at the moment of manual recording were compared.

RESULTS

The proportion of passes under 100 cm and 150 cm differs significantly for each definition of lateral passing distance. The proportion of passes under 150 cm ranges from 15 % to 86 % for extreme definitions of LPD.

Table 1: Percentage of close passes depending on definition of LPD.

Definition of LPD	% of passes < 100 cm	% of passes < 150 cm
Tire to tire	0 %	15 %
Edge of handlebar to body of car	7 %	69 %
Outermost points of cyclist and car	12 %	86 %

Previous studies show that the closer the cyclist rides to the kerb, the larger the LPD (Walker, 2007; Jensen et al., 2017). We used a logit model to describe the probability of a close pass under 150 cm, depending on the distance from the kerb, for all three definitions of LPD. The distance from the kerb is evaluated as significant predictor ($p < 0.05$ for definitions (a) and (b), $p < 0.1$ for definition (c)), the shape of the logit function, however, differs (see Figure 1). In more than 90 % of cases, the distance measured at the moment of manual recording of the passing event was lower than the minimal distance measured by sensors during the passing event. The median difference was 5 cm, with the difference being greater than 31 cm in 25 % of cases.

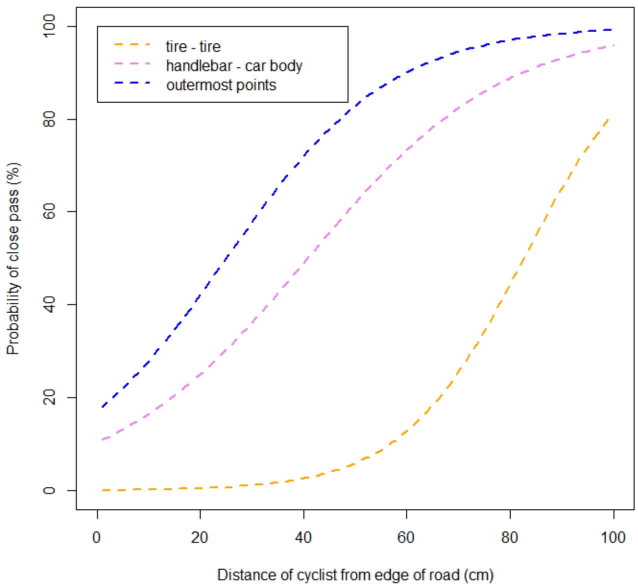

Figure 1: Shape of relation between probability of close pass (< 150 cm) and distance from kerb differs for each definition of LPD.

CONCLUSIONS

The definition of the lateral passing distance influences the measured distance during the passing event. The difference in distances between the various definitions can be more than 50 cm, which makes the results of various studies of LPD incomparable. A very common result of studies of overtaking manoeuvres is the proportion of close passes (with various distances used as the cut-off point for a close pass). We have shown that the definition of distance not only influences the proportion of close passes (from 15 to 86 % dependent on a definition) but also the shape of models which aim to explain it.

Another incomparability issue stems from technological advancements. Modern sensors are capable of capturing up to tens of measurements for a single passing event. When the distance is measured at only one point during a passing event, the measured distance is often (> 90 %) greater than the minimal distance measured by sensors during the passing event.

References

A. Gadsby and K. Watkins, "Instrumented bikes and their use in studies on transportation behaviour, safety, and maintenance", *Transport Reviews*, 40-6 (2020), pp. 774-795.

Jansen, R., Lotan, T., Winkelbauer, M., Bärgman, J., Kovaceva, J., Donabauer, M.,...Van Nes, N. (2017). Interactions with vulnerable road users. UDRIVE Deliverable 44.1. EU FP7 Project UDRIVE Consortium. https://doi.org/10.26323/UDRIVE_D44.1

E. Rubie, N. Haworth, D. Twisk, and N. Yamamoto, "Influences on lateral passing distance when motor vehicles overtake bicycles: A systematic literature review", *Transport reviews*, 40-6 (2020), pp. 754-773.

I. Walker, "Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender", *Accident Analysis and Prevention*, 39-2 (2007), pp. 417-425.

G. R. Watts, *Bicycle safety devices-effects on vehicle passing distances*, No. HS-028 717, 1979.

Details that disrupt – Investigating the relationship between the sense of flow and cycling infrastructure

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Keywords
cycling, design, bicycle infrastructure, city planning, video methodology

Challenge Addressed / Research Problem Investigated

Identify and improve details in the existent cycling infrastructure that somehow disrupt flow and disturb the cyclists experience, leading to behaviours what can be seen by other road users as unsafe or unpredictable.

Abstract

INTRODUCTION

Many cities around the globe want to increase cycling to reduce the use of private cars, traffic congestion and pollution, as well as gain direct and indirect health benefits. Nonetheless, promoting cycling also requires appropriate infrastructure that offers positive and safe cycling experiences, inviting more people to bike. Providing such infrastructure can be a challenge in built-up cities, where cycling has not been historically prioritized. Previous research shows that inconsistencies in infrastructure can lead to suboptimal cycling behaviours, perceived as unpredictable by other road users. But also, that small design changes in the infrastructure can lead to safer behaviour where cyclists experience a sense of flow – a positive feeling of 'keeping on moving'.

To deepen the understanding of which aspects of existing infrastructure disrupt flow and leads to negative consequences, this study tries to answer the question 'how is cycling flow disrupted?'.

METHOD

To define what cycling flow can be, we held a workshop at CRBAM22, where cycling experts explored the surroundings of the conference, looking for and photographing different types of flows, and then jointly delineating aspects of cycling flow and disruption.

A study was then conducted in two cities, Gothenburg, Sweden and Curitiba, Brazil, where these aspects were used as a framework to explore existing infrastructure and find disrupted flow and consequences. Participants that had started everyday cycling in the city in the last 6 months were targeted for recruitment, so that they would not have become too used to the details in the infrastructure.

21 participants from Gothenburg and 10 from Curitiba participated in the study. To contextualize the findings, both Gothenburg and Curitiba are considered hilly and rainy cities. Gothenburg is located on the west coast of Sweden, has around 600.000 habitants and a cycling network of approximately 800 km, whilst Curitiba is located on the southern part of Brazil, 900 meters above ocean level, approximately 2 million habitants and roughly 250 km of cycling lanes.

Following a method developed in previous research, the 31 participants (13 men, and 18 women) were invited to video-record one stretch of everyday cycling using a GPS equipped video-camera (Garmin VIRB Ultra 30) mounted to their bicycles' handlebar. Each participant was then interviewed using a semi-structured script while watching their footage together with the interviewer. The goal was to identify places and situations in both cities that hinder the flow, the reasons why, and the possible consequences.

The data was analysed with an emerging coding scheme focused on categorising the aspects such as unclear signs, sharp turns, illogical movements, low visibility etc. We also looked to identify the consequences of these aspects in terms of the cyclists' behaviours, and their feelings about it.

RESULTS AND DISCUSSION

From the workshop we learned that different types of flows coexist in the city, and that a bicycle friendly infrastructure should allow that. Aspects such as space for adaptation and interaction, good visibility, adequate pavement, and enough width were mentioned as key points. Likewise, predictability and consistency were highlighted by the experts.

The recruited participants in the video-study had different experiences regarding cycling in the city and were divided into 3 categories: experienced cyclist; new to everyday cycling; and experienced cyclist, but new to the city. The distance of cycling recorded was 146 km in Gothenburg and 67,5 km in Curitiba and the average range cycled per participant were quite similar, circa 7 km and 7,5 km respectively.

The analysis highlighted the existence of 16 infrastructure aspects that somehow disrupt flow for cyclists, with an average of 3,4 of those situations/places per km in Gothenburg and 5,3 in Curitiba. Two additional codes emerged from the analysis of the Brazilian city data, one related to lack of public safety and the other to the absence of infrastructure, the latter being the most common code in Curitiba.

The most frequent codes are different among the two cities, but there are some recurrent patterns, like narrowness, unclear signs, low visibility, obstructions, sharp turns, and bumpiness. Not rarely, more than one aspect of flow disruption was present at the same place or situation. The flow disrupting aspects lead to different consequences, classified as behaviours and feelings.

For instance, behaviours identified as consequence of narrowness in the cycling lane varied from cycling on the pedestrian path instead, riding wrong way on the cycling lane, to cycling on the street, depending on the context and presence of other road users. Besides that, when riding on a narrow path, participants mentioned the need to be alert at all times, feeling annoyed when not being able to keep the pace when overtaking was not possible, or even unsafe or vulnerable when it is so narrow that the cyclist is forced into the street.

To attract more people into cycling, bicycle infrastructure must provide a positive experience, allowing cyclists to move as flowy as possible, feeling safe, secure, and comfortable. In contrast, the results show that cyclists' flow is often disturbed, which might hinder new cyclists when making their first attempts and discouraging a broader spectrum of people into cycling.

CONCLUSIONS

The flow disruption aspects identified can often be associated with the fact that cycling infrastructure is squeezed in, but also to non-implementation of cycling infrastructure design manuals' recommendations or due to insufficient recommendations.

This abstract focuses on how the cycling flow is disrupted and its consequences, but the larger project also investigates why disruptions happen, comparing the findings with existing infrastructure manuals and interviewing city planners. We expect that the future categorization will allow for finding patterns that can be used to design infrastructure solutions that are easy to implement and make cycling more pleasant and safer, and cyclists happier.

Can a speedlimit of 30 km/ improve passing distances when overtaking cyclists?

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Challenge Addressed / Research Problem Investigated

Finding out whether there is any relation between the speed limit and lateral passing distances.

Abstract

INTRODUCTION

The German Federal Ministry of Transport and Digital Infrastructure has set an ambitious target for cycling: starting from 2017, riding distances are to be doubled by 2030 (BMDV, 2022). However, there numerous barriers that prevent people from riding a bicycle, one of which is the perceived safety of cycling. Feeling unsafe is one of the most crucial reasons for not using a bike (Balanovic et al., 2016; Götschi et al., 2018; Heinen et al., 2010). Exposure to motorized traffic, especially close overtaking vehicles, has a particularly negative effect on this perception (Lassen, 2019; Springer, 2021). Reducing the number of close passing events can therefore encourage more people to ride a bicycle. A differentiated analysis of lateral passing distances (LPD) appears to be of particular relevance in order to improve the infrastructure in favour of cyclists.

STATE OF RESEARCH

Previous studies are consistent that narrower lanes encourage closer LPD (Huemer, 2019; Nolan et al., 2021; Van Houten et al., 2018). There is disagreement about the role of dedicated bicycle infrastructure: some studies postulate a positive influence of marked bike lanes(Evans et al., 2018; Mchale & Stewart, 2014; Mehta et al., 2015), others a negative one (Beck et al., 2019; Huemer, 2019; Nolan et al., 2021; Parkin & Meyers, 2010). Cyclists were passed with a greater LPD when the road was marked with sharrows (Koppers et al., 2021). Along parked vehicles, cyclists were passed more closely (Beck et al., 2019; Evans et al., 2018; Mchale & Stewart, 2014). If cyclists ride at a greater distance from the curb, vehicles overtake at a significantly lower distance (Jansen et al., 2017; Rasch et al., 2020; Walker, 2007). Oncoming vehicles have a particularly negative effect on the LPD (Evans et al., 2018; Farah et al., 2019; Huemer, 2019; Mchale & Stewart, 2014; Shackel & Parkin, 2014). The influence of a maximum speed limit has so far only been investigated in Australian studies. In states where field studies have been carried out, the minimum passing distance depends on the maximum permitted speed and the actual effect of the maximum speed therefore remains unclear. A distance of at least 1.00 m must be maintained below 60 km/h, and 1.50 m above 60 km/h (Queensland Government, 2022; Victoria Government, 2021). However, this separation value is not directly reflected in the results of Beck et al. (2019). There, the greatest distances were measured at 60 km/h. Lower, but also higher permissible maximum speeds led to lower passing distances. Debnath et al. (2018) found a similar situation, where speeds below 40 km/h and above 70 km/h increased the likelihood of noncompliant passing events.

In 2021 the authors of this abstract carried out a large field study in the city of Dresden. 4,200 passing events have been recorded out of which almost 50% violated the minimum distance of 1.50 m. Narrow lanes with marked dotted bike lanes encourage close passing. As shown in previous studies, oncoming traffic and a second vehicle overtaking in parallel led to significantly lower LPD. The results also indicate that narrow LPD are self-reinforcing: If a vehicle overtook in violation of the rules, the likelihood that a vehicle following a short distance behind would do the same increased by 50%. It was confirmed that trucks and buses overtook at close intervals. It was also found that along stationary traffic on the carriageway, overtaking took place at greater distances. (Reh & Lißner, 2022)

METHOD

A high proportion of non-compliant passing events (70%) was observed on Terrassenufer, a street located in immediate vicinity of the old town of Dresden and the river Elbe. The street has an important function for both the road and the cycling network. On average, the section is frequented daily by 23,400 vehicles and is equally important for commuting and tourist bicycle traffic. A dotted bike lane of 2.15 m width is provided for cyclists riding eastbound, while motorised traffic is left with one lane with a width of 3.00 m in each direction. Westbound cyclists are supposed to ride with the motorised traffic with the footpath being legal to use as well. Currently, the speed limit on this road is at 50 km/h, which will be reduced to 30 km/h on a trial basis over a period of three months in summer 2023 in order to reduce the number of non-compliant passing events (LHD Dresden, 2023).

In order to determine the influence of the reduced speed limit on the overtaking distance, a measuring bicycle identical to Reh & Lißner (2022) is equipped with instruments. To measure the overtaking distance, an ultrasonic sensor will be used. A video camera will be attached to the handlebars to record the traffic flow. A laser pointer is used to keep the distance to the board constant. Data will be collected at two and eight weeks respectively from the introduction of the speed limit with 30 trips at each time period.

RESULTS

Results of the measurement runs as well as the analysis will be available at the begin of October 2023. Changes in the average passing distances will be presented as well as the change in numbers of passing manoeuvres.

References

Balanovic, J., Davison, A., Thomas, J., Bowie, C., Frith, B., Lusby, M., Kean, R., Schmitt, L., Beetham, J., Robertson, C., Trotter, M., Kortegast, P., & Burton, J. (2016). *Investigating the feasibility of trialling a Minimum Overtaking Gap law for motorists overtaking cyclists in New Zealand*. NZ Transport Agency. https://www.nzta.govt.nz/assets/Walking-Cycling-and-Public-Transport/docs/Minimum-Overtaking-Gap-Feasibility-Study-FINAL.pdf.

Beck, B., Chong, D., Olivier, J., Perkins, M., Tsay, A., Rushford, A., Li, L., Cameron, P., Fry, R., & Johnson, M. (2019). How much space do drivers provide when passing cyclists? Understanding the impact of motor vehicle and infrastructure characteristics on passing distance. *Accident Analysis and Prevention*, *128*(March), 253–260. https://doi.org/10.1016/j.aap.2019.03.007.

BMDV. (2022). *Nationaler Radverkehrsplan 3.0* (PTV Group, ifok GmbH, & Fraunhofer-Institut für System- und Innovationsforschung ISI (eds.)). Bundesministerium für Digitales und Verkehr. https://www.bmvi.de/SharedDocs/DE/Artikel/StV/Radverkehr/nationaler-radverkehrsplan-3-0.html.

Debnath, A. K., Haworth, N., Schramm, A., Heesch, K. C., & Somoray, K. (2018). Factors influencing noncompliance with bicycle passing distance laws. *Accident Analysis & Prevention*, *115*, 137–142. https://doi.org/10.1016/J.AAP.2018.03.016.

Evans, I., Pansch, J., Singer-Berk, L., & Lindsey, G. (2018). Factors Affecting Vehicle Passing Distance and Encroachments While Overtaking Cyclists. *Institute of Transportation Engineers. ITE Journal*, *88*(5), pp 40-45. https://trid.trb.org/view/1516818.

Farah, H., Bianchi Piccinini, G., Itoh, M., & Dozza, M. (2019). Modelling overtaking strategy and lateral distance in car-to-cyclist overtaking on rural roads: A driving simulator experiment. *Transportation Research Part F: Traffic Psychology and Behaviour*, *63*, 226–239. https://doi.org/10.1016/j.trf.2019.04.026.

Götschi, T., Castro, A., Deforth, M., Miranda-Moreno, L., & Zangenehpour, S. (2018). Towards a comprehensive safety evaluation of cycling infrastructure including objective and subjective measures. *Journal of Transport and Health*, *8*, 44–54. https://doi.org/10.1016/j.jth.2017.12.003.

Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by bicycle: An overview of the literature. *Transport Reviews*, *30*(1), 59–96. https://doi.org/10.1080/01441640903187001.

Huemer, A. K. (2019). Wie beeinflusst die Infrastruktur für Radfahrer das Überholverhalten von Autofahrern ? I. *Fachveranstaltung Zum ADFC-Fahrradklima-Test 2018, Berlin*. https://www.adfc.de/fileadmin/user_upload/Im-Alltag/Fahrradklimatest/Download/2018/Fachveranstaltung_Vortrag_A.K.Huemer_TU_Braunschweig.pdf.

Jansen, R., Lotan, T., Winkelbauer, M., Bärgmann, J., Kovaceva, J., Donabauer, M., Pommer, A., Musicant, O., Harel, A., Wesseling, S., Christoph, M., & van Nes, N. (2017). Interactions with vulnerable road users. *UDRIVE Deliverable 44.1. EU FP7 Project UDRIVE Consortium*. https://doi.org/10.26323/UDRIVE.

Koppers, A., Ruf, S., Gerlach, J., Leven, T., & Hagemeister, C. (2021). *Radfahren bei beengten Verhältnissen – Wirkung von Piktogrammen und Hinweisschildern auf Fahrverhalten und Verkehrssicherheit. Kurzbericht.* https://nationaler-radverkehrsplan.de/de/praxis/wirkung-von-piktogrammen-und-hinweisschildern-auf.

Lassen, L. F. (2019). *Wahrgenommene Radverkehrssicherheit. Faktoren und Maßnahmen zur Erhöhung der subjektiven Sicherheit im Radverkehr in Berlin* [Technische Universität Berlin]. www.ivp.tu-berlin.de.

LHD Dresden. (2023). *Strategie zur Verkehrsberuhigung Für mehr Sicherheit und Verkehrsberuhigung*. https://www.dresden.de/media/bilder/presse/2023/20230605-Verkehrsberuhigung-Verkehrsversuche.pdf.

Mchale, A., & Stewart, K. (2014). Cycle lanes: their effect on driver passing distance in urban areas. *Transport*, *29*, 307–316. https://doi.org/https://doi.org/10.3846/16484142.2014.953205.

Mehta, K., Mehran, B., & Hellinga, B. (2015). Evaluation of the passing behavior of motorized vehicles when overtaking bicycles on urban arterial roadways. *Transportation Research Record*, *2520*, 8–17. https://doi.org/10.3141/2520-02.

Nolan, J., Sinclair, J., & Savage, J. (2021). Are bicycle lanes effective? The relationship between passing distance and road characteristics. *Accident Analysis and Prevention*, *159*(June), 106184. https://doi.org/10.1016/j.aap.2021.106184.

Parkin, J., & Meyers, C. (2010). The effect of cycle lanes on the proximity between motor traffic and cycle traffic. *Accident Analysis and Prevention*. https://doi.org/10.1016/j.aap.2009.07.018.

Queensland Government. (2022). *Sharing the road with bicycle and personal mobility device riders | Transport and motoring | Queensland Government*. https://www.qld.gov.au/transport/safety/rules/other/cyclists.

Rasch, A., Boda, C. N., Thalya, P., Aderum, T., Knauss, A., & Dozza, M. (2020). How do oncoming traffic and cyclist lane position influence cyclist overtaking by drivers? *Accident Analysis and Prevention*, *142*(April), 105569. https://doi.org/10.1016/j.aap.2020.105569.

Reh, J., & Lißner, S. (2022). Pathways to more space. What factors influence the lateral distance of overtaking vehicles from cyclists? *Transport Research Arena (TRA)*.

Shackel, S. C., & Parkin, J. (2014). Influence of road markings, lane widths and driver behaviour on proximity and speed of vehicles overtaking cyclists. *Accident Analysis and Prevention*, *73*, 100–108. https://doi.org/10.1016/j.aap.2014.08.015.

Springer, S. (2021). *Erste Ergebnisse der „DRadEsel-Studie" zur Verkehrssicherheit liegen vor. Technische Universität Chemnitz.* https://www.tu-chemnitz.de/tu/pressestelle/aktuell/10661.

Van Houten, R., Oh, J.-S., Kwigizile, V., Feizi, A., & Mastali, M. (2018). *Effects of Safe Bicycle Passing Laws on Drivers' Behavior and Bicyclists' Safety* [Western Michigan University]. https://scholarworks.wmich.edu/transportation-reports/4.

Victoria Government. (2021). *Minimum Passing Distance : VicRoads*. https://www.vicroads.vic.gov.au/newsmedia/2021/minimum-passing-distance

Walker, I. (2007). Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender. *Accident Analysis and Prevention*, *39*(2), 417–425. https://doi.org/10.1016/j.aap.2006.08.010.

"aZuR" project (Automated Condition Assessment of Cycling Infrastructure)

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Abstract

The "aZuR" project (Automated Condition Assessment of Cycling Infrastructure) aims to develop a largely automated system for assessing and evaluating rural cycling paths. The lack of sufficient data on the condition of cycling networks makes it challenging to prioritize maintenance and expansion efforts, and there is currently no standardized procedure for evaluating cycling infrastructure.

Building upon existing methods for road condition assessment, the "aZuR" project considers specific requirements for cycling. By employing automated measurement techniques, it aims to enable objective and comparable assessments nationwide. The project will develop an evaluation system tailored to cycling traffic, derive recommendations for technical regulations, and create a pavement management strategy for rural cycling paths.

Specialized survey vehicles equipped with camera technology, GPS, and LiDAR sensors are used to gather raw data on the condition of selected cycling paths. This data allows for the creation of a digital twin, capturing information such as width, damage patterns, gradient, and road surface evenness. Additionally, camera images are taken for visual assessment.

An analysis and evaluation algorithm is then developed based on the digital twin, automating the creation of a quality index. Data processing is intended to be largely automated, with camera images serving for visualization and future analysis after anonymization. The collected sensor data undergoes manual verification in two measurement campaigns to ensure synchronization.

The collected data will be made user-friendly for road authorities, enabling the development of applications for cycling-specific route planning and the publication of data to support transparent financial resource allocation for high-quality cycling paths.

The "aZuR" project contributes to sustainable transportation systems and promotes cycling, aligning with the German government's climate protection program for 2030. It distinguishes itself by considering cycling-specific aspects and utilizing standardized data acquisition methods, georeferenced data, and high-resolution camera technology.

The project involves collaborative efforts between academic institutions, industry partners, and road authorities. The Hochschule RheinMain, Technische Hochschule Lübeck, Ostfalia University of Applied Sciences, and Xenomatix collaborate closely to bring their expertise in

mobility management, condition assessment, architecture and civil engineering, and LiDAR sensor development.

The project consists of multiple phases, capturing raw data, creating a digital twin, and automatically evaluating the data to generate a quality index. The collected data will be published on the mCLOUD platform to facilitate exchange and standardized evaluation, providing access to developers.

By improving the condition assessment and evaluation of cycling paths, the "aZuR" project aims to advance sustainable transportation systems and enhance cycling infrastructure's attractiveness. It has the potential to impact future research and innovation in cycling infrastructure assessment, informing decision-making processes for policymakers, urban planners, and transportation authorities to create a safer and more cyclist-friendly environments.

The collaboration between academic institutions, industry partners, and road authorities fosters interdisciplinary cooperation, enhancing the quality of research outcomes and strengthening the network of stakeholders involved in improving cycling infrastructure. Investing in high-quality cycling infrastructure aligns with global efforts to promote sustainable transportation, reduce greenhouse gas emissions, and alleviate traffic congestion.

In conclusion, the "aZuR" project elevates the condition assessment and evaluation to a new digitalization level. By developing a largely automated system and utilizing advanced technologies, it aims to provide objective and standardized data to inform decision-making, improve infrastructure planning, and enhance the quality of cycling infrastructure in Germany. Through collaboration, knowledge exchange, and transparent data sharing, the project contributes to sustainable transportation systems and promotes cycling as a viable mode of transportation.

AI-based bicycle delay estimation at signalized intersections using sparse GPS data and control signals

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Keywords
AI, bicycle delays, sparce GPS, control signals, intersections,

Challenge Addressed / Research Problem Investigated
We develop AI-based models to accurately estimate bicycle delay at signalized intersections using sparse GPS data and control signals.

Abstract
INTRODUCTION

In recent years, the bicycle has gained significant momentum in terms of daily use and thus policy importance. This surge in popularity is partly due to the advent of e-bikes and the lifestyle changes brought about by the COVID era, leading to an unprecedented increase in cycling (Thigpen, 2020). From a policy perspective, bicycles are increasingly viewed as a sustainable substitute for short to medium-distance car journeys. A growing number of major cities are prohibiting cars from their centers to lower CO2 emissions and create more space for pedestrians and cyclists. Alongside public transport, bicycles offer a sustainable and efficient means of travel from one point to another. They also serve as a crucial link for first/last mile connectivity to public transport. To encourage cycling, authorities - including public transport operators, and local municipalities - are investing in high-quality cycling infrastructure, providing bicycle parking facilities at public transport stations, and launching cycling promotion campaigns. These concerted efforts aim to boost bicycle usage at a national level.

Ensuring precise determination of average delays for road-users, including vehicles, bikes, and pedestrians, is of utmost importance in effectively managing signalized intersections. While field studies are a conventional means to gather delay information, they can prove costly and time-consuming. Analytical methods, commonly employed for estimating delays, often struggle to generate accurate results, especially in scenarios of oversaturated traffic flow. This highlights the need for alternative approaches that can provide more reliable and efficient estimates.

Recently, delay estimation models based on artificial intelligence (AI) have been introduced in the literature to estimate delay more accurately. However, these applications have primarily focused on vehicles (Bagdatli et al., 2021), with limited extension to bicycle traffic in the existing literature. Besides, the feed data for delay estimation models ranges from camera reading (image processing or manual counting) to GPS data (either from smartphones or from on-bike

trackers/Apps). The former data source might provide the ground truth information, but the data extraction process is time-consuming; the latter one might only provide a subset of the total traveler population. As an example, the Talking Bikes program (Talkingbikes, 2020) has been operational in recent years in the Netherlands, collecting GPS data and simultaneously integrating it with the broader "Talking Traffic" initiative. The outcome of the Talking Bikes program is a comprehensive dataset of GPS cycling data (from Apps or bike trackers), with over one million bicycle rides per year, geographically distributed across the Netherlands. While the overall dataset size is substantial, it is worth noting that the distribution of trips at specific intersections may be limited.

Moreover, the data from signalized intersections was available in the VLOG format (Vialis, 2020). The VLOG data contains data on the control phase of traffic lights for motorised vehicles, cyclists, pedestrians, busses, and trams. Furthermore, data from several detection sensors (such as inductive loops on vehicular roads and bicycle lanes, request-green buttons for cyclists and pedestrians) near the intersection is available. This information is deemed to possess close correlation with bicycle delays.

In this work, we propose an AI-based study that focuses on identifying average bicycle delays at signalized intersections using the relatively sparse GPS cycling data from the Talking Bikes program, and the local control signal and flow detection information from VLOG data provided by the municipality of Delft.

CONCEPTUAL FRAMEWORK AND APPLICATIONS

In this work, we develop estimation models ranging from simple linear regression to sophisticated machine learning approaches. These include random forest (RF), k-nearest neighbor (kNN), support vector regression (SVR), extreme gradient boosting (XGBoost), and neural networks (NN). These methods have not previously been applied in the literature for estimating bicycle delays at signalized intersections. We proposed a conceptual framework of all the most relevant factors to explain bicycle delay at intersections as shown in Figure 1. We have identified four categories: characteristics of individual travelers, intersection characteristics, traffic flow conditions, and external factors. The highlighted factors will be included in our estimation models: including intersection characteristics (control signals and detection information from VLOG data, intersection layout and geometric design), external factors (weather information from KNMI, temporal messages).

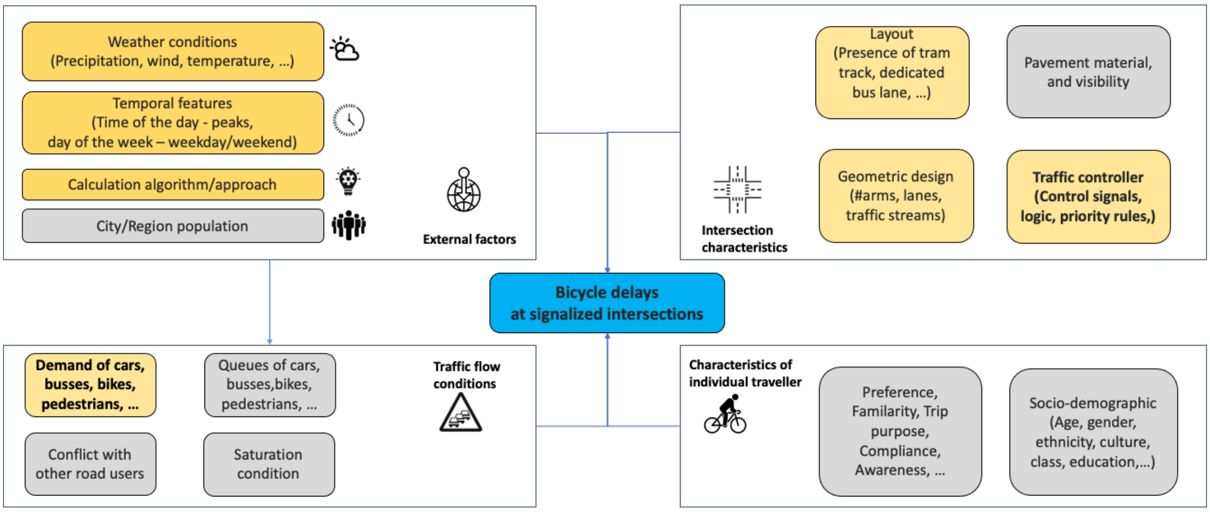

Figure 1: Conceptual framework of bicycle delay at signalized intersections.

The focal intersections are two busy cycling intersections (Jaffalaan - Mekelweg and Westlandseweg - Nieuwe Gracht) in Delft (as shown in Figure 2). Every day, these intersections need to accommodate huge commuting cycling flow to the Delft station and the university (Delft University of Technology), respectively, especially in peak hours before lectures start.

(a)

(b)

Figure 2: Snapshots of the intersections at Jaffalaan-Mekelweg (a) and Westlandseweg-Nieuwe Gracht (b) in the city of Delft.

PRELIMINARY RESULTS

In authors' previous work (Yuan at al. 2023) employing the same model set and considering weather data, demographic, complexity, and time information, the R-squared value of the best performing model (the RF model) was approximately 13%. This result was derived from training the model using data from 18 intersections. The current result demonstrates that by incorporating additional intersection controller and detection information, the model performance has increased, namely the R-squared value of the RF model can be elevated significantly, even when utilising data from just 1 or 2 intersections. To provide specific examples, when using data from a single intersection (Westlandseweg - Nieuwe Gracht), which had relatively limited total data samples but more comprehensive signal control and demand detection information for cars, bikes, pedestrians, busses and trams, the model's performance improved regarding model fit and estimation accuracy of bike delay medians. Similarly, when using data from the two intersections, to maintain data consistency, certain data features, such as bus/tram signal and pedestrian detection information, had to be sacrificed. That means not all the influential features can be included in the estimation models However, the interpretability of the AI model and the accuracy of delay estimation remained consistent in both scenarios. These findings suggest that applying this AI-based model to a broader range of intersection data (with more samples and varying conditions) has the potential to enhance model accuracy and broaden its applicability.

OVERLOOK

In the full paper, we will illustrate the elaborated estimation performance of various estimation models, and highlight the significant influential factors revealed by the learning models. Also we will identify the directions for future research. This estimation application and its result should provide sufficient images for policy makers and cooperating authorities on average bicycle delay on specific intersections, for instance, to determine priority and function maps for bicycle users (as well as for car users), or to design traffic management measures for both specific or generic intersections.

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References

[1.] C. Thigpen. Rethinking Travel in the era of COVID-19: Survey Findings and Implication for Urban Transportation, Support for Micromobility. 2020. URL: https://www.li.me/blog/rethinking-travel-in-the-era-of-covid-19-new-report-shows-global-transportation-trends-support-for-micromobility. Accessed: July 2023.
[2.] M. E. C. Bagdatli, and A. S. Dokuz. Vehicle Delay Estimation at Signalized Intersections Using Machine Learning Algorithms. Transportation Research Record, 2675(9), 110–126. 2021. URL: https://doi.org/10.1177/03611981211036874
[3.] Siemens en RingRing verzamelen fietsdata voor Talking Bikes (2020). URL: https://www.mobiliteitsplatform.nl/artikel/siemens-en-ringring-verzamelen-fietsdata-voor-talking-bikes. Accessed: July 2023.
[4.] Vialis. V-Log protocol en definities (2020). Published by CROW. June 2020.

Y. Yuan, K. Wang, D. Duives, S.P. Hoogendoorn, S. Hoogendoorn-Lanser, and R. Lindeman. Bicycle data-driven application framework: A Dutch case study on machine learning based bicycle delay estimation at signalized intersections using nationwide sparse GPS data. Submitted to TRB 103rd annual meeting. Washington D.C.: Transportation Research Board. 2024.

Chances and challenges in using bike simulators as a tool for studying cycling behavior

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Abstract

INTRODUCTION
Bicycle simulators are used as a tool to investigate cyclists' behavior since they allow the precise reproduction of specific conditions in a controlled environment as well as the collection of data for further research. However, to obtain reliable data, a simulator must provide a realistic cycling sensation to the riders. For this purpose, an appropriate technical design of the simulator, fitting to the intended purpose has to be chosen. Furthermore, the hardware control and software components have to be parametrized in order to reach the required degree of realism for allowing the rider to show a realistic riding behavior. To find the right parameter set is often an iterative process. The final set-up has to be validated with real world data which is often difficult to obtain.

In recent years, there is a rising interest in bicycle-simulator-based research. A basic prerequisite is the evaluation of the accuracy and realism of these systems. E.g. Dialynas et al (2019) and Shoman and Imime (2020) explored objective criteria for accurate and realistic models of the physics and dynamics of cycling and report on their development of bicycle simulator hardware and software. Subjective criteria such as simulator sickness (Matviienko et al., 2022; Mittelstädt et al., 2018), the sense of presence (Grassini et al., 2021; Gyoung & Biocca, 2018) or acceptance (Martinez Garcia, 2021) serve as metrics for the usefulness of a certain simulator set-up and/or study design.

METHOD
The bicycle simulator at the DLR – Institute of Transportation Systems (Fischer et al., 2022) has been built and improved in an iterative process (Martinez Garcia, 2021, 2022, 2023). The hardware set-up is shown in Figure 1.

The latest improvements are:

- the introduction of a whipple-model for the calculation and presentation of more realistic bicycle physics, especially regarding lateral force feedback.
- the introduction of a position control of the motion pitch in order to allow for a realistic leaning behavior of the test subjects
- the usage of an incremental encoder for acceleration and disc brake measurement and control in order to reduce latencies
- a dynamic and velocity-dependent headwind control

Figure 1. Bicycle simulator at the MoSAIC-VRU-Lab

An evaluation study took place in order to assess the latest set-up (Martinez, 2023), to portray a realistic experience, reduce simulator sickness and increase acceptance. To evaluate the human perception of the simulator, several criteria were analysed. Simulation sickness was measured by the Simulator Sickness Questionnaire SSQ (Kennedy et al., 1993) and the misery scale MISC (Bos et al., 2005; Reuten et al., 2021), acceptance was evaluated with the Acceptance Scale (Van Der Laan et al., 1997) and presence was measured by the Presence Questionnaire PQ vs. 3.0 (Witmer & Michael, 1998). To evaluate realism, a series of self-developed questions and statements were presented after each trial. The main objective criteria used for the objective evaluation of the test subjects driving behaviour are the leaning angle of the bicycle, the steering angle and the driving velocity.

Currently, a validation study is in preparation which shall deliver insights in real world cycling behavior for typical cycling maneuvers and deviations of observable riding behavior in reality and with the bicycle simulator.

RESULTS

Evaluation criteria, both objective and subjective, showed that the longitudinal cycling behaviour is already in a good condition and was widely accepted. Whereas the situation regarding lateral accelerations and steering controllability is more ambiguous. Subjective ratings did not show a clear preference of the current set-up and overall realism regarding lateral aspects were rated quite low. However, objective metrics such as leaning angle and steering angle distributions seem to be more realistic and the set-up allows for a more controlled driving than earlier versions.

CHANCES & CHALLENGES

A main challenge that has been faced during the development process is the reproduction of the leaning behavior of the bicycle. The relation between steering and leaning behavior is very dependent on several factors, i.e. the physical characteristics of the rider, the physical characteristics of the bicycle and the cyclists driving behavior and driving style. Another challenge is the derivation of mathematical models and standardization of the results. Furthermore, the 2 DoF platform that controls the leaning of the bicycle simulator has limitations in both software and hardware. This complicates the development process and restricts the realism that can be experienced. Due to technical restrictions of VR-glasses and the simulation software, it is difficult to portray a realistic riding velocity while completely avoiding simulator sickness. Another challenge is the development of realistic motion cueing algorithms and how to consider perception effects in the presentation of the motion signals. Finally, the validity of a simulator according to its usability in the context of a certain research question or cycling task has to be proven. These challenges have to be solved in order to obtain valid research results when utilizing bike simulators.

However big the challenges might seem, the chances a bicycle simulator offers are worth the effort. First of all, such a simulator enables the study of cycling in critical situations without endangering the test subject. Furthermore, all situations and conditions are repeatable, so that the obtained data provides a profound base for analysis. After a successful parametrization and validation of the simulatior set-up, realistic riding behavior can be observed and used for studying a huge number of different research areas, e.g.:

- Evaluation of intersection measures for cyclists (e.g. protected intersections) to investigate the influence of complementary infrastructure elements for bicycle safety.
- Perform simulator studies to investigate operating ranges for AVFs with a focus on VRU interaction
- Obtain insight in cyclist behavior in different situations for understanding trigger actions, motivation aspects and other influencing factors on cycling behavior for the development of cyclist simulation models
- Support design and evaluation of new communication concepts between automatic vehicles and other road users
- Assessment of cooperation between road users in complex scenarios with multiple interaction partners

Continuous work on improving and validating bicycle simulator facilities will lead to raised importance of the usage of this kind of research tools in future activities towards improving cyclist road safety.

References

Bos, J. E., MacKinnon, S. N., & Patterson, A. (2005). Motion sickness symptoms in a ship motion simulator: Effects of inside, outside, and no view. Aviation Space and Environmental Medicine, 76(12), 1111–1118.

Dialynas, G., Happee, R., & Schwab, A. L. (2019). Design and Hardware Selection for a Bicycle Simulator. Mechanical Sciences, 10, 1–10. https://doi.org/https://doi.org/10.5194/ms-10-1-2019.

Fischer, M., Temme, G., Gröne, K., Martinez Garcia, D., Grolms, G., & Rehm, J. (2022). A VRU-simulator for the evaluation of pedestrian- and cyclist-vehicle interaction – Design criteria and implementation. Proceedings of the Driving Simulation Conference, 153–160.

Grassini, S., Laumann, K., de Martin Topranin, V., & Thorp, S. (2021). Evaluating the effect of multi-sensory stimulations on simulator sickness and sense of presence during HMD-mediated VR experience. Ergonomics, 64(12), 1532–1542. https://doi.org/10.1080/00140139.2021.1941279.

Gyoung, K., & Biocca, F. (2018). Immersion in Virtual Reality Can Increase Exercise Motivation and Physical Performance. International Conference on Virtual, Augmented and Mixed Reality, 94–102.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An Enhanced Method for Quantifying Sim K.ulator Sickness. The International Journal of Aviation Psychology, 3(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3.

Martinez Garcia, D. (2021). Construction, parameterization and evaluation of a bicycle simulator for a realistic and interactive simulation environment. Technische Universität Braunschweig.

Martínez García, D., Gröne, K., Quante, L., Fischer, M., Thal, S., & Henze, R. (2022). Parameter tuning of a bicycle simulator for a realistic riding behaviour and motion perception. 1–2.

Martinez Garcia, D., Gröne, Janssen, V., Jacobi, D., Ackermann, S., Zhao, M. Nicolay, E., Bergen, M. and Fischer, M. (2023).Technical adjustments of a bicycle simulator - Impact on simulator sickness, presence and acceptance, Proceedings of the Driving Simulation Conference 2023.

Matviienko, A., Müller, F., Zickler, M., Gasche, L. A., Abels, J., Steinert, T., & Mühlhäuser, M. (2022). Reducing Virtual Reality Sickness for Cyclists in VR Bicycle Simulators. Conference on Human Factors in Computing Systems - Proceedings. https://doi.org/10.1145/3491102.3501959.

Mittelstädt, J. M., Wacker, J., & Stelling, D. (2018). Effects of display type and motion control on cybersickness in a virtual bike simulator. Displays, 51, 43–50.

Reuten, A. J. C., Nooij, S. A. E., Bos, J. E., & Smeets, J. B. J. (2021). How feelings of unpleasantness develop during the progression of motion sickness symptoms. Experimental Brain Research, 239(12), 3615–3624. https://doi.org/10.1007/s00221-021-06226-1.

Shoman, M., & Imine, H. (2020). Modelling and Simulation of Bicycle Dynamics. Proceedings of 8th Transport Research Arena TRA 2020. https://doi.org/10.5281/zenodo.3752031

Van Der Laan, J. D., Heino, A., & De Waard, D. (1997). A simple procedure for the assessment of acceptance of advanced transport telematics. Transportation Research Part C: Emerging Technologies, 5(1), 1–10. https://doi.org/10.1016/S0968-090X(96)00025-3.

Witmer, B. G. ., & Michael J., S. (1998). Measuring Presence in Virtual Environments: A Presence Questionnaire. Presence: Teleoperators and Virtual Environments, 7(3), 225–240.

Effects of gradient on bicyclists' behaviour – A work in progress presentation

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Keywords
bicyclists' behaviour, gradient, instrumented bicycle, bicycle simulator, controlled experiments

Challenge Addressed / Research Problem Investigated
Bicycle usage is lagging in regions with significant topography.

Abstract
INTRODUCTION
While the bicycle's share in modal split is increasing in many cities and regions, its development is lagging where valleys are deep, and hills are steep. In Germany, Nobis (2019) found that bicycle usage has a strong negative correlation with the average gradient in the area around a person's home. At the same time, more bicycles with motor assistance so called e-bikes, pedelecs or s-pedelecs are sold (Zweirad-Industrie-Verband (ZIV) 3/15/2023) which have the potential to reduce the manual pedalling power required to reach a desired speed up to a legal maximum. Mitigating the required physical effort, this technological trend could have a positive effect on bicycle usage and change the modal split in hilly regions over time. However, bicycle technology and especially infrastructure might not be prepared for growing demand, yet. Therefore, the present research aims to provide insights into the influence of gradient on bicyclists' behaviour. Mid-term this will offer support both for infrastructure planning processes and for novel bicycle technology specifically designed to enable bicycling on routes with gradient safely and conveniently, an important precondition for promoting bicycling.

METHODS
The research approach combines two methodologies, a real-world experiment presented in this publication, and a bicycle simulator experiment as the next step. The controlled real-world experiment was conducted using an instrumented bicycle in June and July 2023. A sample of 35 participants bicycled in regular mixed traffic on a 3.2 km round trip climbing 60 m of elevation with a gradient range of -9% to +9% in Wuppertal, Germany. The infrastructure of the round trip was mainly a two lane, single direction street with mixed traffic (no dedicated bicycle infrastructure). The route had three signalised intersections and two intersections where right of way needed to be given to the crossing street. Off-the-shelf sensors and a bicycle computer were installed on the participants' personal bicycles to record speed, cadence, manual pedalling power, heart rate and GNSS trajectory. Feedback on the participants' subjective workload experience was gathered in a post-ride survey utilizing the NASA-TLX method (Hart and Staveland 1988). Additionally, an action camera recorded the participants' front view and an audio recorder recorded verbal expressions for a think-aloud-protocol. Both recordings were transcribed with the objective to take note of any external

restrictions in the participants free bicycling and unintended events. The awareness of external restrictions during the experimental rides is important to allow for analyses of the desired speed and desired manual pedalling power of the individuals.

RESULTS

All participants were adult staff and students at the University of Wuppertal. Requirements for participation were frequent bicycling and good physical fitness to ensure the participants safety. Participant age and gender association were assessed along with a questionnaire on the individual bicycling experience and current usage to allow conclusions on the representativeness of the sample. The bicycle computer recorded sensor input over time. The data was converted and plotted over the distance of the trip to standardize the range of the abscissa for all subjects. An exemplary plot for one participant is shown in Figure 1). Comparison of speed and manual pedalling power towards gradient show the relations to describe a function for desired speed and desired pedalling power depending on gradient. To derive the logic and parameters, the parts of the individual data sets need to be isolated where free bicycling was unrestricted. Cardio activity is investigated as an indicator for the stress experienced by the participants. Relations between heart rate and manual pedalling power, speed and gradient indicate the influence of gradient on stress. Participants' interactions with the bicycle drives over the course of the round trip are investigated by looking at torque and gear ratio derived from the measured variables. Changes in both parameters reflect the participants' usage of their adjustable gears and their preferences for cadence and torque depending on gradient. Experiences expressed in form of the 6 TLX factors for uphill and downhill were analysed to reveal indicators for the dependency of the subjective workload on gradient.

Transcripts of the video and audio recordings provide a list of the occurrences of restrictions and unintended events.

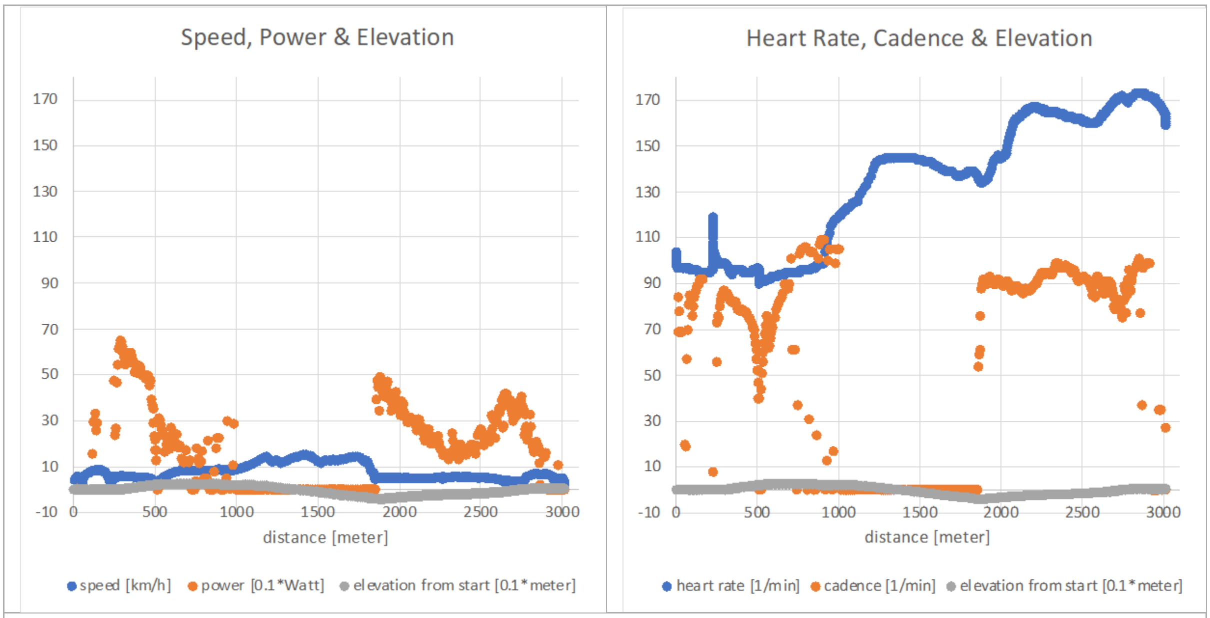

Figure 1. Quantitative variables over the distance of the round trip

CONCLUSIONS

Speed and manual pedalling power show a clear correlation on the uphill sections. Restrictions in free bicycling become visible in form of the participants slowing down on their approach and accelerating past the event. On uphill sections the heart rate rises as participants invest more power to maintain speed and gain elevation. On the downhill section, the heart rate rises, too, despite zero cadence and manual pedalling power. Correlating to this observation, increasing mental load is reported in the TLX when bicycling downhill, a potential explanation for the increase of stress. The analysis of participants' interaction with the bicycle shows that they tend to maintain a desired cadence and adjust their gears and manual power input according to the influence of the gradient.

OUTLOOK

The presented real-world experiment provided data for a route with -9 to +9% gradient and a group of frequent bicyclists. To expand the data collection a bicycle simulator experiment is planned as the next step. A controlled immersive virtual environment allows gathering data on routes which can be designed independently of their availability in real-world. Moreover, it is safe to also invite participants with less physical strength and bicycling experience on hilly infrastructure. The bicycle simulator is going to be calibrated by testing the virtual twin of the real-world route to ensure transferability of the results.

The analysis of the combined data is going to reveal patterns in the behaviour of bicyclists depending on gradient. A goal of this research is to turn these patterns into behaviour models and implement them into the microscopic simulation software SUMO in future. Findings and raw data are going to be published open access to promote more research in this field of bicycle traffic and support technological improvements.

References

Hart, Sandra G.; Staveland, Lowell E. (1988): Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research 52, pp.139–183. DOI: 10.1016/S0166-4115(08)62386-9.

Nobis, Claudia (2019): Mobilität in Deutschland. MiD Analysen zum Radverkehr und Fußverkehr. 1.0th ed. With assistance of infas, DLR, IVT, infas 360. Bundesministerium für Verkehr und digitale Infrastruktur (BMVI). Bonn.

Zweirad-Industrie-Verband (ZIV) (3/15/2023): Marktdaten Fahrräder und E-Bikes 2022. Pressekonferenz. Available online at https://www.ziv-zweirad.de/fileadmin/redakteure/Downloads/Marktdaten/ZIV_Marktdatenpraesentation_2023_fuer_GJ_2022.pdf, checked on 6/30/2023.

Use of Bicycle Simulators to Better Promote and Communicate Bicycle Projects to Project Stakeholders

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Keywords
Stakeholders, Virtual Reality, Simulation, Infrastructure

Challenge Addressed / Research Problem Investigated
Improve the communication of bicycle infrastructure projects through virtual reality bicycle simulators.

Abstract
Communication of perspective transportation projects can be difficult, especially as many stakeholders are typically interested in such projects, as a project may have broad effects on how they get from A to B. These stakeholders can be but are not limited to politicians, citizens, businesses, government bodies, etc. As there is such a wide variety of interested parties in transportation projects, it is essential that communications of said projects should be as clear as possible to improve the chances of the said project being successful (Agyekum et al., 2022). As communication is such a key point to the success of a project, especially in public works, it is crucial that the communication of said project is as clear and concise as possible. To have good communication of said projects, it is essential that stakeholders can imagine and visualize said projects. With clear communication of the project, stakeholders can understand why it should be done and what benefits it will bring.

This transparent communication and visualization are crucial for transportation projects that focus on improving bicycle infrastructure as many stakeholders have difficulty understanding which benefits this will bring, especially when the said project may bring negative effects like the removal of space currently used for motorized vehicles (Aldred et al., 2019, 149-159). To help improve the communication and visualization of a proposed bicycle project, a bicycle simulator is proposed to improve said communication and visualization. A bicycle simulator could help communicate a project's benefits for bicyclists and other users, as stakeholders could experience the benefits virtually with a virtual rendering and scenarios. Why use virtual reality instead of more traditional methods? Virtual reality can bring more realism to the project; thus, the benefits could seem more attainable or easier to understand. As it has a higher sense of realism than traditional methods like digital image renders, stakeholders' views could be more positive. It could also be used to identify problems with projects prior to construction. If users continue to misuse the infrastructure in the virtual simulation of the project, it can be identified and changed easily. If the virtual visualization of said project is effective in communicating with stakeholders the benefits of projects, it could be a very cost-effective way to improve communication. It may be able to improve the success of a project being approved and implemented.

Although using a bicycle simulator to help communicate such projects could be very promising, there has been no research into this and its effects on stakeholders. There are also issues that come with using a virtual reality bike simulator, such as motion sickness and disorientation, as the movement can feel unnatural to the user as they move within the virtual space, which could have a negative impact on stakeholders' opinions. Other difficulties come from the ease of implementation of such a system, such as setting up a simulator for this use and importing designs of a said project into the virtual world.

References

Agyekum, A. K., Fugar, F. D. K., Agyekum, K., Akomea-Frimpong, I., & Pittri, H. (2022, 04). Barriers to stakeholder engagement in sustainable procurement of public works. *Engineering Construction & Architectural Management*. 10.1108/ECAM-08-2021-0746.

Aldred, R., Watson, T., Lovelace, R., & Woodcock, J. (2019, 10). Barriers to investing in cycling: Stakeholder views from England. *Transp Res Part A Policy Pract.*, 149-159. 10.1016/j.tra.2017.11.003.

Chow, V., & Leiringer, R. (2019, 11 07). The Practice of Public Engagement on Projects: From Managing External Stakeholders to Facilitating Active Contributors. *Project Management Journal*, *51*(1). https://doi.org/10.1177/8756972819878346.

Estaswara, H. (2020, 01). Defining Communication Problems in Stakeholder Relations Based on Stakeholder Theory. *Jurnal ASPIKOM*. 10.24329/aspikom.v5i1.540.

Gelders, D., Bouckaert, G., & van Ruler, B. (2007, 04). Communication management in the public sector: Consequences for public communication about policy intentions. *Government Information Quarterly*, *24*(2), 326-337. https://doi.org/10.1016/j.giq.2006.06.009.

Joos, H. C., Knyphausen-Aufseß, D. z., & Pidun, U. (2020, 05 12). Project Stakeholder Management as the Integration of Stakeholder Salience, Public Participation, and Nonmarket Strategies. *Schmalenbach Business Review volume*, *72*, 447-477. https://doi.org/10.1007/s41464-020-00092-0.

Shakeri, H., & Khalilzadeh, M. (2020, 08). Analysis of factors affecting project communications with a hybrid DEMATEL-ISM approach (A case study in Iran). *Heliyon*. 10.1016/j.heliyon.2020.e04430.

Microscopic modelling and simulation of bicycle-car interaction

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Abstract

Improving cycling infrastructure is important because it allows for efficient movement of more people within limited road space. Cycle lanes are encouraged in many cities worldwide as part of strategies to promote cycling and reduce reliance on cars. This approach can contribute to the development of a sustainable transportation system in the long term. However, cycle lanes are not always feasible, e.g. due to space constraints. This issue is particularly problematic at bottleneck locations, where increasing queues of cars during peak hours can extend to intersections upstream, adversely affecting the overall traffic performance of the network and of all modes of transport. Therefore, cyclists still often need to share road space with cars and some links and nodes.

This creates a mixed traffic situation, where the dynamics of movement can vary based on the traffic conditions. Understanding these dynamics is essential for assessing the travel time loss experienced by different user types and evaluating the overall performance of the road network. When the demand is low, cars have the opportunity to overtake cyclists due to their higher speed capabilities. In such situations, cyclists may move closer to the side of the road, allowing cars to pass safely. This flexibility in positioning enables a smoother flow of traffic and minimizes disruptions caused by the speed differential between cars and cyclists. However, in congested traffic situations, cyclists often exhibit an advantage over cars in terms of maneuverability. With their smaller size and ability to navigate through narrower gaps, cyclists can effectively navigate alongside queues of stationary or slow-moving cars. This maneuverability allows cyclists to maintain a relatively faster pace compared to cars, resulting in a potential reduction in their travel time loss. This ability to keep moving in congested traffic is a significant advantage for cyclists and contributes to the efficiency of their travel. Due to this complex interaction, the experienced delay can differ for various user types since it depends not only on the traffic state but also on the specific characteristics and behaviors of each class.

While significant advancements have been achieved in microscopic modeling and simulation of bicycle traffic, there remains a notable gap in capturing the intricate interaction between bicycles and cars. Current models primarily focus on the dynamics among cyclists and fail to fully consider the complexities of bicycle-car interactions elaborated above. These models, including the Ghazi-Herman Rothay models, Falkenberg model, safety distance models, psychological force models, and social force models, predominantly focus on the behavior of cyclists themselves. Furthermore, they often treat bicycles as either slow cars or fast pedestrians within the simulation frameworks. While this approach is applicable when modelling cyclist on dedicated cycle lanes, it is not ideal when the objective of the simulation extends beyond modeling cyclists in isolation, for example in shared road space with cars. In such cases, it is important to create integrated simulations that holistically considers multimodal transport and can evaluate the interactions and impact of both bicycles and cars.

To this aim, this research develops a microscopic model within the sublane framework of SUMO simulation to capture bicycle-car interaction. This is achieved by developing car-following models and lane-change models that specifically account for the complex bicycle-car interactions. These models will accurately capture the distinctive behaviors, characteristics, and decision-making processes of both cyclists and motorists. The models are implemented in SUMO and tested for a variety of

infrastructure design and traffic scenarios. By incorporating a more realistic representation of bicycle-car interactions into the simulation frameworks, transportation planners and researchers can gain insights into the effects of different infrastructure designs, traffic management strategies, and policy interventions on the overall performance of multimodal transportation systems.

Empirical Study of Bicycle Traffic Characteristics Relevant for Microscopic Simulation

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Abstract

Microscopic traffic simulation serves as a useful tool for planning efficient traffic, and a key component of microscopic traffic models is the representation of interactions between vehicle-driver units. While microscopic models for motorized traffic have been developed over decades, there is a noticeable lack of microscopic models for bicycle traffic. Even though widely-used and commercial microscopic traffic simulators allow for multi-modal traffic analysis, the inclusion of bicyclists is usually difficult (P´erez Castro et al. 2022). In general, the adaptation of existing models to bicycle traffic remains uncertain due to the distinctive characteristics of bicycle traffic.

The study of characteristics of bicyclists is then essential for understanding how bicyclists interact with each other, and developing suitable microscopic models for traffic simulation. Compared to motorized traffic, bicycle traffic is highly diverse in the individual physical and kinetic characteristics of bicyclists (Twaddle & Grigoropoulos 2016, Mohammed et al. 2019). Another distinctive aspect of bicycle traffic is its traffic composition. The properties of different types of bicycles may play a significant role in traffic dynamics. To provide a comprehensive understanding of bicycle traffic flow dynamics through simulation, the distinctive characteristics of bicycle traffic, including the various forms of micro-mobility that share the space with bicyclists, should be modeled.

Based on empirical data on real-world bicycle traffic, obtained through video-based data collection techniques, the objective is to describe characteristics of free riding, following, and overtaking, that are relevant for simulating bicycle traffic on bidirectional bicycle paths exclusive for bicyclists. Additionally, we examine for significant differences in these characteristics as a result of variations in the type of bicycle used.

Video data are collected on a bicycle path in Stockholm, Sweden, that accommodates bidirectional traffic. The analyzed bicycle path segment is straight, flat, and fully separated from motorized traffic by curbs and barriers. We use the two-camera Viscando OTUS3D System (Viscando AB 2013) to obtain automatically extracted trajectory data over a week in September 2021. In total, the trajectory data set contains 21 759 trajectories, which have, in average, a duration of 8.5 seconds. By placing an additional hand-held camera, operated by a person on-site, we annotate the type of bicycle of a sample of 2 580 bicyclists. Lastly, we measure wind speeds to control for their potential impact on the speed choice of bicyclists. In this work, we focus on characteristics of bicycle traffic during the morning peak period as it carries the highest flows, ensuring a greater number of interactions between bicyclists.

The findings indicate that the speed distribution of bicycle traffic is multimodal due to the distinctive preferences of bicyclists that vary according to the type of bicycle used. The speed distribution captures how bicyclists are predominantly grouped around two distinct peaks: at approximately 5.4 m/s, and 6.5 m/s. The first peak is closely situated near the observed mean speed of conventional bikes and e-scooters. This peak concurs with the 20 km/h (5.56 m/s) maximum speed permitted for electric scooters in Sweden. The second peak is centered around the mean speed of both e-bikes and racing bikes. The peak in the distribution of e-bikes also agrees with Swedish regulations limiting the use of electric assist to speeds up to 25 km/h (6.94 m/s) for bicycles. On average, we observe that e-bikes and racing bikes ride 0.8 m/s and 1.3 m/s faster than conventional bikes, respectively. Based on wind measurements, we conclude that there is no statistically significant effect on mean free speed from wind speeds in the range of ±3 m/s.

Lateral position preferences are also diverse and strongly correlated to the type of bicycle used. The lateral position distribution of bicyclists is also multimodal as two distinct peaks are observed: one on the oncoming traffic lane, and another in the middle of the respective lane of the travel direction. The first peak is potentially explained by overtaking activity, which seems more prevalent among e-bikes and racing bikes. The second peak represents a general tendency for bicyclists to ride in the middle of the lane. Nonetheless, subtle differences exist among types of bicycles. For example, e-bikes and racing bikes often ride relatively closer to the line dividing the two opposing traffic streams, compared to conventional bikes and e-scooters. The lateral position distribution of free bicyclists also reveals that, the distance that bicyclists keep to the edge is clearly reduced if no fixed objects are present at the edge of the bicycle path. Therefore, the path width effectively used by bicyclists is potentially reduced by the infrastructure design. Furthermore, we observe that bicyclists tend to move toward the edge of the path when meeting oncoming traffic. A plausible explanation for this behavior may be related to a perception of safety, in which bicyclists prefer more space between themselves at meetings. Lastly, we observe that

bicyclists generally keep shorter lateral distances (side by side), when overtaking compared to when meeting oncoming traffic. Differences in the lateral positions highlight the impact of traffic and the infrastructure on the spatial behavior of bicyclists, which ultimately influences traffic performance.

The high heterogeneity in characteristics of free-riding, following, and overtaking highlights the importance of including various user preferences and behaviors when simulating bicycle traffic. This work demonstrates the need for developing data collection methods that allow efficient and accurate identification of various characteristics of bicycle traffic. We also demonstrate that installing a sideview camera is adequate for identifying different types of bicycles. However, implementing image recognition algorithms for the identification of types of bicycles could significantly streamline the process, leading to a more comprehensive analysis of various characteristics of bicycle traffic.

Future research involves the development of microscopic models that incorporate the distinctive characteristics of bicycle traffic into microscopic traffic simulation. By explicitly modeling the high heterogeneity of a bicyclist population, traffic performance evaluations using simulation could be particularly useful for planning bicycling infrastructure that ensures efficient traffic.

References

Mohammed, H., Bigazzi, A. & Sayed, T. (2019), ‘Characterization of bicycle following and overtaking maneuvers on cycling paths’, Transportation Research Part C: Emerging Technologies 98(November), 139–151.

Pérez Castro, G., Johansson, F. & Olstam, J. (2022), ‘How to Model the Effect of Gradient on Bicycle Traffic in Microscopic Traffic Simulation’, Transportation Research Record: Journal of the Transportation Research Board 2676(11), 609–620.

Twaddle, H. & Grigoropoulos, G. (2016), ‘Modeling the Speed, Acceleration, and Deceleration of Bicyclists for Microscopic Traffic Simulation’, Transportation Research Record: Journal of the Transportation Research Board 2587(1), 8–16.

Viscando AB (2013), ‘Traffic Insights Made Easy’. URL: https://www.viscando.com/.

A physical microscopic bicycle model

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Challenge Addressed / Research Problem Investigated

Modelling a free cyclist from a physical perspective with _me and energy as output for a given route.

Abstract

This abstract is a summary of a proposed paper published on the preprint server SSRN h8ps://dx.doi.org/10.2139/ssrn.4088432.

This paper presents a physical model, which enables high accuracy, to predict the driving behaviour of a free cyclist (a cyclist who is not constrained by other cyclists). The meaning with this contribution to CRBAM23 is to discuss this kind of model and the type of data needed to verify such a model.

When observing cyclists, each of them used to have a personal speed and in steady-state conditions also a quite constant speed. Bicycling means to overcome driving resistances such as aerodynamic drag, rolling resistance, climbing resistance and inertia during acceleration but increase in potential / kinetic energy. The individual cyclist, here defined as a human being and the corresponding bicycle, can affect these driving resistances, e.g. by choosing clothes affecting aerodynamic drag, by choosing tyres or tyre inflation pressure affecting rolling resistance, by choosing the route affecting climbing resistance and by choosing a driving style affecting all of the named resistances. However, also the responsible party for infrastructure can affect these driving resistances, by designing e.g. surroundings to infrastructure affecting aerodynamic drag, the road roughness affecting rolling resistance, the cycle track inclination affecting the climbing resistance and the traffic lights controls affecting the need for repeated decelerations and accelerations.

In addition, driving resistances in combination with available power are the main causes for travel _me. And travel _me is one of the most important factors regarding choice of route and mode of transport, (Bovy & Bradley 1985, Stinson & Bhat 2003, Caulfield et al. 2012, Bhat et al. 2015).

This means, those who want to increase the number of cyclists in utility trips (trips in everyday life where cycling is a means of transport and not a means of training) need to focus on and reduce driving resistances for cyclists. Detailed modelling of the longitudinal dynamics of cyclists will help to understand where most energy and _me are spent and where efficiency can be increased.

In general, this kind of energy and motion model enables the realisation of "eco-cycling", in accordance with "eco-driving" for motorised vehicles. It could help to design infrastructure (the longer way around the hill vs. the short way over the hill?) or "green waves" at traffic lights along an alley etc.

BICYCLE MODELS

A lot has been done within automobile simulation tools. In the bicycle domain Hoogendoorn & Daamen (2016) presented a microscopic bicycle traffic model based on the individual headway consisting of a minimum headway and a free headway as stochastic variables. With this the model takes care of constrained and unconstrained cyclists.

Many models are based on stochastic approaches. Acceleration of cyclists was modelled by Ma & Luo (2016) based on statistical analysis of naturalistic data collected by means of GNSS (Global Navigation Satellite System) by 11 cyclists. The main question was the probability for the cyclist to overtake another bike or not. In addition, they combined these data with socio-economic factors and found that both gender and agility of the cyclists affected acceleration.

Arnesen et al. (2020) modelled the bicycle speed based on slope and horizontal curvature based on GNSS data from a cycle-to-work project in the city of Trondheim, Norway. They utilised a Markov model to take the dependency between the observations into account.

In addition, there are physical models available as Berg (2017) compared in a report. These models have in common that they are quasi-static models. This means they can calculate e.g. energy consumption at a given speed for constant conditions (road inclination, wind, etc.) Simulating a cyclist along a certain track is not possible yet.

Johansson et al. (2020) have identified the need of bicycle models, i.a. what they call the model of a free cyclist. This is specifically important since it should be a basis for other models because some of the driving resistances during cycling are independent of the surrounding traffic, e.g. rolling resistance, aerodynamic drag and climbing force.

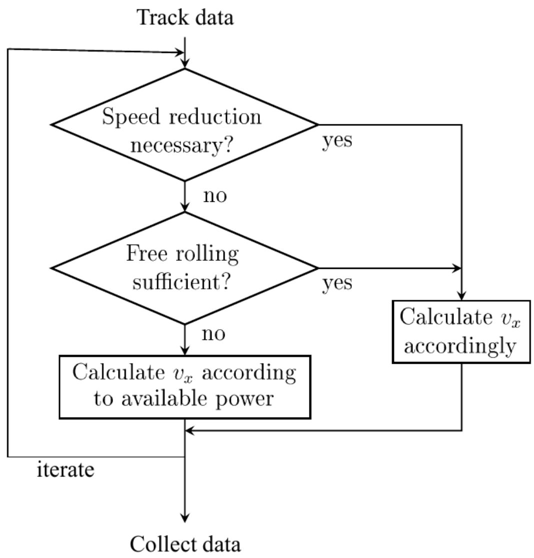
Further models from literature will be presented in the full paper.

PHYSICAL MODEL

The scope of the present model is to simulate the bicycle speed profile and the energy usage over a given route for a representative cyclist. The model is divided into two parts, a shell providing the necessary data, and the core model calculating bicycle speed and energy over distance. The core model is based mainly on the equation for driving resistance power.

$$P_{driver,const} = P_{airdrag} + P_{rollingresistance} + P_{climbing} + P_{acceleration} \quad (1)$$

The general process of the core model is visualised in the figure below.



The model receives the input data and runs through the route by means of the map data. Each road segment is broken down into steps of 1 cm length to get a sufficient resolution for the calculation. In each of these steps the model operates in a steady-state way. A possible speed reduction is calculated based on lateral acceleration deviated from the map data or based on traffic environment. If the bicycle speed must be reduced, this has highest priority and the power applied is reduced accordingly or set to zero. Details of the model as well as a case study will be presented at CRBAM23 as well as in the full paper.

FOR DISCUSSION AT CRBAM23

A physical bicycle model builds, as the nature of driving is, on power. However, a human being is not a machine. Next to power a maximum speed and a "good enough speed" are defined as well as a short-term power-overshoot for e.g. short inclinations. Anyhow, one aspect for discussion is whether it is a feasible approach to assume a (constant?) power of a cyclist. Another aspect for discussion is the validation of the model. Which kind of data is needed and how can these data be collected? Even if the model is not based on statistics directly, there is need for statistical data (e.g. the power of a cyclist). Where does a statistical model end and a physical model begin?

References

Arnesen, P., Malmin, O. & Dahl, E. (2020), `A forward Markov model for predicting bicycle speed', Transportation (Dordrecht) 47 (5), 2415-2437.

Baldissera, P., Delprete, C., Rossi, M. & Zahar, A. (2020), `Experimental comparison of speed-dependent rolling coefficients in small cycling _res', Tire science & technology.

Barnes, M. & Brennan, S. (2012), Simulation, design, and verification of an electrified bicycle energy model, in `ASME 2012 5th Annual Dynamic Systems and Control Conference Joint with the JSME 2012 11th Motion and Vibration Conference, 2012-MOVIC 2012 DSCC', Vol. 1, pp. 875-880.

Bhat, C. R., Dubey, S. K. & Nagel, K. (2015), `Introducing non-normality of latent psychological constructs in choice modelling with an application to bicyclist route choice', Transportation Research. Part B: Methodological 78, 34-363.

Bigazzi, A. & Lindsey, R. (2018), `A utility-based bicycle speed choice model with _me and energy factors', Transportation (Dordrecht) 46(3), 995-1009.

Bovy, P. & Bradley, P. (1985), Route Choice Analyzed with Stated Preference Approaches, Transportation Research Record, Transportation Research Board, pp. 11-20.
Caulfield, B., Brick, E. & McCarthya, O. (2012), `Determining bicycle infrastructure preferences - A case study of Dublin', Transportation Research Part D: Transport and Environment 17(5), 413-417.
Hoogendoorn, S. & Daamen, W. (2016), `Bicycle headway modelling and its applications', Transportation Research Record 2587 (1), 34-40.
Johansson, F., Liu, C., Ekström, J. & Olstam, J. (2020), Modelling of bicycle traffic - analysis of needs and knowledge (Cykeltrafikmodellering - Behovsanalys och kunskapsläge), Technical Report 1064, Swedish National Road and Transport Research Institute (VTI).
Liang, X., Mao, B. & Xu, Q. (2012), `Psychological-physical force model for bicycle dynamics', J Transpn Sys Eng & IT 12(2), 91-97.
Ma, X. & Luo, D. (2016), `Modeling cyclist acceleration process for bicycle traffic simulation using naturalistic data', Transportation Research. Part F, Traffic Psychology and Behaviour 40, 130-144.

Lane and band formation in mixed traffic flow

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Keywords

Mixed traffic flow, lane and band formation, quenched and annealed heterogeneity

Challenge Addressed / Research Problem Investigated

Modeling the collective dynamics of lane and band formation in mixed traffic flow using quenched and annealed heterogeneity models

Abstract

Flows of self-avoiding agents, such as pedestrians or cyclists, can describe many types of collective dynamics (Boltes et al. 2018). Examples include coordinated motion, stop-and-go waves, lane formation, jamming, clogging, oscillation, and patterns at bottlenecks and intersections. In this presentation, we will show using an agent-based motion model how heterogeneity in agent behavior can initiate segregation and the spontaneous formation of lane or band patterns.

We consider a mixed flow and two modeling approaches of heterogeneity:

- M1: *Agent heterogeneity (quenched heterogeneity)* – We statically assign two different values for the model parameters to the two types of agents. We aim to model different types of agents (for instance pedestrians and cyclists) with specific characteristics in terms of desired speed, desired time gap, size, etc.
- M2: *Heterogeneity of the interactions (annealed heterogeneity)* – We dynamically assign the two different values to the model parameters depending on the type of the neighboring agent in the interaction. In contrast to model M1, where the heterogeneity lies in static agent characteristics, we aim to model heterogeneity in the interactions. Such a case may correspond, for instance, to a cyclist adapting his/her behavior when sharing the road with pedestrians.

Simulation results show that phase transitions and self-organized lane and band formations arise spontaneously when the difference between the two attributed parameter values is sufficiently large (Khelfa et al. 2022). More specifically, we observe the emergence of horizontal lanes when the heterogeneity lies in the agents (model M1), while vertical bands arise if we assume heterogeneity in the interactions (model M2). The different organizations of the flow strongly influence the system performance. Lane patterns significantly improve the flow, while band patterns result in low performance. The collective dynamics occur in relatively short time intervals and are partly robust to stochastic perturbations.

References

Boltes, M., Zhang, J., Tordeux, A., Schadschneider, A. & Seyfried, A. Empirical Results of Pedestrian and Evacuation Dynamics, 1–29 (Springer, Berlin, Heidelberg, 2018).

Khelfa, B., Korbmacher, R., Schadschneider, A., & Tordeux, A. Heterogeneity-induced lane and band formation in self-driven particle systems. *Sci. Rep.* **12**:4768 (2022).

Advancing inclusion and equity in active transport in cycling cities

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Keywords
inclusion, equity, mobility justice, policy, Amsterdam,

Challenge Addressed / Research Problem Investigated
The challenge in this research is how to translate academic research in mobility justice into practical, city-wide, general policy for mobility in cycling when a) equity and inclusion in mobility require an intersectional and highly contextual approach and b) little is known so far on how to do it.

Abstract
Traditional approaches to transport planning inherently neglect the social characteristics of individuals or systemic differences in accessibility to social and economic opportunities. While equity and justice in urban planning have a long-standing history, there is a recent rise in this discussion within the domain of urban transport. This has incited a growing interest in ensuring equitable access to social and economic opportunities through transportation for all segments of society (Verlinghieri and Schwanen, 2020; Lucas & Musso, 2014; Preston & Rajé, 2007). Mobility justice examines how power and inequality influence how people move and how resources and information are shared by considering the unequal patterns in mobility and immobility (Sheller, 2018). In cycling research, it can encourage exploring policies that address diverse communities' mobility needs through the lens of cycling. However, practical implementation challenges still persist. Hence, the following research question emerges: How do Amsterdam residents representing multiple and intersecting identities experience exclusion in their mobility practices and what policy measures could alleviate exclusion and advance mobility justice?

While this growing interest in research has increased in cycling research, little has been done in the context of mature cycling cities. Several factors have contributed to this gap, with one prominent issue being the existing oversimplification of cycling profiles within cycling research, which fails to address the diversity in cycling behaviours and attitudes (Félix et al., 2017). In addition, data gaps exist in cycling statistics and qualitative experiences, highlighting the need for comprehensive collection and policy interventions to understand better demographic disparities, minority group experiences, and the challenges of inclusion (Lam, 2022).

Furthermore, the prevailing vision and governance of planning for cycling replicates deeply rooted ideals of efficiency, speed and functionality, which reinforces the negative perceptions of well-established transportation systems and leads to exclusion (Cox & Koglin, 2020). Specifically, in cycling mature cities with high rates of cycling, speed differences in combination with busyness on cycling lanes can affect feelings of safety and inclusivity (Cox, 2022; te

Brömmelstroet et al., 2017). Mobility scholars raise debates on how the practice of planning needs new ways to challenge, rather than repeat, how we deal with urban systems, including how we get around in cities (te Brömmelstroet et al., 2022). . Vélomobility, focusing on people-centred transportation, encourages a major shift in the way we think about mobility, emphasising concepts like playfulness, social interaction, and shared resources, and reconsidering what's truly necessary when it comes to transportation (Cox, 2022; Cox, 2019; Koglin, 2014). For example, infrastructure should be seen as more than just pathways, considering its multifaceted functions, while also encouraging social interaction among various cyclists and other road users (Cox, 2022).

DEFINING AN INTERSECTIONAL APPROACH TO CYCLING POLICY

Urban mobility is influenced by structural and spatial inequalities, which can be seen in cycling disparities based on gender, race, and socioeconomic factors. For example, female cyclists are more risk-averse and prefer slower speeds and quieter lanes (Lam, 2022). In addition, cycling diversity involves considering cycling for all abilities, but issues such as parking facilities need to be addressed before cycling can fully become accessible to people with disabilities (Andrews et al., 2018). Intersectional approaches to inclusion in transport and cycling are essential for developing solutions that cater to the unique needs of marginalised populations (Barajas, 2020). For example, immigrant women cycle less than both immigrant men and native-born Dutch men, highlighting cultural and gendered differences in travel behaviour (van der Kloof et al., 2014). Therefore it is vital to recognize the impact of various factors on accessibility through an intersectional lens and identify how these differences interact with existing mobility systems and perpetuate unequal mobilities (Sheller, 2018). This comprehensive approach enables recognising and rectifying injustices within our current transport systems, paving the way for just and equitable cities.

RESEARCH DESIGN AND METHODOLOGY

To explore this research question, we use qualitative methods and an exploratory case study (Yin, 2003). In-depth, qualitative research is vital for tackling transport and mobility justice concerns, as highlighted by Verlinghieri and Schwanen, who stress the importance of ethical exploration in investigating equity and justice in transportation (Verlinghieri and Schwanen, 2020). In addition, further research underscores the value of qualitative methods in identifying adverse outcomes and their root causes, enabling more inclusive community involvement in planning initiatives (Karner et al., 2020; Fields et al.; 2020; Adorno et al., 2016). A series of semi-structured interviews (n = 22) were conducted with community leaders from minority groups. The community leaders were generally considered individuals within a community who exhibit leadership qualities or actively engage in initiatives to bring about positive change. For this research, we chose to focus on how migrants, people with disabilities and the elderly experience exclusion in their mobility practices. These groups were identified in the literature review and chosen given their diverse perspectives in formulating a comprehensive understanding of mobility justice in the case of Amsterdam. Interviews lasted between 45-75 minutes, and were audio-recorded, transcribed and coded using Atlas.ti software.

The interviews followed a semi-structured format using an interview guide and encouraged a natural conversation. A specific focus of the interview questions is set on the process of exclusion that prevents people from participating in economic, political, and social life due to various characteristics. These interviews served to further contextualise the state of mobility justice in cycling within these communities and understand the role of exclusion and inclusion in Amsterdam's cycling in connection to other mobility practices.

The case we use to investigate this research is geographically centred in Amsterdam, the Netherlands. The city, known for its high cycling rates and innovative cycling policies, offers valuable insights for other cities aiming to improve cycling environments and promote sustainable mobility (Glaser et al., 2021). However, participation is unevenly distributed, socially and spatially, particularly among minority groups (Gemeente Amsterdam, 2017). At the same time, Amsterdam's transition to 'autoluw' may pose challenges for those relying on cars, living in areas with limited alternative transportation options, or not cycling. Despite these challenges, there is limited understanding of the diversity inherent within cycling in this context. The case of Amsterdam presents a unique opportunity to explore the role of inclusion and social equity in cycling as a form of mobilty.

PRELIMINARY FINDINGS

Preliminary findings from the interviews uncover three key overarching themes:

1. **Discrepancies Between Policy and Lived Experience**: Clear disparities emerge between policy formulation and the real-life experiences of individuals.
2. **Technical Quantification in Transport Planning**: Transport planning and participation in traffic replicates undesirable technical-political systems of transportation
3. **Inequitable Access to Resources**: There are significant disparities present in the accessibility of resources, disproportionately affecting minority groups

These findings uncover forms of exclusion that limit equal participation of social and economic opportunities in everyday mobility practices. The purpose of the upcoming discussion is to explore how to translate these findings into tangible policy suggestions. With a focus on the principles of mobility justice, these recommendations aim to improve the equity and inclusion of Amsterdam's cycling policy and mobility planning.

References

Adorno, G., Fields, N., Cronley, C., Parekh, R., & Magruder, K. (2016). Ageing in a low-density urban city: transportation mobility as a social equity issue. *Ageing & Society*, *38*(2), 296–320. https://doi.org/10.1017/s0144686x16000994.

Andrews, N., Clement, I., & Aldred, R. (2018). Invisible cyclists? Disabled people and cycle planning – A case study of London. *Journal of Transport & Health*, *8*, 146–156. https://doi.org/10.1016/j.jth.2017.11.145.

Barajas, J. M. (2020). Supplemental infrastructure: how community networks and immigrant identity influence cycling. *Transportation*, *47*(3), 1251–1274. https://doi.org/10.1007/S11116-018-9955-7/TABLES/1.

Clayton, W., Parkin, J., & Billington, C. (2017). Cycling and disability: A call for further research. *Journal of Transport & Health*, *6*, 452–462. https://doi.org/10.1016/J.JTH.2017.01.013.

Cox, P. (2019). *Cycling: A Sociology of Vélomobility*. Routledge.

Cox, P. (2022). Vélomobility is to degrowth as automobility is to growth: prefigurative cycling imaginaries. *Applied Mobilities*, 1–21. https://doi.org/10.1080/23800127.2022.2087134.

Cox, P., & Koglin, T. (2020). *The politics of cycling infrastructure: Spaces and (In)Equality*. Policy Press.

Félix, R., Moura, F., & Clifton, K. J. (2017). Typologies of Urban Cyclists: Review of Market Segmentation Methods for Planning Practice. *Transportation Research Record*, *2662*(1), 125–133. https://doi.org/10.3141/2662-14.

Fields, N., Miller, V. J., Cronley, C., Hyun, K., Mattingly, S. P., Khademi, S., Nargesi, S. R. R., & Williams, J. R. (2020). Interprofessional collaboration to promote transportation equity for environmental justice populations: A mixed methods study of civil engineers, transportation planners, and social workers' perspectives. *Transportation Research Interdisciplinary Perspectives*, *5*, 100110. https://doi.org/10.1016/j.trip.2020.100110

Gemeente Amsterdam. (2017). Meerjarenplan Fiets 2017-2022. In *Https://Openresearch.Amsterdam/Nl/Page/57825/Meerjarenplan-fiets-2017-2022*.

Glaser, M., Blake, O., Bertolini, L., te Brömmelstroet, M., & Rubin, O. (2021). Learning from abroad: An interdisciplinary exploration of knowledge transfer in the transport domain. *Research in Transportation Business & Management, 39*, 100531.

Harms, L., Bertolini, L., & te Brömmelstroet, M. (2014). Spatial and social variations in cycling patterns in a mature cycling country exploring differences and trends. *Journal of Transport and Health*, *1*(4), 232–242. https://doi.org/10.1016/J.JTH.2014.09.012.

Karner, A., London, J., Rowangould, D., & Manaugh, K. (2020). From transportation equity to transportation justice: within, through, and beyond the state. *Journal of Planning Literature*, *35*(4), 440–459. https://doi.org/10.1177/0885412220927691.

Koglin, T. (2014). Vélomobility and the politics of transport planning. *GeoJournal*, *80*(4), 569–586. https://doi.org/10.1007/s10708-014-9565-7.

Lam, T. (2022). Towards an Intersectional Perspective in Cycling. *Active Travel Studies*, *2*(1). https://doi.org/10.16997/ats.1264.

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport Policy*, *20*, 105–113. https://doi.org/10.1016/J.TRANPOL.2012.01.013.

Lucas, K., & Musso, A. (2014). Policies for social inclusion in transportation: An introduction to the special issue. *Case Studies on Transport Policy*, *2*(2), 37–40. https://doi.org/10.1016/j.cstp.2014.06.002.

Luz, G., & Portugal, L. (2021). Understanding transport-related social exclusion through the lens of capabilities approach. *Transport Reviews*, *42*(4), 503–525. https://doi.org/10.1080/01441647.2021.2005183.

Preston, J., & Rajé, F. (2007). Accessibility, mobility and transport-related social exclusion. *Journal of Transport Geography*, *15*(3), 151–160. https://doi.org/10.1016/j.jtrangeo.2006.05.002.

Sheller, M. (2018). Theorising mobility justice. *Tempo Social*, *30*(2), 17–34. https://doi.org/10.11606/0103-2070.ts.2018.142763.

te Brömmelstroet, M., Nikolaeva, A., Glaser, M., Nicolaisen, M. S., & Chan, C. (2017). Travelling together alone and alone together: mobility and potential exposure to diversity. *Applied Mobilities*, *2*(1), 1–15. https://doi.org/10.1080/23800127.2017.1283122.

te Brömmelstroet, M., Mladenović, M. N., Nikolaeva, A., Gaziulusoy, İ., Ferreira, A., Schmidt-Thomé, K., Ritvos, R., Sousa, S., & Bergsma, B. (2022). Identifying, nurturing and empowering alternative mobility narratives. *Journal of Urban Mobility*, *2*, 100031. https://doi.org/10.1016/j.urbmob.2022.100031.

van der Kloof, A., Bastiaanssen, J., & Martens, K. (2014). Bicycle lessons, activity participation and empowerment. *Case Studies on Transport Policy*, *2*(2), 89–95. https://doi.org/10.1016/J.CSTP.2014.06.006.

Verlinghieri, E., & Schwanen, T. (2020). Transport and mobility justice: Evolving discussions. *Journal of Transport Geography*, *87*, 102798. https://doi.org/10.1016/j.jtrangeo.2020.102798.

Yin, R. K. (2003). *Case study research: Design and Methods*. SAGE.

Rethinking elementary school cycling training

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Keywords
cycling test, primary school, mobility education, children, infrastructure

Challenge Addressed / Research Problem Investigated

Broadening the safety-oriented cycling test in elementary school by developing an educational measure that focuses on exploring and evaluating the cycling infrastructure from children's eyes.

Abstract
In our contribution we will present and discuss teaching and learning materials that are currently developed in the research project ‚Mobilitätsbildung' (mobility education). For this project, the working groups Integrated Transport Planning (Technische Universität Berlin) and Primary Science Education (Humboldt-Universität zu Berlin) have joined forces to develop educational resources in cooperation with kindergarten and primary school teachers. In our project, we understand mobility education as a tool to

a) foster independent child mobility and active modes of transport,
b) enable children to critically reflect on the existing transport environment and how it supports or limits their mobility,
c) advance the participation of children in transport planning (Stiller et al. 2023).

To kick-off our research project, we first conducted an interview study to understand the current challenges and opportunities of mobility education. In Germany, mobility education in elementary school is often limited to the mandatory cycling test in grade 3 or 4. The cycling training consists of a theoretical and practical part. While it is essential to put all children on bikes – no matter if their parents/guardians cycle or not – the training's content and concept are in urgent need of an update. In Germany, most bike lessons take place in 'traffic schools', fenced off areas where children can safely ride their bikes. But according to the interviewed experts, this hardly adds to the safety of children, on the contrary: Children often lack the experience of riding their bike in real-life traffic. They further criticize the short amount of time committed to actually riding a bike, the exam-like character and the lacking consideration of

the children's needs. Regarding the content of the cycling training, the focus on personal bike safety is highly problematic, as children are hold responsible for their safety, while the (lacking) quality of the bike infrastructure is not being discussed (for the historical roots of this responsibility-based approach see Rossol 2018).

Based on previous research and the results of our interview study, we developed the ‚Radverkehrs-Check' (bike infrastructure check-up), which can be integrated in the cycling training. The aim is to evaluate the local bike infrastructure from a children's perspective, as children and grown-ups often have different requirements (McDonald 2012; Spinney 2020). The ‚Radverkehrs-Check' therefore improves the cycling training by putting the theoretical content (traffic rules, different types of bike paths, infrastructural elements etc.) into a local context and thereby adding a spatial/geographical perspective. It further adds a political dimension to the training by raising awareness to the fact that urban design and the division of space according to certain functions are results of decisions making processes and can thus be adapted and improved.

As of now, we have implemented the ‚Radverkehrs-Check' once with one of our partner schools, more schools will follow soon. The result is a map showing the children's evaluation of the bike infrastructure in their neighbourhood. If taken further, the check-up can also be an opportunity for schools, urban planners and municipalities to cooperate. Thus, the method does not only add to the quality of the cycling training, but may also be a useful tool for planners to learn about children's perspectives on bike infrastructure and urban space in general. The findings of the check-up can for example be integrated in the school's traffic safety and mobility policy. The European Transport and Safety Council (2023, 28) suggests that these policies are developed in cooperation with all relevant partners, which includes the municipality, police, community, parents and students.

During CRBAM23 we will share our understanding of mobility education. Furthermore, we seek to give a short introduction to the mandatory cycling training before we will present the idea behind the ‚Radverkehrs-Check'. Together with the participants of our session, we hope to generate additional ideas for improving the cycling training.

References

European Transport and Safety Council (ETSC) (2023): LEARN Flash 3 - Linking Education on Sustainable Mobility with Traffic Safety. Brussels.

McDonald, N. (2012): Children and Cycling. In: J. Puchler & R. Buehler (ed.) (2012): City Cycling, 235–255. Cambridge: MIT Press.

Rossol, N. (2018): Policing, Traffic Safety Education and Citizenship in Post-1945 West Germany. Journal of Contemporary History Vol. 53(2) 339–36. DOI: 10.1177/0022009416667793.

Spinney, J. (2020). Understanding Urban Cycling: Exploring the Relationship Between Mobility, Sustainability and Capital. New York: Routledge.

Stiller, J., Röll, V., Miehle, L., Stage, D., Becker, D., Pech, D. & O. Schwedes (2023): Berliner Modell zur Mobilitätsbildung. Ein interdisziplinäres Modell. DOI: 10.18452/25709.

Influence on well-being of modal choice of school children on their trip to school

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Keywords
Well-being, modal choice, school children, school trip mobility, children mobility

Challenge Addressed / Research Problem Investigated
The research generates data that connects mode choice and the trip to school with the well-being of school children, to find other reasons to promote active mobility besides school performance and psychological and physical health long-term benefits.

Abstract
In current research, the impact of active mobility on health and performance has been widely studied in different contexts and time frames, and many positive effects of active mobility have been identified (Robert Koch-Institut 2018; Hendriksen et al. 2010). Looking at school children, influences on academic performance were mainly investigated. However, the positive correlations found might not be a sufficient justification to promote active mobility on the way to school. The main societal focus should lie on the well-being of children, not solely on performance.

While current literature shows a long-term reduced risk of mental diseases, depending on the domain of physical activity (White et al. 2017), an analysis of short-term impacts of active mobility on well-being has not been conducted yet. Research targeting the effects of active mobility in children show a positive correlation between usage of active modes and the ability to concentrate in school (Rasmussen et al. 2012). This effect is shown on the same day as the realized mobility, which hints to the existence of psychological short-term effects.

The focus of this research project is on the self-reported psychological well-being of students in the first hours of a school day. Insights from such data can be valuable for motivating changes in mobility behaviour on the way to school. Thus, this research project collected a data set that connects mobility behaviour on the way to school with the well-being of school children at the beginning of school days.

For the research project, a survey was conducted at Gymnasium Mellendorf, a secondary school close to Hanover, Germany. Gymnasium Mellendorf, as a typical school in a German rural area, promises diverse mobility behaviour of the school children on the way to school. The questionnaire was based on the WHO5 well-being questionnaire (Psychiatric Research Unit 1998). The questions targeting the well-being were complemented by questions on the realized mobility behaviour on the trip to school. Furthermore, sociodemographic data was surveyed. In this survey, children of classes 7 to 10 answered questions about their way to school in the first minutes of the first lesson and assessed their well-being throughout a week.

The survey was conducted in June 2023 and a data set containing more than 700 answers was collected.

In the analysis of the collected data there was found no influence of time spent travelling on the way to school on the well-being. With widely spread scores and R^2 values lower than 0.055 for different age-groups, genders and modes, a causal relation is most unlikely. On the other hand the analysis suggests a causal relation between well-being and modal choice. While bike trips to school significantly boost the well-being of school children by 6.18 % (95 % [3.364, -Inf], $t(7.581) = 3.428$, $p<0.01$), walking and public transit significantly reduce the reported well-being (walking: -4.97 % [-Inf,-1.618], $t(207.4) = 2.545$, $p<0.01$, PT: -3.1 % [-Inf, -0.523], $t(758.1) = 1.988$, $p = 0.024$). Children brought to school by car do not show any deviation in their reported well-being.

The results show an influence of the modal choice on the well-being of school children, at least in the surveyed school. To ensure that these findings are not unique to Gymnasium Mellendorf, the survey should be repeated in other schools, within other surroundings, namely spatial structure, the predominant socio-economic background of the children and their families, other school forms and age groups. When validated the results could be used to change the societal and political view on school trip mobility. Instead of viewing the challenges as solely logistical, best solved by public transport to and from school, a shift could be made, towards sustainable and active mobility in the best interest of the children. How such a shift can be accomplished and what would be necessary in schools and the bicycle education of children has to be evaluated further and will be discussed at the CRBAM23.

References

Hendriksen, Ingrid J. M.; Simons, Monique; Garre, Francisca Galindo; Hildebrandt, Vincent H. (2010): The association between commuter cycling and sickness absence. In Preventive medi-cine 51 (2), pp. 132–135.

Psychiatric Research Unit (1998): WHO (fünf) - Fragebogen zum Wohlbefinden. With assis-tance of Frederiksborg General Hospital. WHO Collaborating Center for Mental Health. Hillerød, Dänemark.

Rasmussen, Silke Rosendal; Roug, Torben Ingerlsev; Madsen, Kristian Levring; Himmelstrup, Mie (2012): Masseeksperiment. Konzentration og smag. Kopenhagen.

Robert Koch-Institut (2018): Körperliche Aktivität von Kindern und Jugendlichen in Deutsch-land – Querschnittergebnisse aus KiGGS Welle 2 und Trends.

White, Rhiannon Lee; Babic, Mark J.; Parker, Philip D.; Lubans, David R.; Astell-Burt, Thomas; Lonsdale, Chris (2017): Domain-Specific Physical Activity and Mental Health: A Meta-analysis. In American journal of preventive medicine 52 (5), pp. 653–666.

Rotterdam Moslima: Ventrolquism and the creative power of cycling as a form of mobility justice

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Abstract
This paper is an examination of how muslim women in Rotterdam, the Netherlands produce their identity between the act of cycling, their practice of islam, their embodied feminism, and connection to place . My case analysis will explain how these women ventriloquize cycling to situate their identities in the hostile context of western european society. Ventriloquism (the art where a Dummy is made to speak by its human interlocutor) has been utilized as a communication metaphor to explain how non-human entities are made to speak. A research question for my project is: How does transportation choice interact with how these women craft their identities? I will interrogate this question through a rhetorical analysis of an interview of two Rotterdam Moslima women, Fatima Amina and Meryam Khaldi. Through this analysis I will argue that the bicycle is a communicative device that allows these individuals to negotiate the tension between hegemonic white dutch culture and their own positionality.

I am trained as an environmental and organizational communication scholar. In my discipline cycling has been theorized to produce a ventriloquial effect on the cyclist. Communication scholars have utilized ventriloquism, the art (where a dummy appears to be talking, yet a human is talking for them) as a metaphor that explains how communication operates in contexts where non-human entities are made to speak. This type of communication is either ventriloquized through people or it ventriloquizes people. People ventriloquize social ideas when they enact culturally situated behaviors. An example is how my participants continued cycling because of the accessibility it provided them. People are ventriloquized when their practice of a dominant cultural behavior reinforces that behavior. An example of this is "car brain" in the United States. Drivers with "car brain" become adversarial to pedestrians and transit riders. Here is a definition of the ventriloquial approach by Dr. Ziyu Long, an organizational communication scholar.

"The ventriloquial approach showcases how "human interactants [usually operating as 'the ventriloquist'] position themselves (or are positioned) as being constrained or animated by different principles, values, interests, (aspects of) ideologies, norms, or experiences, which operate as 'figures' that are made to speak to accomplish particular goals or serve particular interests" (Long, 2016, p. 426)

Long's definition of the ventriloquial approach explains how communication works between people and non-human entities. Non-human entities are made to speak through human interpretation and action. Communication research has examined how ventriloquial interpretation exists in the context of cycling as a commuting behavior. Wilhoit and Kisselburgh (2019) explored how cyclists self-identify as minorities on US roadways. Their research provides two reasons why the dominant modes available in a transportation environment ventriloquize commuter behavior. First, is that dominant and alternative practices, people, and objects exist in relation to each other, and it is through their contrasting relationship that behaviors either seem normal or abnormal (Wilhoit and Kisselburgh, 2019). Second, the relationship between practices and people is ventriloquized or made to speak so that the contrast between activities foregrounds the meaning of the normal practices and backgrounds the meaning of the abnormal practices (Wilhoit and Kisselburgh, 2019).

Ventriloquism as a communication metaphor, explains how the built environment of a transportation system and someone's vehicle of choice can be made to speak. In the case of Wilhoit and Kisselburgh's research cycling was the abnormal practice and car driving was the normative practice. Cycling in the Netherlands is normal behavior. A cyclist in this environment communicates with the silent machine of the bicycle and the transportation environment. These non-human elements are made to speak through a person's relationship to cycling. Ventriloquism can be useful to understand how communication plays a role in explaining people's transportation choices

The challenge that I am addressing in this paper exploring how race plays a role in how people come to understand how they make transportation choices. This research follows in the vein of mobility justice a term coined by Dr. Mimi sheller. Mobility justice is an intersectional approach to understanding how mobility operates as an ontological positioning. Mobility can be seen as an ontology because the way people either move themselves or are forced in motion by global forces like war and climate change, impacts how they choose to move throughout the world around them. In the context of my paper, the identity of Rotterdam Moslima is assembled by Meryam and Fatima through their experience cycling. Through cycling they deterriotoriziale the meaning of Dutch identity and assemble that identity in a way that is inclusive for muslim women in Rotterdam. These actions demonstrate the bicycles potential as a communicative device that allows the women to construct a relationship between their muslim identity, their position as women, and the city that is their home through their mobility choice.

I want to utilize my presentation space at crbam to push the boundaries of how we understand the meaning people ascribe to cycling. My paper articulates how it is more than just a transportation choice. My presentation will provide a starting point for a discussion to expand how we as cycling researchers understand the concept of transportation justice. Transportation justice in cycling research has been utilized to analyze how accessible certain areas of an urban space are for certain types of transportation choices. During the workshop time after I have given the presentation part I would hope to discuss with colleagues about how they can include understanding of mobility justice into their cycling research. I think this is an important discussion to take place at CRBAM because it provides cycling research with a humanities lens to explore bicycling as a way for people to interpret how they interact with the world around them.

Becoming Cycling Cities: Mobilizing Cycling Histories in the Pursuit of Cycling Futures

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Abstract

Becoming Cycling Cities: Mobilizing Cycling Histories in the Pursuit of Cycling Future Planners and advocates seeking to spur change and elevate cycling in their cities often unintentionally dress their arguments in narratives of mobility change that reduce complex and highly disruptive social and political processes to their resulting infrastructure. Reducing those changes into a simple process of top-down, non-disruptive, rational decision making is not reflective of historical accounts. But perhaps more importantly, divorcing mobility histories from both their radical underpinnings and their temporal and cultural contexts is unlikely to yield the lasting change that those narratives portend, and that those advocates envision.

A common perspective among bicycle planners and advocates–and one identified by Cervero, Caldwell, and Cuillar (2013) as a powerful slogan for bicycle advocacy in the US–is “if you build it, they will come.” This denotes infrastructure is the key to driving behavior change. Oldenziel, conversely, writes that a sole focus on infrastructure is most likely to yield lightly traveled bike lanes. Mobility justice scholars Hoffmann and Lugo lament the shift within bicycle advocacy from the political activism of critical mass to emphasis on the reliance on physical infrastructure projects (Hoffman and Lugo p. 4-6). This infrastructure-first mentality risks more than empty bike lanes. Hoffmann and Lugo argue that it also exacerbates gentrification and exclusion, eroding potential support for cycling from those most harmed by automobility's dominance.

That is precisely what often happens during city-level planning and infrastructure delivery processes. Goals for increasing cycling’s modal split become actionable solely or primarily through infrastructure. Municipal budgets, staffing, and procedures codify this emphasis, in the process elevating and empowering technical knowledge and holders of that knowledge to the detriment of social knowledge and knowledge-holders. This cycle further entrenches the perspective that infrastructure drives change. This disconnect between scholarly understandings of mobility change and practitioner efforts to realize change, results in a singular cycling city paradigm that cities either reflect or not. The flawed logic here is that elevating cycling requires physically resembling cities that have successfully elevated cycling.

Cycling advocates would do well to understand and internalize these histories of mobility change, not solely as the infrastructure they realized, but the social and political actors who shifted balances of power. Framed in this way, past mobility changes seem progressions of destabilizations and reconstitutions, each encapsulated by infrastructure that, according to Amin, “both embody and enact symbolic power and social selectiveness, privileging certain groups above others…” (Amin 2014). Gartner expands this framing of infrastructure as “symbolis[ing] existing power struggles… and existing as the material outcomes of social-political relationships that exist within fragmented and inequitable societies” (Gartner 2016, p. 382). Infrastructure is not, in itself, a catalyst for social change, but a reflection and

encapsulation of social and political power. Mobilizing these histories means moving beyond building bike lanes–even beautifully protected ones–and toward embracing the humble bicycle's enduring role as a tool for contesting systems of power.

The overarching goal of my research is to operationalize histories and scholarship of cycling and mobility changes to empower the work of planners and advocates today, who are striving to become cycling cities. I will first expand the scholarship of these cycling histories by exploring the history of cycling in a city from the United States: Minneapolis. Mobilizing these histories, however, requires identifying commonalities in patterns and themes that comprise these histories–which can be seen in Oldenziel's five factors of cycling cities (2016). As a former bicycle planner, I am most interested in producing research that is immediately usable in affecting change and elevating cycling. That said, I am also keenly aware of the complicated role that urban planning as a profession has historically played in the pursuit of change. Particularly when prioritizing technical expertise and infrastructure projects above social constructions of space, systems of power, and patterns of practice, planners can fall into the trap of, what Cox describes, as "assuming that all infrastructure is imposed on a passive, malleable populace" (Cox 2019, p. 21). In mobilizing these complex socio-political histories of cycling change, and recognizing the important, if also limited role of planners, my research question is as follows:

- How have Minneapolis, Rotterdam, and Johannesburg become cycling cities, and how can a comparison of those histories empower and innovate the work of planners today?

The dynamics that go into managing change are complex, and invariably mediated by power (Bruno and Nikolaeva 2020; Petzer, Wieczorek, and Verbong 2021). In his unpacking of automobility's rise in the United States, Norton writes that, "when new social groups join an existing attack on a problem, they tend to begin by accepting the prevailing framework" (Norton 2011, p. 109). So too, do planners and advocates often unknowingly act according to, and in support of, an automobility system that they seek to alter, if now supplant.

My research intention is to unpack the challenge of achieving cycling change, specifically, and mobility change broadly, by questioning the underlying assumptions that influence the work of mobility planning in cities. The sub questions, progress from expanding the breadth and diversity of cycling histories, by adding an example from the US, to enabling cities to assess themselves based on social and political understandings of how cycling change has happened, to unpacking the multimodal

component of coalitions in challenging automobility, and finally to the role of urban planning within city government in enabling and/or stymieing change. My four research questions are as follows:

1. Viewed through the Cycling Cities framework, how has Minneapolis developed as a US cycling city?
2. How can cities more easily assess themselves based on the five factors of cycling cities?
3. How did cycling in Minneapolis, Rotterdam, and Johannesburg benefit from advocacy coalitions of cycling, walking, and transit?
4. How does the role of urban planning in Rotterdam, Minneapolis, and Johannesburg impact planners' ability to affect change?

References

Amin, Ash. 2014. “Lively Infrastructure.” Theory, Culture & Society 31(7–8):137–61. doi: 10.1177/0263276414548490.

Bruno, Matthew, and Anna Nikolaeva. 2020. “Towards a Maintenance-Based Approach to Mode Shift: Comparing Two Cases of Dutch Cycling Policy Using Social Practice Theory.” Journal of Transport Geography 86:102772. doi: 10.1016/j.jtrangeo.2020.102772.

Cervero, Robert, Benjamin Caldwell, and Jesus Cuellar. 2013. “Bike-and-Ride: Build It and They Will Come.” Journal of Public Transportation 16(4). doi: http://doi.org/10.5038/2375-0901.16.4.5.

Cox, Peter, and Till Koglin, eds. 2019. The Politics of Cycling Infrastructure: Spaces and (in)Equality. 1st ed. Policy Press.

Gartner, Candice. 2016. “The Science and Politics of Infrastructure Research: Asserting Power, Place, and Agency in Infrastructure Knowledge.” Journal of Human Development and Capabilities 17(3):377–96. doi: 10.1080/19452829.2016.1198309.

Melody Lynn Hoffmann, and A. Lugo. 2014. Who Is ” World Class ”? Transportation Justice and Bicycle Policy Adonia Lugo. Urbanities 4, no. 1: 45–61.

Norton, Peter D. 2011. Fighting Traffic: The Dawn of the Motor Age in the American City. 1. paperback ed. Cambridge, Mass.: MIT Press.

Oldenziel, Ruth, and Adri Albert de la Bruhèze. 2011. “Contested Spaces.” Transfers 1(2):29–49. doi: 10.3167/trans.2011.010203.

Oldenziel, Ruth, Martin Emanuel, A. A. Albert de la Bruheze, and Frank Veraart. 2016. Cycling Cities: The European Experience. Hundred Years Policy and Practice. Www.Cyclingcities.Info.

Petzer, Brett J. M., Anna J. Wieczorek, and Geert P. J. Verbong. 2021. “The Legal Street: A Scarcity Approach to Urban Open Space in Mobility Transitions.” Urban Transformations 3(1):3. doi: 10.1186/s42854-021-00018-0.

Cycling Paradise or Cycling Compromise? Experimental Niches and Historical Mobility Campaigning in the Netherlands

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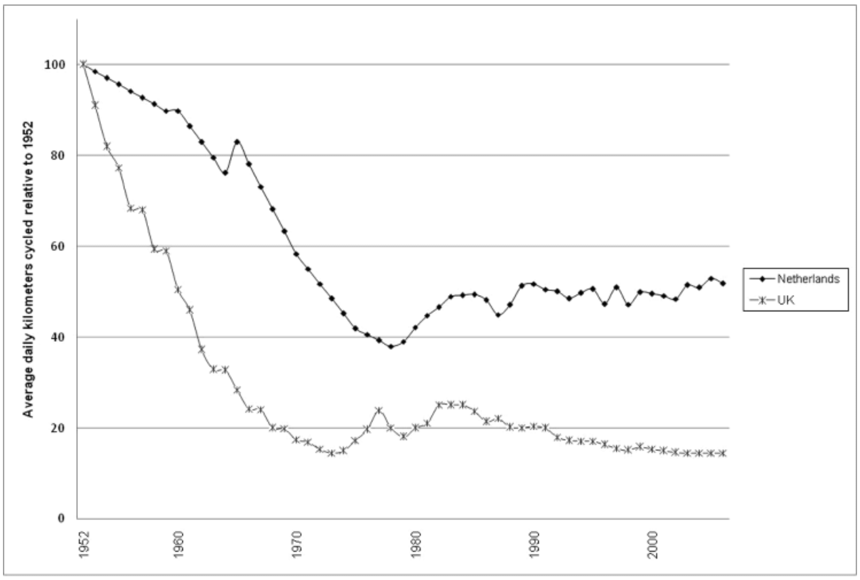
Abstract

The Netherlands exists in both popular culture and academic literature as a common shorthand for a “cycling paradise” – however, the historical development of the Netherlands into such a state is poorly understood, likewise, the base assumptions and implied meaning inherent to the words “cycling paradise” remain largely unchallenged. A notable example of literature holding up the Netherlands as a positive case of cycling development is Pucher and Buehler's 2008 paper “Making Cycling Irresistible” – a paper which, notably, also provides a counterpoint to the “cycling paradise” narrative in a graph, reproduced as Afbeelding 1 below, which indicates that the Netherlands experienced a similar steep decline to the United Kingdom (a nation generally not considered synonymous with “cycling paradise” discourse), with a partial rebound through the 1980s, followed by a period of stagnation.

This project seeks to adopt and potentially build upon the framework of Savini and Bertolini, 2019, in understanding Dutch cycling as an “experimental niche” in order to assess the impact of various social movements (most notably, Stop De Kindermoord) in driving the evolution of the niche and the outcomes thereof, and in particular the factors behind the lack of a full rebound to historical cycling rates, as indexed to 1952. The project seeks to combine empirical measurements and simulation with interview and (auto)ethnographic work in order to investigate the evolution of cycling in the Netherlands between 1970 and 1990, the peak years and aftermath period of the above-mentioned campaigning.



Sources: Department for Transport (2007); Netherlands Ministry of Transport (2007)

Figure 1. Graph from "Making Cycling Irresistible"- Pucher & Buehler, 2008

References

Pucher, John; Buehler, Ralph; “Making Cycling Irresistible” (2008) http://dx.doi.org/10.1080/01441640701806612.

Savini, Federico; Bertolini, Luca; “Urban Experimentation as a Politics of Niches” (2019) https://doi.org/10.1177/0308518X19826085.

Afbeelding 1: Graph from "Making Cycling Irresistible"- Pucher & Buehler, 2008.

Exploring Contextual Challenges of Cycling Planning in a Car-Centric Environment

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Abstract

The bicycle is emerging as a simple tool that plays an effective role in addressing complex urban challenges and transforming various aspects of our urban life. It can take over short trips, combine with public transportation for long trips, alleviate many environmental problems, promote individual and social community health, improve human relationships and social ties, build socio-cultural identities with others and places, and play a leading role in creating human-centered cities.

Despite these obvious benefits, planning for cycling in car-oriented environments is politically contentious and presents several contextual challenges. Tehran, as a car-dominated city, has experienced ups and downs in urban cycling development over the past two decades and faces many challenges in staying on track with a long-term planning process due to a variety of factors.

In 2017, a new round of infrastructure development for this mode of transportation began with the preparation of Bicycle Masterplan Tehran (BMT), a five-year plan for cycling, which brought progress in transforming our urban mobility system. According to the master plan, the required approaches and measures are defined in three dimensions: Hardware, Software, and Orgware. All three aspects have been defined as closely related and must work hand in hand.

The hardware part includes the construction of safe bike lanes, safe intersections, bike parking, etc., usually known as "hard infrastructure." The software part includes training, education and communication, awareness raising, public events, breaking down mental barriers, etc., known in the cycling literature as "human infrastructure," and the orgware part also includes budgeting, traffic regulation, involvement of relevant stakeholders, inter-organizational coordination, etc.

On the way to developing and promoting cycling in Tehran in this period of time, various contextual challenges have arisen related to these three aspects, but also to other aspects such as political discourse, urban planning discourse, social and cultural norms, etc., which slow down the development process. Unfortunately, with the coming to power of a rival political party, the bicycle development process has been stopped by the government and urban organizations, and a new stagnation period has started in 2021. There is an urgent need for exploring the challenges of our cycling planning and policies.

While the slogans of municipal policies in the previous era were *"inclusive city"*, *"Tehran, a city for all"*, and *"people-centered city"*, in the new era, the slogans of the *"parking building movement"* and the *"highway movement"* are being raised, and car-centered development is once again the focus of city management. Nevertheless, grassroots movements and cycling activists continue to advocate for cycling through community-led initiatives.

Our study seeks to discuss socio-political processes and address the main challenges that have contributed to critical tensions in cycling planning in this car-centric environment and attempts to identify processes that have been growing nevertheless from the bottom-up practices. Failure to take cycling seriously as a reliable mode of transportation, dominance of the car-oriented planning paradigm, contradictions in planning discourses, short-term project-driven approaches, insufficient attention to human infrastructure and community engagement, poor hard infrastructure with "build it and they will come" logic, lack of awareness and education, top-down bureaucratic leadership, lack of institutional collaboration in cross-cutting areas, gender gap in bicycle planning, political trends in policymaking, and lack of project monitoring and evaluation will be among the key issues we will discuss.

The intersection of the bicycle with various environmental, social, cultural, economic, and political dimensions makes cycling planning a complicated process, especially in car-dominated cities. The purpose of our work is to provide an overview and classify the socio-political processes and the real-world challenges involved in cycling development in a car-centric environment, and how small steps are being taken despite the top-down impasse on cycling development.

Leapfrogging socio-technical change: short cuts to a cycling city

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Keywords
Cycling, measures, intervention, technological determinism, alternatives

Challenge Addressed / Research Problem Investigated

How can cities advance their ambition to become a cycling city, especially if their existing cycling infrastructure lags behind the standards of better resourced and established cycling cities?

Abstract

With this paper, I seek to broaden existing conceptions of the evolution of urban cycling in order to unveil alternative avenues for the pursuit of socio-technical transitions towards cycling friendly cities.

Suitable cycling infrastructure plays an important role in the provision of better conditions for urban cyclists. Cycling infrastructure is also viewed as a decisive leverage to advance the share of cycling in urban mobility patterns. Especially environments with low cycling uptake it is argued that separation from motorized traffic is crucial in order to make urban cycling more attractive to risk averse residents who abstain from cycling due to safety concerns. The argument extends to higher efficiency of dedicated cycling infrastructure allowing its users to shorten travel time and thereby add to the appeal of urban cycling.

Leading cycling cities, which already enjoy the privilege of high-quality cycling infrastructure, now pursue strategies that seek to take cyclists back to the streets. The logic of this strategy argues that the next step in the evolution of urban cycling is to (re-)claim spaces reserved for motorists. Ultimately, the goal is to priorities cyclists over motorists by pushing against the dominance of the latter over the use of urban mobility infrastructure.

The decisive question, this paper asks is: Do we need to accept this evolution? Is it an indispensable first step of pro-cycling policies to start with the creation of dedicated cycling infrastructure that separates motorists from cyclists (for safety reasons)? Is this first step a precondition for a subsequent shift to a policy that promotes rejoining cyclists with motorists after cycling participation has risen to higher levels? In other words, the question arises, if there is a short-cut to the long and expensive progression towards truly cycling friendly cities. Is it necessary to build this entire cycling infrastructure only to remove it later on, once the share of cyclists has risen to higher levels?

Against the backdrop of the wider ambition of contributing to deliberate socio-technical change towards cycling friendly cities, I suggest that a short cut may be possible (at least to some degree).

Based on an empirical case study, I draw on the example of a city that has enjoyed a considerable increase of urban cycling with a relatively low share of separated bicycle infrastructure (exclusively dedicated to cyclists). The municipality pursued an alternative strategy by introducing a comprehensive speed limit of 30kmh already more than thirty years ago. Such an introduction of a comprehensive speed limit favors shared road space over separation and thus advance the safety of a joint use of urban streets.

With its much earlier introduction of the comprehensive speed limit, Graz is an anomaly in the progression of cycling policies. Advanced cycling cities discuss the introduction of a comprehensive speed limit only now after they have achieved sublime levels of urban cycling. The Graz-anomaly proves however, that **leapfrogging** in the evolution to cycling cities may be possible indeed.

To be sure, this paper does not argue against the need of dedicated cycling infrastructure. Yet, a deeper understanding of processes of socio-technical change towards cycling friendly urban environments may open up more avenues for the pursuit of pro-cycling policies. Rethinking accustomed assumptions of the arduous evolution towards cycling friendly cities may boost the morale of those who live in places with low shares of cycling in the modal split.

Cycling policies come to the fore that do not assume sublime cycling infrastructure or high levels of urban cycling as a precondition for effective measures that make urban cycling a safer and more enjoyable experience.

METHODS

Using a case study approach, this paper draws on an empirical reconstruction of cycling policies from the 1970s to date. This analysis of policy documents will be complemented with a documentation of actually implemented measures to provide a thorough understanding of the existing cycling infrastructure and how it evolved over time. Modal split data will be used to understand the role of pro-cycling measures in the uptake of urban cycling. The analysis will be complemented with existing literature on the evolution of cycling friendly cities and the role of the (policy) measures they implemented.

References

Bijker, W.E., 1995. Of Bicycles, Bakelites, and Bulbs. Toward a Theory of Sociotechnical Change. MIT Press, Cambridge and London.

Björkman, L., Harris, A., 2018. Engineering cities: mediating materialities, infrastructural imaginaries and shifting regimes of urban expertise: engineering cities. Int. J. Urban Reg. Res. 42 (2), 244–262. https://doi.org/10.1111/1468-2427.12528.

Dufour, D., 2010. PRESTO Cycling Policy Guide. Cycling Infrastructure. European Commission, Brussels.

Gartler, K., Hierzegger, H., Scüsz, I., Zcilincsar, W., 1977. Grundlagen zum Stadtentwicklungskonzept Graz. Naturraum – Besiedelung – Bevölkerung, 1. ed, STEK Graz. Magistrat der Stadt Graz – Stadtplanungsamt, Graz.

Geels, F.W., 2011. The multi-level perspective on sustainability transitions: responses to seven criticisms. Environ. Innov. Soc. Transit. 1 (1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002.

Golbuff, L., Aldred, R., 2011. Cycling Policy in the UK. A Historical and Thematic Overview. University of East London, London.

Klinger, T., Lanzendorf, M., 2016. Moving between mobility cultures: what affects the travel behavior of new residents? Transportation 43 (2), 243–271. https://doi.org/10.1007/s11116-014-9574-x.

Koller, K., Luser, H., Sammer, G., 1987. Gesamtverkehrskonzept für Graz. Verkehrspolitische Leitlinien und generelles Maßnahmenkonzept. STEK Graz. dbv-Verlag der TU Graz, Graz.

Köstenberger, H., Lackner, H., Sammer, G., Fallast, K., 1980. Sachprogramm Verkehr. Fuß- und Radwegenetz. Diskussionsentwurf 1980. STEK Graz. dbv-Verlag der TU Graz, Graz.

OECD, 2004. National Policies to Promoed Cycling. Implementing Sustainable Urban Travel Policies: Moving Ahead. OECD Publications Service, Paris.

Oldenziel, R., Emanuel, M., de la Bruhèze, A.A., Veraart, F. (Eds.), 2016. Cycling Cities: The European Experience; Hundred Years of Policy and Practice. Foundation for the History of Technology, Eindhoven.

Rogl, J., Benedikt, E.M., Inninger, B., Marinecs-Bertović, N., 2011. Stadtentwicklungskonzept Graz. Entwurf 2010/2011, STEK Graz. Magistrat der Stadt Graz – Stadtplanungsamt, Graz.

Röschel, G., 2019. Mobilitätsverhalten. Mobilitätserhebung der Wohnbevölkerung 2018.

RoSPA, 2017. RoSPA Policy Paper. Cycling. The Royal Society for the Prevention of Accidents, Birmingham.

Sammer, G., Baier, H., 1976. Diskussionsentwurf Innerstädtisches Verkehrskonzept. Sofortmaßnahmen, 1. ed, STEK Graz. Magistrat der Stadt Graz – Stadtplanungsamt, Graz.

Cycling promotion using financial incentives: A case study in São Paulo, Brazil

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Keywords
Cycling Promotion, Financial Incentives, Mobility Data Justice, Smart Cities, Urban Computing

Challenge Addressed / Research Problem Investigated
This research aims to design a financial incentive-based policy for cycling promotion, offering insights for the development of sustainable urban mobility strategies in car-centric cities.

Abstract
INTRODUCTION

The promotion of cycling as a mode of transportation has been recognized as a key strategy for achieving sustainable urban mobility and improving public health. Regardless, cycling remains a marginal mode of transport in many cities around the world. In São Paulo, Brazil's largest city with more than 12 million inhabitants and 28 million trips daily, only 0.8% of all trips were made by bicycle in 2017 (Metrô São Paulo, 2017). This is far below the potential demand for cycling estimated at 17% by our research group in a recent study (Freire et al., 2023). Despite the expansion of the cycling network from 5.8 km before 2007 to 722 km in 2023 (CET, 2023; City Hall of São Paulo, 2020), the desired related increase in bike trips has not been achieved. In response to this challenge, São Paulo's City Hall approved the Bike SP Program in 2016 (Municipal legislation, 2016), an innovative legislation aimed at encouraging cycling by granting mobility credits to individuals who utilize bicycles as a means of transportation. In the literature, personal economic incentives have been demonstrated to be successful in promoting several health-related behaviors, including smoking cessation, weight loss, physical activity, and vaccination (Kane et al., 2004; Mantzari et al., 2015; Vlaev et al., 2019).

However, the use of financial incentives to promote cycling as a mode of transportation on a large scale in a metropolis is still relatively rare and under-researched.

This lack of relevant large-scale precedents and scientific studies hampered the operationalization of the Bike SP Program. In response, we are designing, conducting, and evaluating a pilot research project in collaboration with municipal agencies and cycle mobility experts. This paper focuses on the design stage of the pilot. Across all stages, we adopt a multidisciplinary approach that combines data science and experimental modeling techniques with social science concepts on mobility data justice and cycling cities. The overall aim of the pilot is to reach a deeper understanding of the complex dynamics between financial incentives, cycling behavior, urban context, and social justice to inform the policy process of upscaling and wider implementation of the Bike SP program in São Paulo.

The objectives of the overall study are to: (1) evaluate the impact of the Bike SP program on the volume of bicycle trips made in São Paulo; (2) estimate the price elasticity of the Bike SP program, i.e., how the bicycle travel demand responds to different remuneration levels; (3) identify the demographic and socioeconomic profiles and the regions of the city that are most responsive to the Bike SP program and should be prioritized for policy targeting; and (4) consider the social justice implications at design, implementation, and evaluation stages. This paper discusses how these objectives can be addressed in the pilot's design phase.

RESULTS OF THE DESIGN PHASE

The design phase takes place in spring-autumn 2023, with a view toward implementing a six-month pilot with 600 to 900 participants from late 2023 to early 2024. We report initial findings and insights from this stage, specifically around the following four areas.

Considering a social justice perspective: The pilot project's recruitment strategy and selection criteria will take into account demographic factors, income disparities, access to cycling infrastructure, and other elements, with an attempt to balance these aspects among participants. This is informed by the five factors identified by Cycling Cities (Oldenziel et al., 2016) and the mobility data justice framework (Behrendt & Sheller, 2023). This framework will be applied in the pilot design to prevent any unintended biases in our data collection and analysis and to ensure that our outcomes do not inadvertently reinforce social injustices.

Defining implementation variables: Regarding the pilot's structure, one of the setups under consideration is that we will divide the six-month pilot into three periods of two months each. In the first period, the participants will be randomly assigned to one of three groups: (1) control group - which receives no financial incentive for cycling, (2) low incentive group – which receives a fixed amount of mobility credits for each kilometer traveled by bicycle, and (3) high incentive group - which receives a higher amount of mobility credits for each kilometer. The amounts that each group receives will change at the beginning of every two-month period.

Mobile app development: We developed a mobile application[1] so that participants can register their cycling trips during the pilot. The data gathered with the app will be used to compensate users and provide input for the evaluation phase.

Setting up the evaluation: We set up the evaluation phase, to assess how financial incentives affect citizens' riding habits, what the social justice implications are, and to weigh the costs and benefits of the Bike SP Program. We will use data from the pilot project to measure changes in cycling frequency, duration, distance, and mode choice among participants in different socioeconomic and demographic categories. We will also employ data from surveys gathered during the program to measure changes in perceptions, attitudes, and preferences regarding cycling before and after the pilot. The results across groups will be compared using appropriate statistical techniques to test for differences and causal effects. Qualitative observations by the researchers will also be recorded. The cycling cities and mobility data justice framework will be used to identify further challenges and opportunities for scaling up the pilot.

CONCLUSION

This study seeks to enhance our understanding of the connections between financial incentives, cycling behavior, and social justice, thereby supporting the development of inclusive and effective policies for sustainable urban mobility not only in São Paulo but also providing valuable perspectives for cycling research in the Global South. This way, the findings from this research aim to provide practical lessons for urban planners, policymakers, and researchers intending to increase cycling modal share in similar contexts worldwide, as well as serve as a model for addressing the challenges faced by other cities characterized by a car-centric culture. By participating in CRBAM23, we hope to gain valuable insights and knowledge from other researchers in the field of cycling research and contribute to the advancement of cycling promotion strategies.

References

Behrendt, F., & Sheller, M. (2023). Mobility data justice. *Mobilities*, *0*(0), 1–19.
https://doi.org/10.1080/17450101.2023.2200148.
CET, C. de E. de T. (2023). *Mapa de Infraestrutura Cicloviária*.
http://www.cetsp.com.br/consultas/bicicleta/mapa-de-infraestrutura-cicloviaria.aspx
City Hall of São Paulo. (2020). *O uso da bicicleta na cidade de São Paulo: Uma comparação dos resultados das pesquisas OD 2007 e 2017*.
https://www.prefeitura.sp.gov.br/cidade/secretarias/upload/Informes_Urbanos/42_IU_ciclistas_2020_final.pdf.
Freire, P. G., Kon, F., Lemos, L. L., & de Souza, H. A. (2023). *The Design and Implementation of a Robust Cycling Potential Index* (SSRN Scholarly Paper 4476082).
https://doi.org/10.2139/ssrn.4476082.

[1] Code available at https://gitlab.com/interscity/bikesp/bikespapp.

Kane, R. L., Johnson, P. E., Town, R. J., & Butler, M. (2004). A structured review of the effect of economic incentives on consumers' preventive behavior. *American Journal of Preventive Medicine*, *27*(4), 327–352. https://doi.org/10.1016/j.amepre.2004.07.002.
Mantzari, E., Vogt, F., Shemilt, I., Wei, Y., Higgins, J. P. T., & Marteau, T. M. (2015). Personal financial incentives for changing habitual health-related behaviors: A systematic review and meta-analysis. *Preventive Medicine*, *75*, 75–85.
https://doi.org/10.1016/j.ypmed.2015.03.001.
Metrô São Paulo. (2017). *Pesquisa Origem e Destino | Portal da Transparência*.
https://transparencia.metrosp.com.br/dataset/pesquisa-origem-e-destino
Municipal legislation. (2016). *Lei Nº 16.547—Institui o Programa Bike SP no âmbito do Município de São Paulo*.
https://legislacao.prefeitura.sp.gov.br/leis/lei-16547-de-21-de-setembro-de-2016

Oldenziel, R., Emanuel, M., Albert de la Bruheze, A. A., & Veraart, F. (2016). *Cycling Cities: The European Experience. Hundred Years Policy and Practice. www.cyclingcities.info*.

Vlaev, I., King, D., Darzi, A., & Dolan, P. (2019). Changing health behaviors using financial incentives: A review from behavioral economics. *BMC Public Health*, *19*(1), 1059.
https://doi.org/10.1186/s12889-019-7407-8.

Bicycle commuting as a tool for equity advancement in Diepsloot township in Johannesburg

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Keywords
Bicycle riders, transport justice, ethnographic analysis, township

Challenge Addressed / Research Problem Investigated
Bicycle mobility contribution to advancing mobility and transport justice in a disadvantaged neighbourhood.

Abstract
This paper investigates to what extent bicycle mobility contributes to advancing mobility and transport justice in Diepsloot, a township in the Johannesburg metropolitan area. In this challenging context, characterized by informal and partially illegal settlements with a high density of immigrant workers, the paper analyzes through what strategies different actors negotiate the township's transportation issue, what the role of cycling is among the available transport supply and how township bicycle riders can be supported to improve their mobility practices. Framing the topic in the debate on transport related social exclusion and outlining how cycling has a varying potential to be both an emancipatory and a forced practice, the paper introduces the findings of an ethnographic analysis carried out through surveys, interviews and travel-along research, of the needs and constraints of bike commuters in Diepsloot, and proposes some integrated policy measures for contrasting spatial segregation in the township.

Urban Cycling and Mobility Cultures in Transition – A Berlin Case Study

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Keywords
Mobility Cultures, Urban Cycling, Cycling Cultures, Berlin, Radbahn Berlin

Challenge Addressed / Research Problem Investigated
Understanding transitions in urban cycling and mobility cultures and bridging the gaps between cycling initiatives, planning and research.

Abstract
The media and politicians are increasingly talking about a culture war in the transport sector involving fundamental negotiations such as the question "Who owns the street?". One of the central agreed objectives is to make transport sustainable and to decouple it from its harmful effects on the environment and society, while maintaining people's mobility as a means of their social participation at the same time (SenUVK 2021; Schwedes & Rammert 2020; Umweltbundesamt 2019). But even if the call for more sustainability in mobility is getting louder and louder, both politically and in terms of everyday life, the concept of culture has so far been severely neglected within transport planning and politics. However, the topic is of central importance, because culture is the connecting element of different areas of society and can act both as a driver and as an obstacle to a traffic turnaround (Hoor 2023).

In an urban setting, cycling is regarded as a beacon of hope for sustainable transport development. In many places, cycling is drawing attention to itself through rapid growth figures, lifestyle trends and cycling policy demands – while it also shows aspects of social exclusion and gentrification (Hudde 2022; Buehler & Pucher 2021). Urban initiatives, scenes and subcultures are central actors who promote the social normalization of cycling and enrich it with new everyday practices and attributions of meaning (Hoor 2020; Vivanco 2013; Furness 2010): cycling and the bicycle are becoming the means of distinction and lifestyle for many urbanites. This goes hand in hand with changed ideas about good urban coexistence, which in turn is used by politics, planning and commercial enterprises as an economic productive force (Spinney 2021). Nevertheless, in relation to the hegemonic automotive culture, cycling remains a subordinate, critical practice that struggles for urban space as well as political and planning status. Urban cycling shows that culture could move from being a blind spot to becoming an important dimension in transport policy and planning – a cultural perspective on mobility and transport is therefore essential.

To address this desideratum, I worked in a deeply interdisciplinary and transdisciplinary manner and brought together theories and working methods from cultural studies, mobilities research, and transport planning. Empirically, I investigated urban cycling cultures in Berlin, such as local cycling research and planning, cycling policy initiatives. I also looked at different scenes and subcultures that have emerged from a sports and lifestyle context, such as the

fixed-gear and the gravel scene. I examined these case studies in a multi-method approach based on cultural studies and ethnography: participatory observation, systematic reflections and introspections, media analysis and qualitative interviews with actors in the field being the central survey methods (Barker & Jane 2016; Breidenstein et al. 2015; Ege 2013; Lindner 2010).

Bicycle initiatives are to be considered as one of the central instances that make an important contribution to the traffic turnaround and show ideas and ways of sustainable traffic development. Building on this, I will focus on one specific case study in Berlin, examining the role of imaginations in cycling policy initiatives of Radbahn Berlin and Volksentscheid Fahrrad. Both projects show specific visions of the future, in which the bicycle functions as a central subject of negotiation on questions of mobility and the good life. It's about riding safely and comfortably through the city, replacing the car and pushing forward ideas of a city worth living in.

In this respect, both projects have helped shape the discourse around mobility and urban development as well as politics in recent years: At the end of 2015, the architectural renderings of the Radbahn Berlin triggered discussions by appealing to the emotional and symbolic aspects of urban cycling and projected a visionary place of longing within a specific urban landscape. Almost at the same time, in 2016, the bicycle referendum of the Volksentscheid Fahrrad succeeded in a major effort and completely turned around Berlin's bicycle policies. This was achieved through a changed understanding of planning – in which a comprehensive, safe and comfortable cycling infrastructure was required – as well as through classic measures of social movements and citizen participation, such as local networks, demonstrations, vigils, public campaigns and direct democracy. This laid the foundation for the Berlin Mobility Law which was passed in 2018 and a cycling infrastructure program worth one billion Euros (von Schneidemesser 2023).

Finally, I will discuss derivations and recommendations for action for the promotion of cycling, (cycling) traffic planning and the change in mobility cultures on the way to the traffic turnaround. My results indicate that the connection between cultural studies research and mobilities and transport research is very fruitful and allows new strategic perspectives on inclusive cycling planning, politics and promotion. This would enable us to better prepare Berlin and other cities for future needs and to implement sustainable urban and transport planning.

References

Barker, Chris & Emma A. Jane (2016): Cultural Studies. Theory and Practice. SAGE, Los Angeles u.a.

Breidenstein, Georg, Stefan Hirschauer, Herbert Kalkhoff & Boris Nieswand (2015): Ethnografie. Die Praxis der Feldforschung. UVK, Konstanz & München.

Buehler, Ralph & John Pucher (2021): Cycling for Sustainable Cities. The MIT Press, Cambridge & London.

Ege, Moritz (2013): Ein Proll mit Klasse: Mode, Popkultur und soziale Ungleichheiten unter jungen Männern in Berlin. Campus, Frankfurt am Main.

Furness, Zack (2010): One Less Car. Bicycling and the Politics of Automobility. Philadelphia, Temple Press

Hudde, Ansgar (2022): The unequal cycling boom in Germany. Journal of Transport Geography 98.

Hoor, Maximilian (2023): Public Mobility and a New Mobility Culture: Foundations, Developments and Paths to a Cultural Transport Turnaround. In: Schwedes, Oliver (Hrsg.): Public Mobility. Prerequisites for human-oriented transport planning. Springer VS, Wiesbaden.

Hoor, Maximilian (2020): The bicycle as a symbol of lifestyle, status and distinction. A cultural studies analysis of urban cycling (sub)cultures in Berlin. Applied Mobilities.

Lindner, Rolf (2000): Die Stunde der Cultural Studies. Universitätsverlag Wien, Wien.

Schwedes, Oliver & Alexander Rammert (2020): Was ist Integrierte Verkehrsplanung. Hintergründe und Perspektiven einer am Menschen orientierten Planung. IVP Discussion Paper 15, Berlin.

Senatsverwaltung Umwelt, Verkehr und Klimaschutz (SenUVK) (2021): Stadtentwicklungsplan Mobilität und Verkehr Berlin 2030. Maßnahmenkatalog. SenUVK, Berlin.

Spinney, Justin (2021): Understanding Urban Cycling. Exploring the Relationship Between Mobility, Sustainability and Capital. Routledge, London.

Umweltbundesamt (2019): Veränderungen im Mobilitätsverhalten zur Förderung einer nachhaltigen Mobilität. Abschlussbericht. Umweltbundesamt, Dessau-Roßlau.

Vicanco, Luis (2013): Reconsidering the Bicycle': An Anthropological Perspective on a New (Old) Thing. London and New York, Routledge.

von Schneidemesser, Dirk (2023): Public Mobility and New Forms of Governance: The Example of the Berlin Bicycle Referendum. In: Schwedes, Oliver (eds.): Public Mobility. Springer VS, Wiesbaden, p. 125-147.

Towards A Sustainable Transport System: Exploring Capacity Building Needs for Active Travel In Africa.

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Keywords
Capacity building, active travel, sustainability, participatory GIS

Challenge Addressed / Research Problem Investigated
What does capacity building mean for Africa's transport in the context of active travel?

Abstract
The promotion of active travel is deemed a crucial component of transitioning to sustainable urban mobility. However, many barriers thwart policy implementation and uptake. Some evidence suggests that capacity building could be a useful tool for deepening sustainability efforts, but a clear framework for understanding the dimensions of capacity building for active travel is lacking. Furthermore, most research and findings use cases within a Global North context, constricting implications and transferability to the Global South, especially African cities. This paper responds to the dearth of scholarly work exploring Global South cases and fills a gap in knowledge regarding capacity building in the case of active travel.

Through a literature review, this study examines the dimensions of capacity building necessary to improve active travel in African cities. We focus on multilevel transportation governance, with highlights from five (5) African cities. Our findings suggest that the literature and policies on transport in Africa have key dimensions for capacity building for active travel but lack the introduction of key instruments and strategic pathways to meet these requirements for improved sustainable mobility. We propose a guiding framework for integrating capacity-building for active travel policies and implementation.

Representing Urban Cycling

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Keywords
cycling, representation, governance

Challenge Addressed / Research Problem Investigated

Fundamental mobility change is constraint by dominant cycling representations.

Abstract

Cycling's multiple co-benefits (e.g. emission-free, healthy, socio-economic advantageous) are evidenced broadly in research and practice. Infrastructural and regulatory measures that make for safer, more just, and seamless cycling from the street-level to urban environments are furthermore well described. Acknowledging cycling, decision-makers, and planners on various levels express ambitions, develop plans, policies, and programs to move away from motorized individual transport and strengthen 'sustainable' forms of urban mobility. Yet, cycling levels in most urban areas are negligible and progress in advancing cycling is slow. In this talk we step back to re-investigate cycling's 'implementation gap' (Banister & Hickman 2013).

The way we think, talk, write about, and enact cycling –the way it is represented– has implications on how cycling is governed and how cycling futures are envisioned and approached (e.g. te Brömmelstroet et al. 2022). Vice versa, how cycling is governed –how it is acted on and for– affects its representations. We suggest that the notion of 'representation' (Hall 1997) offers insight into why progress in transforming urban mobility is hampered. In addition to narrative or discursive approaches, we explore the notion of representation to capture cycling as embodied practices, the (im)mobile person as practice performers, (bi)cycles and cycling infrastructure as semiotic artefacts. We see storylines, narratives and discourses on mobility and cycling interwoven with representations. In this talk, we employ the concept to explore the relations between cycling and its governance. Two aims guide our investigation: First, to explore *how* cycling representations are entwined with governance. Second, to explore how alternative or subjugated cycling representations might leverage and engender transformative governance processes. Far from exhaustive, we selected three 'channels' through which representations circulate: research (Valentini et al. 2023), municipal planning, and grassroots initiatives (Valentini & Butler 2023).

From a research perspective, we chose the field of sustainability transitions for its change-oriented, socio-material conceptualization of systems to review scholarly engagements with urban cycling. We found that transitions research has so far largely focused on technological cycling innovations, representing cycling as a service and cycles as electrified vehicles. Advances to investigate existing governance arrangements and their underlying suppositions and rationales about the (future) role of cycling in mobility systems are rare (e.g. Sengers 2017). We further find that the roles actors on the fringes of established governance regimes can

(and could) play to reposition cycling in urban mobility systems deserves more scholarly attention.

From a municipal planning perspective, we explore cycling representations in Uppsala (Sweden). We show how the municipality constructs cycling in policy and planning documents as an urban 'success' that is supported by a strong cycling culture and 'sufficient' but improvable cycling conditions. Mirroring an already strong position of cycling in Uppsala, planning emphasizes incremental infrastructure upgrades, maintenance, management and behavioral measures to maintain, rather than advance cycling. From actors' perspectives, citizens' input through error reports and surveys, as well as an advocacy organization's evaluations of municipal cycling promotion provide important epistemic indicators to represent cycling and 'cyclists'. Jointly, varied representations guided Uppsala to achieve national recognition as a progressive cycling-promoting municipality while only marginally challenging automobility, spatial and social mobility injustices.

Lastly, we foreground alternative cycling representations observed in a local sustainability initiative. In Bike Kitchens, a material perspective on (bi)cycles to govern cycling can be observed. Community self-repair workshops (Bike Kitchens) govern cycling's quality and safety by engendering assisted cycle self-repair, with implication for how cycling in conjunction with repair is represented as a sustainable and sufficient social practice. The cycle becomes more than a vehicle; an entity of care, affection, and socialization (Abord de Chatillon 2022).

Jointly, the foregrounded representations exemplify how cycling is acted *on*, seldomly acted *for*. Fundamental reconsiderations on the role of mobility and cycling are needed to foster more diverse cycling imaginaries. The governance *for* cycling, we suggestively conclude, depends on how we conceive of cycling and represent its multiplicity. For instance, cycles as more than mere transport vehicles. Cycling as numerous signifying practices beyond recreation and utility (e.g. care, service, wellbeing). People as not only (potential) cyclists or non-cyclists, but as people with needs and values that reflect in their practices. Previous research has pointed towards the importance of "identifying, nurturing and empowering alternative mobility narratives" (te Brömmelstroet et al. 2022). We add that narrative seeds find fertile ground in the cracks of dominant mobility narratives, where cycling is already experienced and embodied differently. More practice-oriented, transdisciplinary research incorporating, but also questioning, the meaning of cycling and its governance is needed (e.g. Mock 2023; Barry et al 2022; Gössling 2023). Particularly the intersection between cycling's semiotic representations connecting to the meaning of other social practices suggest promising avenues.

References

Abord de Chatillon, M. (2022) Appropriating the Bicycle: Repair and Maintenance Skills and the Bicycle-Cyclist Relationship. In: Adam M and Ortar N (eds.) *Becoming Urban Cyclists*. Chester: Chester University press, pp. 215–43.

Banister, D., & Hickman, R. (2013) Transport futures: Thinking the unthinkable. *Transport Policy*, 29 (C), 283–293. doi:10.1016/j.tranpol.2012.07.005.

Barry, Southern, J., Baxter, T., Blondin, S., Booker, C., Bowstead, J., Butler, C., Dillon, R., Ferguson, N., Filipska, G., Hieslmair, M., Hunt, L., Ianchenko, A., Johnson, P., Keane, J., Koszolko, M. K., Qualmann, C., Rumsby, C., Oliveira, C. S., Schleser, M., Sodero, S., Soliz, A., Wilson, L. A., Wood, H. & Zinganel, M. (2023) An agenda for creative practice in the new mobilities paradigm. *Mobilities*, 18(3), 349–373. https://doi.org/10.1080/17450101.2022.2136996.

Gössling. (2023) Extending the theoretical grounding of mobilities research: transport psychology perspectives. *Mobilities*,18(2), 167–183. https://doi.org/10.1080/17450101.2022.2092886.

Hall, S. (1997) The Work of Representation. In Hall S. (Ed.), Representation: Cultural Representation and Signifying Practices (pp. 13-58). London: Sage.

Mock, M. (2023) Making and breaking links: the transformative potential of shared mobility from a practice theories perspective. *Mobilities*, 18(3), 374–390. https://doi.org/10.1080/17450101.2022.2142066.

te Brömmelstroet, Mladenović, M. N., Nikolaeva, A., Gaziulusoy, İ., Ferreira, A., Schmidt-Thomé, K., Ritvos, R., Sousa, S., & Bergsma, B. (2022) Identifying, nurturing and empowering alternative mobility narratives. *Journal of Urban Mobility*, 2, 100031–. https://doi.org/10.1016/j.urbmob.2022.100031.

Sengers, F. (2017) Cycling the city, re-imagining the city: Envisioning urban sustainability transitions in Thailand. *Urban Studies* (Edinburgh, Scotland), 54(12), 2763–2779. https://doi.org/10.1177/0042098016652565.

Valentini, D. & Butler, A. (2023) Bike Kitchens and the sociomateriality of practice change: exploring cycling-repair relations, *Urban, Planning and Transport Research*, 11:1, DOI: 10.1080/21650020.2023.2259235.

Valentini, D., Wangel, J. & Holmgren, S. (2023) Representations of urban cycling in sustainability transitions research: a review. *Eur. Transp. Res. Rev.* 15, 28. https://doi.org/10.1186/s12544-023-00603-3.

Shared bike and shared e-scooter: a story of companionship and competition?

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Keywords
Bike sharing, shared e-scooters, mode choice behavior, discrete choice modelling

Challenge Addressed / Research Problem Investigated
Define the relationship between bike and e-scooter sharing systems in regards to their competition in the travel mode choice set.

Abstract
Bike-sharing programs are a frequent mobility service in urban environments. Regardless of their modal split or the trip purposes that they serve, shared bikes are now considered a well-established shared mode in multiple European cities. In the last five years, shared e-scooter schemes have also been introduced.The co-existence of these two systems has raised questions on whether they complement or compete to each other.

Past studies suggest both differences and similarities concerning the trips that the two modes serve (Zamir et al., 2019). Until today, only very few studies, such as the research of van Kuijk's (van Kuijk et al., 2022) and Reck's teams (Reck et al., 2021), have explored the competition between the two shared micromobility alternatives in the mode choice context. The present study aimed at providing further insight into the factors that influence the usage of shared bike and e-scooter schemes and the competition level between them. By exploring how people choose their mode when both shared micromobility schemes are available, the research enriches the existing literature on the competition between these two transport modes.

To analyse the factors that could affect people's decision to travel by shared bikes and shared e-scooters, data on their preferences for the two modes and the conditions that could encourage them to use them are necessary. A survey was developed to collect the necessary data. The survey design aimed at obtaining information on which travel mode characteristics could affect the competition between the two shared micromobility modes and the conditions that could make one of the modes more attractive. The survey entailed questions on respondents' sociodemographic and mobility characteristics. The survey participants also reported their familiarity with shared bikes and e-scooters by indicating how frequently they travell by each mode. A stated preference experiment was added to the survey to collect data on mode choice behaviour when both micromobility modes are available. In the experiment, seven different modes were considered: shared bike, shared e-scooter, public transport, shared car, own bike, own car, and walking. Time components, cost and digitilisation level were the attributes that varied per mode. The attributes' levels were selected so that at least one level coincided with the current value faced during real-life micromobility trips. Each survey respondent faced six different hypothetical scenarios.

The city of Vienna, the capital of Austria, was selected as the case study. Vienna has a cycling modal split of around 8%. In addition, bike and e-scooter sharing systems have been operating in the city since 2003 and 2019, respectively (Moran et al., 2020). Thus, it was assumed that the relationship between the two modes is already well-established and that Vienna is an appropriate study area for this research. Responses to the survey were recorded online during two months (December 2022 -January 2023). In total, 579 people provided a valid, complete survey response.

The data on the usage frequency of the two shared micromobility modes were analysed to identify whether the frequent users of the two modes coincide or diverge regarding sociodemographic characteristics. The degree of competition between the two modes was defined via the estimation of a nested logit model. The findings suggest that bike and e-scooter sharing schemes are competing for the same population group. However, the two modes still differ regarding their particular usage cases.

References

Moran, M., Laa, B., Emberger, G. 2020. Six scooter operators, six maps: Spatial coverage and regulation of micromobility in Vienna, Austria. Case Studies on Transport Policy. Vol 8.

Reck,D., Martin, H., Axhausen, K. 2022. Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. Transportation Research Part D. Vol 102.

Van Kuijk, R., Correira, G., van Oorrt, N., van Arem, B. 2022. Preferences for first and last mile shared mobility between stops and activity locations: A case study of local public transport users in Utrecht, the Netherlands. Transportation Research Part A: Policy and Practice. Vol 166.

Which road safety-related factors influence users' acceptance towards Smart e-bikes: A European based survey

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Keywords
Cycling safety, E-bikes, UTAUT2, User acceptance, SEM

Challenge Addressed / Research Problem Investigated
E-bikes are a great example of a sustainable transport mode, however, the number of crashes is increasing. This work highlights the role of bicycle technologies in improving comfort and safety and attracting more people to cycling.

Abstract
INTRODUCTION
Electric bicycles (e-bikes), an emerging transport mode gaining popularity in recent years, can contribute to reducing emissions and congestion in cities by replacing motor vehicles [1]. However, e-bikes potentially lead to a higher number as well as more severe crashes since they are usually faster and heavier than regular bicycles [2]. E-bike users are facing many crashes worldwide, and many countries are developing or adjusting bicycle infrastructure to address this issue. Recent years have witnessed a growing academic interest in addressing cycling safety issues by adopting new technologies, such as bicycle sensors and the Internet of Things (IoT), to prevent and reduce e-bike crashes [3]. However, research to date has not yet determined users' intention to adopt new bicycle technologies that increase safety and comfort. To address this gap, the aim of this study is twofold: 1) to investigate users acceptance of the smart e-bike by collecting data from e-bike users and people interested in buying an e-bike across five European countries (Austria, Belgium, Germany, Greece, Netherlands) and 2) to examine the role of different safety-related factors such as available cycling infrastructure and perceived safety on people's perception towards the smart e-bike that can enhance cycling safety and comfort. A smart e-bike consists of surrounding detection, collision avoidance, speed warnings and post-accident notifications [4].

METHODOLOGY
In this study, the framework of the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) was adopted [5]. The conceptual model with the constructs is presented in Figure 1. Following the UTAUT2, it is hypothesized that users' intentions to adopt new technologies in e-bikes are related to performance, effort expectancy, social influences and hedonic motivation. In addition, we included 'social status and 'perceived safety' as factors that could affect people's intention. Data used in this survey was collected between November 2022 and January 2023 in Austria, Belgium, Germany, Greece and the Netherlands, targeting people who

already use an e-bike or are willing to buy one. These countries vary in size, cycling infrastructure, cycling rate and cycling safety.

RESULTS AND DISCUSSION

To investigate users' intention to use new technologies on e-bikes, a SEM model was analysed and the path coefficient for the total sample are presented on the Figure 2. Investigating cross-country differences is evidence that performance expectancy has a strong and positive impact on user intention across all countries, while hedonic motivation has no significant impact in the Austrian sample. Additionally, perceived safety positively influences user intention in Belgium, Germany, and Netherlands. Social influence has a stronger relationship and is significant to the Dutch and Austrian responders. Finally, there is no significance on social status construct; this tendency is similar in all five countries. These results are presented in Table 1. This model was also tested with a series of controls against user intention. In this attempt, we controlled our model to gender, age, lack of infrastructure, and perceived cycling safety. Results show that user intention significantly increases with increasing age in all counties except Belgium. Gender significantly impacts user intention in Belgium, while the rest variables are not statistically significant across all countries.

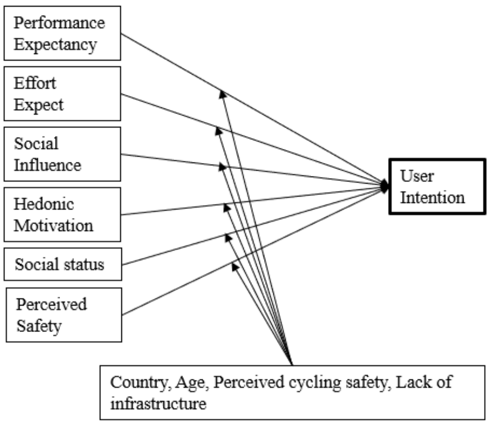

Figure 1. Conceptual model (Extended UTAUT2)

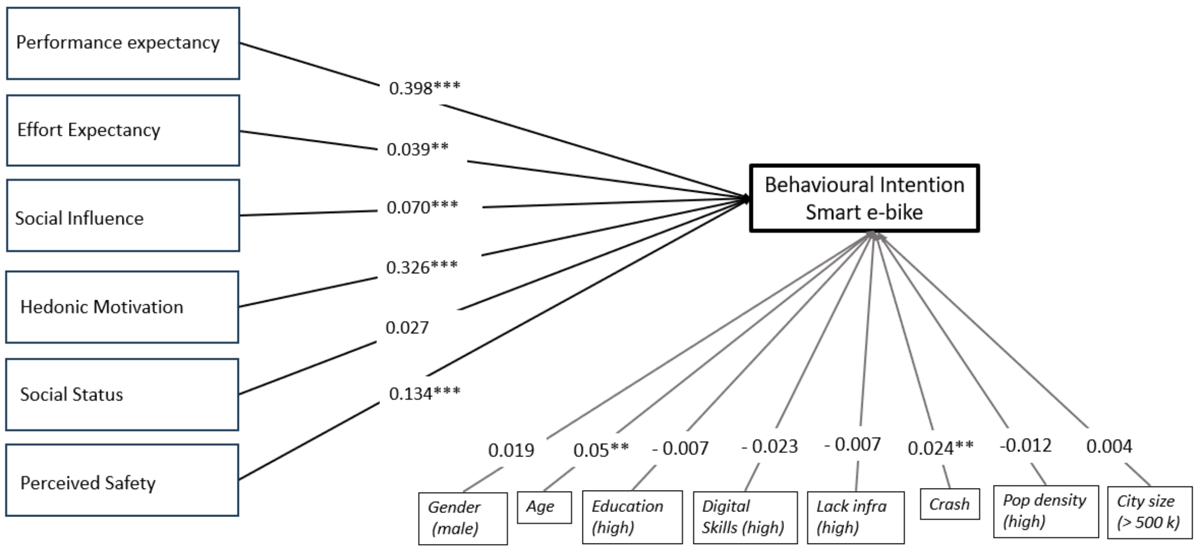

Figure 2: Path coefficient diagram

CONCLUSIONS

This study provides novel results for the user acceptance of new technologies on e-bikes as a potential solution to improve e-bike safety and comfort. Performance expectancy has a higher impact across all countries. The Netherlands shows a high impact on hedonic motivation and social influence, while there is a negative impact and no significance on social status. Perceived safety remains a strong impact in the Netherlands, Belgium and Greece. Additionally, we controlled the model with socio-demographic, infrastructure and safety variables. We found that user intention increases with increasing age in all countries but not in Belgium. However, no significant effects were found for the rest variables.

Table 2. Results of cross-country analysis

Variables	Austria	Belgium	Germany	Greece	Netherlands
Dependent variable: Intention					
Performance expectancy	0.455***	441***	0.461***	0.444***	0.369***
Effort expectancy	0.114	0.026	0.043	0.047	0.050*
Social influence	0.160**	0.004	-0.085	0.069	0.120***
Hedonic motivation	0.113	0.273**	0.284**	0.276***	0.359***
Social status	0.068	0.032	0.099	0.077	-0.016
Perceived safety	0.115	0.190**	0.186**	0.077	0.129***
Age	0.045*	0.027	0.059**	0.069**	0.066***
Gender (male)	0.044	0.044	0.035	- 0.002	- 0.003
Perceived cycling safety (high)	- 0.043	- 0.019	- 0.040	0.051	- 0.027
Lack of cycling infrastructure	0.006	- 0.012	- 0.021	- 0.026	0.007

***: p-value < 0.001, **: p-value < 0.05, *:p-value < 0.1

References

1. Fishman, E. and C. Cherry, *E-bikes in the Mainstream: Reviewing a Decade of Research.* Transport Reviews, 2016. **36**(1): p. 72-91.
2. Panwinkler, T. and C. Holz-Rau, *Causes of pedelec (pedal electric cycle) single accidents and their influence on injury severity.* Accident Analysis and Prevention, 2021. **154**.
3. Oliveira, F., et al., *A survey of technologies and recent developments for sustainable smart cycling.* Sustainability (Switzerland), 2021. **13**(6).
4. Kapousizis, G., et al., *A review of state-of-the-art bicycle technologies affecting cycling safety: level of smartness and technology readiness.* Transport Reviews, 2022: p. 1-23.
5. Venkatesh, V., J.Y.L. Thong, and X. Xu, *Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology.* JSTOR, 2012. **36**: p. 157-178.

User Acceptance of Urban Cargo Bicycles

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Keywords
Cargo Bicycles, Urban Bicycle Infrastructure, User Acceptance, Bicycle Usage Evaluation, User Perspective

Challenge Addressed / Research Problem Investigated

Identify issues and needs for urban cargo bicycle riders

Abstract

The increasing need for sustainable and efficient urban transportation solutions has led to a growing interest in electric cargo bikes. These vehicles offer a promising alternative to traditional delivery methods, as they are environmentally friendly, cost-effective, and can navigate congested urban areas more easily. However, there are reservations regarding the use of electric cargo bikes. On the one hand, this is due to insufficiently planned infrastructure, e.g., bicycle lanes' width and turning radii have historically been designed and planned for conventional bicycles. On the other hand, this is also because cargo bikes are perceived as an evolution of existing conventional bicycles rather than a distinct and novel type of vehicle such as e-scooters (Keler, 2021). Our study aims to identify the advantages and disadvantages of electric cargo bicycles from the users' perspectives. It explores the requirements and potential of electric cargo bikes. The findings indicate clear recommendations for municipalities and cargo bicycle manufacturers to adapt to user acceptance and a more sustainable urban living.

To this end, our study comprises two parts of surveys. Short- and long-term test subjects were provided with cargo bikes, and their subjective and objective data were collected. We first describe the methodology consisting of the selection of test subjects and the data collection. Then, we list first results of the subjective and objective data analyses. In the end, we summarize the findings and discuss future steps to increase the user acceptance of urban cargo bicycles.

A targeted scientific analysis was conducted to achieve the study's objectives. We employed a combination of qualitative and quantitative methods, including surveys, interviews, and field observations (Vogt (2022), Keler (2023), Lindner (2022)). Short-term users were provided with the opportunity to test multiple cargo bikes, after which they were interviewed to gather their initial impressions. Long-term users were equipped with multiple cargo bikes for several months and were surveyed at the beginning, during the testing phase, and at the end. Their position data were recorded and documented throughout the duration of the study. Both subjective and objective data were collected from the test riders. As a result, these surveys were not anonymous. The long-term data collection involved different individuals than those surveyed as short-term users.

Figure 1 shows the available four cargo bicycles by Riese&Müller, Urban Arrow, Butchers&Bicycles (all of which have their transport box in the front), and Cube (which has its transport box in the rear and two degrees of freedom).

Figure 1. Available cargo bicycles during the user study: (a) Riese&Müller Packster 70, (b) Urban Arrow Family, (c) Butchers&Bicycles MK1-E Touring, (d) Cube Dynamic Cargo (prototype)

Short-term Users
- 37 arbitrary participants
- Short test rides with several different cargo bicycles
- Surveys conducted at different locations in downtown Munich
- Subjective data: two-part questionnaire: before and after the test rides

Subjective and Objective Data Acquisition

Long-term Users
- 12 participants
- Access to one cargo bicycle for approx. 2-4 weeks for personal and/or professional use
- After one phase of usage, direct switch to another cargo bicycle
- Extensively test riding of different cargo bicycle models for approx. 2-3 months
- Objective data: ride and position recordings
- Subjective data: three-part questionnaire: before, during and after testing period

The results of the short-term users' survey revealed that nearly 85% of respondents had never ridden a cargo bike before. However, 70% of them expressed willingness to consider using a cargo bike in the future. Both surveys revealed various requirements from both the municipalities responsible for public space and infrastructure, and manufacturers of electric cargo bicycles.

Infrastructure requirements: The most common conflict reported during the rides was the lack of or limited opportunities for overtaking due to narrow bicycle lanes. Furthermore, issues arose with non-lowered curbs when both ascending and descending. The long wheelbase of the cargo bikes made it challenging to maintain stability when going down a step. One drawback of longer bicycles is that demand-controlled traffic lights, which switch to green once a push button is activated, are often challenging to reach. A (long) bicycle needs to be pushed onto the road to activate the signal and then be pulled back, which is not acceptable from a traffic safety perspective. Further, participants often mentioned the challenge of crossing tram tracks. It is crucial to ensure that the front wheel does not slip into the tracks. Therefore, in bicycle network planning, it is important to pay increased attention to ensuring that bike paths do not run parallel to tracks but rather intersect them perpendicularly.

Bicycle hardware requirements: Three of the bikes have their transport box in the front, while only the Cube bike has a rear cargo box. The survey revealed that approximately one-third of respondents preferred the cargo box in the front. The remaining participants preferred the cargo box in the rear to experience a more natural riding behavior. Additional features that were mentioned by the participants included luggage racks, a more practical kickstand, USB charging options for smartphones, and a phone holder. Furthermore, a turn signal was mentioned to facilitate turning, as the bikes with the front cargo box are difficult to steer with one hand (for hand signals). Under snowy and icy conditions, it was reported that the two-wheeled bikes were extremely difficult to steer on slippery surfaces due to their long length, and the bikes frequently slipped. The three-wheeled bikes were perceived as better and more stable in these conditions. However, once, a rain cover froze in the snow. As a result, the zippers became immovable and subsequently broke.

The objective data analysis mainly indicated that bicycle riders prefer appropriate infrastructure (lane width) and separate road networks for motorized vehicles and bicyclists. The research highlighted the positive user acceptance of electric cargo bikes in the urban public street space. Users appreciated the bikes' versatility, ease of use, and ability to navigate through traffic congestion. The study indicates through high user acceptance a predicted modal shift towards electric cargo bicycles. We can therefore expect a potential reduction of traffic congestion, air pollution, and noise levels in urban areas, all well-known objectives of municipalities and citizens. The agile and compact design of these vehicles allows for efficient maneuvering in narrow streets and crowded areas. Moreover, the electric propulsion system provides a sustainable and cost-effective alternative to traditional delivery vehicles, reducing carbon emissions and operating costs. However, challenges such as limited infrastructure, charging facilities, and regulatory frameworks need to be addressed to establish a widely accepted urban cargo bicycle usage. As most important and crucial, we see separate road networks for motorized traffic and cycling without shared spaces.

References

Andreas Keler, Lisa Kessler, Fabian Fehn, and Klaus Bogenberger (2021). Movement patterns of electric cargo bike commuters – first insights from field experiments and trajectory analyses. Proceedings of the ICA, 30th International Cartographic Conference (ICC 2021).

Andreas Keler, Lisa Kessler, Simone Weikl, Johanna Vogt, and Klaus Bogenberger (2023). How does the used vehicle influence the performed manoeuvre? - insights from an active mobility tracking experiment on a test field. 31st International Cartographic Conference (ICC 2023) (accepted).

Johannes Lindner, Lisa Kessler, Andreas Keler, and Klaus Bogenberger (2022). A virtual reality electric cargo bicycle simulator for experiencing realistic traffic scenarios. DSC 2022 Europe VR.

Johanna Vogt, Simone Weikl, Lisa Kessler, Andreas Keler, and Klaus Bogenberger (2022). On the perception of traffic stress – a controlled experiment with pedestrians and bicyclists. 16th International Conference on Travel Behaviour Research.

Sense making by sufficiency? Finding paths for a cultural shift to a cycling society

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Keywords
Culture & Attitude

Challenge Addressed / Research Problem Investigated

The contribution addresses the challenge of turning the current bike-selling boom into a cycling boom. The Goal of the presentation is to (re)think paths of changing mobility culture to a wide cycling society. To this end, the presentation opens a discussion about whether and how the concept of sufficiency can contribute to make sense of cycling as a widespread mobility practice

Abstract

Like many other countries in Europe, Germany has experienced a bicycle boom in recent years with increasing sales figures on the bicycle market. The rising sales figures are primarily the result of sales of pedelecs as a relatively new sales market. Due to the pedal support, also older and less active people (re)discover the joy of cycling. Cycling advocacies may be glad about this boom. However at a closer look, the bike boom seems to be more about getting a bike as a "must have" or as a leisure activity than about cycling as transport mode. Indeed the number of cyclists on the street partially increases, but there is only a moderate increase of cycling in the modal split. Instead, the number of registrations of private cars continues to rise, so that the much cited *bike boom* is overshadowed by an ongoing *car boom*. Accordingly, no wide modal shift towards an increase of cycling as transport mode can be identified. Actually only some selected milieus or social groups make use of bicycles as transport mode. For example, Hudde (2022) shows that mostly well-educated persons travel regularly by bike while other social groups show less significant increase in cycling. In addition, bicycles and Pedelecs are increasingly being sold with higher quality components, which further increases the price level, while at the same time there is a clearer trend towards second or third bicycles (ZIV 2022). This suggests that not only higher educated but also mainly high-income groups are participating in the bicycle boom by buying increasingly expensive bikes. Besides, social and cultural studies figure out as to whether, alongside the right car or car brand, the high-end bicycle is gradually becoming a status symbol for those who can afford it (e.g. HOOR 2020). These explorations raise the question if the bicycle boom is more a consumer trend and therefore primarily about acquiring a status symbol and using it for fun and leisure purposes. With reference to the climate policy goals and the efforts to strengthen liveable cities, however, the focus should not be on the popularity of bicycles itself but on cycling as a sustainable mobility practice. A bike boom as a *bike-selling boom* or consumer trend would causes even more resource consumptions with little benefit for sustainable and inclusive mobility. Instead of a bike-selling boom, the goal should therefore be to promote a cycling boom, with which the bicycle gains in importance as a means of transport in the wide society. That would mean that we need a wide shift in mobility culture and in the way people make sense of good and attractive mobility.

However, it is still unclear how bicycles or pedelecs can gain importance as a means of transport as well.

A shift in mobility culture would address a shift in values and attitudes, in routines and self-understanding, in the whole way of making sense of mobility (Cox 2015). At the same time, the mobility culture happens in the context of a consumerist society. At the one hand, this fosters the perception of bikes as a consumer good. At the other hand, it implies the understanding that mobility and the means of transport always have to follow the dogma *higher faster further*. Promoting cycling as a sustainable mode of mobility goes against this mind-set when it comes to using fewer resources and producing fewer emissions. In consequence making a change in mobility also has to deal with making a change in consumeristic patterns in society. Here, the research strands of degrowth economy and degrowth society can provide helpful approaches of how to find paths of a sustainable mobility (CATTANEO ET AL. 2022; JACKSON 2017). In this context, the concept of *sufficiency* opens up paths of a different way of making sense of good an attractive mobility (ALEXANDER & GLEESON2022; LINZ 2004). In contrast to the leading dogma *higher, faster and further* in a consumeristic society, sufficiency focuses on what people really need for being mobile in a fulfilled life. In this context attributes as individual life quality, health, freedom and self-efficacy lead to a different understanding of how people wish to be mobile in their everyday life.

The presentation opens up a contrast between a bike selling boom and a cycling boom understood as a shift to cycling as mode of transport in the wider society. The aim of the presentation is to (re)think paths of changing mobility culture to a wide cycling society. To this end, the presentation takes up the concept of sufficiency from a degrowth research strand to discuss whether and how the concept of sufficiency can be a way to understand cycling as a desirable mobility practice.

The presentation first examines characteristics of the bike boom in the German context. In doing this, the presentation figures out the problems of a bike-selling boom as a consumer trend and shows up the problems of cycling as a social selective phenomenon. For this, the presentation sums up empirical findings about the images of cycling, the motives for buying a bike, the motivation to cycle and the usage after buying a bike or pedelec in some parts of the society. Building on this, the presentation discusses how to promote a change in mobility culture by understanding cycling in the context of sufficiency. Here, the rising positive image of bikes may be an anchor for sense-making processes in which cycling as lived and performed sufficiency gets into practice. For example, cycling may become a healthy and honourable practice that generates social capital. The presentation concludes with a discussion of how an intertwining of infrastructure planning and media campaigns can help to understand cycling as a desirable mobility practice.

References

ALEXANDER, S., GLEESON, B. (2022). Collective Sufficiency: Degrowth as a Political Project. In: Alexander, S., Chandrashekeran, S., Gleeson, B. (eds) Post-Capitalist Futures. Alternatives and Futures: Cultures, Practices, Activism and Utopias. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-16-6530-1_5.

CATTANEO, C.; KALLIS; G.; DEMARIA, F.; ZOGRAFOS, C.; SEKULOVA, F.; D'ALISA, G.; VARVAROUSIS, A. & M. CONDE (2022): A degrowth approach to urban mobility options: just, desirable and practical options, Local Environment, DOI: 10.1080/13549839.2022.2025769.

COX, P. (Ed.). (2015). Cycling cultures. University of Chester.

GERMAN BICYCLE INDUSTRY ASSOCIATION ZIV (2022) Market Data – Bicycles and E-Bikes Figures and Analyses for 2022 Press conference in cooperation with the Association of the German Bicycle Trade (VDZ) March 15th 2023.

HOOR, M. (2020). The bicycle as a symbol of lifestyle, status and distinction. A cultural studies analysis of urban cycling (sub)cultures in Berlin. Applied Mobilities, 1–18. https://doi.org/10.1080/23800127.2020.1847396.

HUDDE, A. (2022): The unequal cycling boom in Germany. In: Journal of Transport Geography 98 (1). Elsevier. DOI:10.1016/j.jtrangeo.2021.103244.

JACKSON, T. (2017): Prosperity without Growth. Foundations for the Economy of Tomorrow. 2nd Edition. Routledge.

LINZ, M. (2004): Weder Mangel noch Übermaß: Über Suffizienz und Suffizienzforschung, Wuppertal Papers, No. 145, Wuppertal Institut für Klima, Umwelt, Energie, Wuppertal, https://nbn-resolving.de/urn:nbn:de:101:1-200911021828.

Balancing 'push and pull' measures to encourage car drivers to become cyclists

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Keywords
Cycling promotion, push-pull measures, comparative analysis, active mobility, urban transport

Challenge Addressed / Research Problem Investigated
Identify measures to simultaneously promote cycling and walking while reducing car usage in European cities, considering their cycling modal share.

Abstract
PROBLEM STATEMENT
The significant rise in greenhouse gas emissions is closely linked to the car-oriented development. To address the social and environmental paradigm we face today, promoting the use of bicycles presents an opportunity for a healthy, sustainable, and cost-effective mobility that requires minimal space and encourages engagement with urban structures. Bicycles are especially competitive for short and medium distances. Consequently, the use of bicycles as a transport mode has witnessed a significant rise in numerous European cities in recent decades, leading to the expansion of cycling policies and infrastructures.

Despite these positive developments, cars still dominate urban streetscapes, and an increase in bicycle use does not always result in a proportional decrease in car use. 'Push and pull' measures promote cycling while simultaneously implementing restrictions on cars. These measures are necessary to increase the share of cycling and improve the actual and perceived safety of bicycle use, while favoring simultaneously pedestrians.

RESEARCH QUESTIONS
The main goal of this research is to find the different 'push and pull' measures that need to be implemented in cities with different cycling modal share. Firstly, to increase the number of cycling trips while reducing car use proportionally. Furthermore, to make sure these 'push and pull' policies also favor the amount of walking, considering the importance of the alliance between pedestrians and cyclists to achieve the predominance of active mobility in cities.

In the last decades, many researchers focused on the study of this 'push and pull' measures from a precise location or compared cities with similar percentage on cycling use. However, there are limited studies in the literature which compare the policies implemented in diverse metropolitan areas in terms of bicycle use. This analysis is intended to help transfer the findings to cities with different cycling modal share.

CASE STUDIES
In order to understand the level of success in implementing such measures in cities with different local contexts and mobility cultures, a comparative analysis needs to be performed.

As case studies, three cities with different modal share in cycling are chosen: Madrid, in the initial phase; Munich, in the growth phase; and Amsterdam, as one of the leading cities. In the three chosen case studies, a significant proportion of trips under 7.5 km are made by car, which presents a promising opportunity for bicycle traffic. Therefore, the bicycle can help compete with the convenience of door-to-door car travel. That's why it is essential to find a balance between "push and pull" measures.

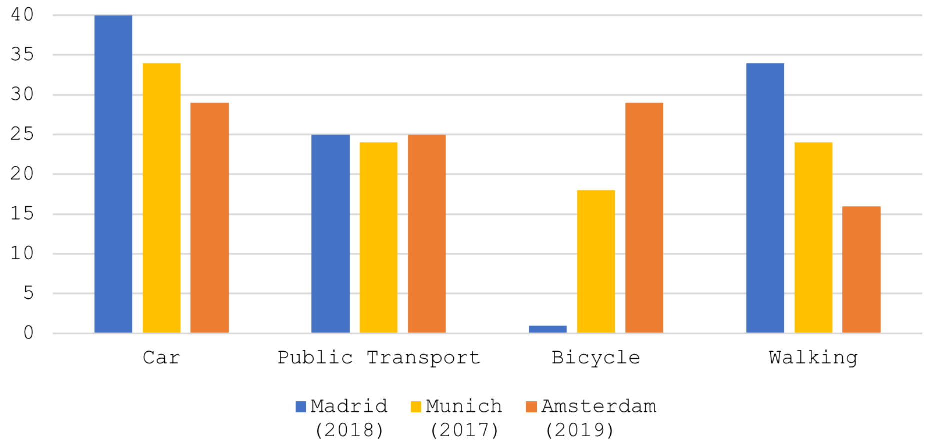

Figure 1: Modal share in three european cities (%)
Sources: European Mobility Venture 2021 Report (MCube, TUM), "Household Mobility Survey 2018 (Consorcio Regional de Transportes de Madrid)" and own elaboration.

In the graph (Figure 1), we can observe that the percentage of public transportation is very similar in the metropolitan areas of these three cities. It is also evident that increased bicycle usage corresponds to decreased car usage, but this relationship is not proportional. This is because many bicycle users come from trips that could be easily walkable, which does not foster the alliance between pedestrians and cyclists. Additionally, it fails to overcome the main challenge we face: reducing the number of car trips and promoting active mobility, both pedestrian and cycling.

In the case of Madrid, it is a city with a low modal share of cycling (less than 1%). Numerous restrictions are being imposed on motorized vehicles, but there are not enough attractive, reliable, and safe alternatives to promote cycling mobility, resulting in a minimal decrease in car trips in the last years and general discontent among the population regarding these restrictions. On the other hand, the city of Munich is experiencing a boom in cycling. The challenge in the face of this cycling success is that cars continue to dominate the streetscape. The existing cycling infrastructure is sometimes discontinuous and a significant number of them have been integrated into sidewalks, which could be the cause of walking trips decreasing by 3% since the 2008 survey. As for Amsterdam, among the three cities, it has the lowest car usage, although it remains prevalent. It is also one of the model cities in terms of bicycle usage. Despite this, active mobility also includes pedestrians, and it has a low percentage of walking trips compared to Munich and especially Madrid.

METHODS

The methodology includes a literature review on ‘pull and push’ measures in cycling, presenting variety in terms of cities with different cycling culture and use in the European context. A summary table will be provided comparing ‘pull and push’ measures explored in the existing literature, indicating if the researchers focus on a city in the initial phase, in the growth phase of cycling or on a leading city. On the other hand, a comparative analysis on the amount of bicycle use and existing `push and pull' measures in Madrid, Munich and Amsterdam will be performed. This will be obtained from reports and media. In this way, the positive and negative aspects of the existing measures will be shown in relation with the necessary measures that were found in the literature. This 'pull and push' measures will be summarized and discussed and could be transferred and adapted to cities with similar cycling culture and use.

EXPECTED OUTPUT

The aim of a future paper about this topic is to extract the 'pull and push' measures for different cities depending on their modal share of cycling. Therefore, this could help decision making for evaluating the possible policies and infrastructures to promote and develop. To analyze policies that benefit active modes is relevant to create a development direction that leads to achieving the goals of reducing car use and addressing the many challenges of fast-growing cities. Only in this way can we shift from car-centric to active-centric planning praxis.

Cycling to the rescue: Bicycles can enhance urban mobility resilience in times of disruption

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Keywords
Disruptive events, Mode choice, Urban resilience, mode-switching behavior

Challenge Addressed / Research Problem Investigated
The challenge is to identify how different disruptive events affect mode choice behavior and to examine the role of the bicycle as a resilient transport mode that can ensure sufficient adaptability of transportation systems.

Abstract
THEORETICAL BACKGROUND
Transportation systems are susceptible to various exogenous shocks, such as extreme weather events, pandemics, and abrupt infrastructure changes. These shocks can impair the availability, accessibility, and affordability of different transport modes. Consequently, people may have to temporarily adopt alternative transport modes to achieve their mobility goals. The feasibility of this adaptation depends on the resilience of the transportation system. According to Lara et al. (2023), one of the important aspects of urban mobility resilience is the transportation system's ability to minimize the impacts of a disturbance and provide alternatives to basic mobility (adaptability). This implies that when a certain transport mode is temporarily unavailable, other modes should be accessible without overloading the transportation system. Previous research has mainly examined the influence of certain events on mode choice behaviour either from an individual perspective ("mobility biographies approach", Müggenburg et al., 2015) or focused on single external events such as the pandemic (Bucsky, 2020). Systematic attempts to identify a broad range of influential events and possible common mode choice shift patterns are still lacking. This contribution aims to address this gap. Specifically, it investigates the role of the bicycle as a resilient transport mode that can ensure sufficient adaptability of transportation systems in response to a broad range of disruptive events.

METHOD
Using data from an online survey conducted in 2023 in Germany, we examine mode choice shift patterns after various disruptive events (n = 1.873). Participants were acquired via sending postcards to 15.000 randomly selected residents of the three German cities Leipzig, Bad Hersfeld and Dresden in cooperation with local resident registration offices. In addition, press releases and social media posts drew attention to the survey throughout Germany.

Participants of the survey reported their experience with various disruptive events that affected their daily mobility. These events are categorized into 14 types as shown in Figure 1. Additionally, participants ranked the experienced events by the degree to which the events

altered their behaviour. If participants indicated an event changed their mode choice for specific routes, they were asked to specify which transport mode they used before, during and after the event. This allows a deeper understanding of which transport modes are more vulnerable to different exogenous shocks and which modes can enhance the adaptability of transportation systems.

RESULTS

Results indicate that the most commonly experienced disruptive events in the sample are the pandemic, positive financial changes in public transport, temporary failure of public transportation as well as temporary breakdown of a private means of transport. Participants were asked to rank their top three most influential disruptive events among those they reported. Figure 1 shows the adjusted importance of each category, which is the probability of an event being ranked as very influential given that it was experienced. This means that the higher the value, the greater the impact of the event on mobility when it occurs.

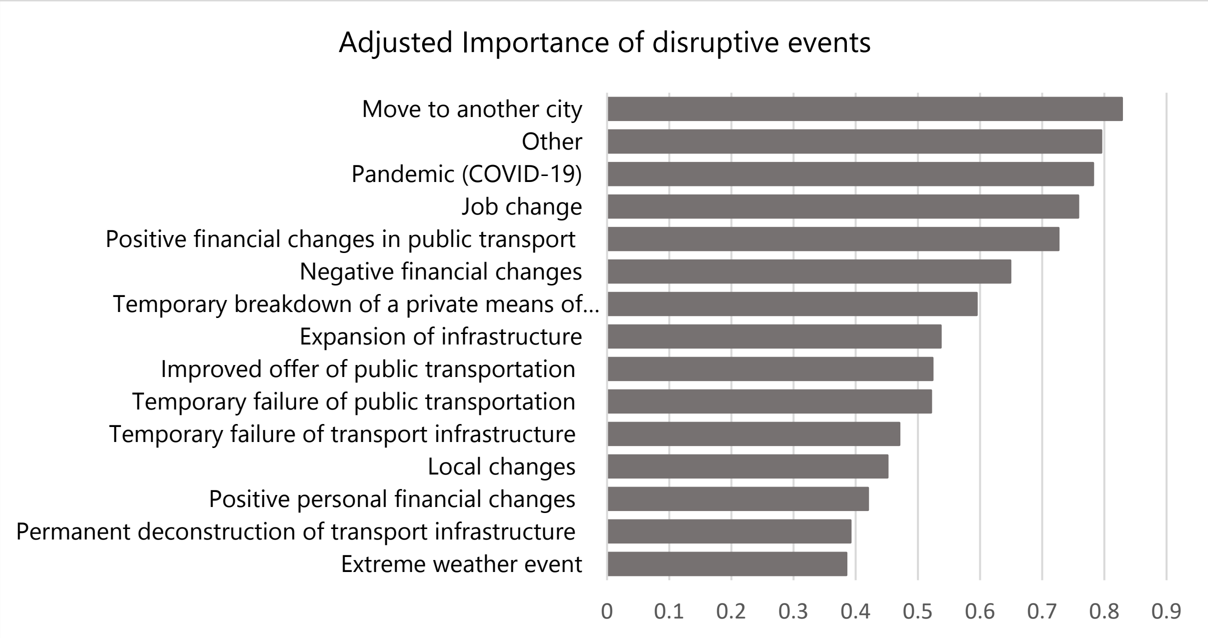

Figure 1. Adjusted importance of disruptive events.

As figure 2 illustrates, cycling is a common and preferred transport mode in response to disruptions. When disruptive events induce a modal shift, the transport mode that increased most in its share was the bicycle. Public transport and walking did not undergo significant changes, while the share of motorized private transport halved. Motorized private transport (MPT) users mainly switched to cycling, followed by public transport. Public transport users mainly switched to either cycling or motorized private transport. Cycling users mainly switched to public transport.

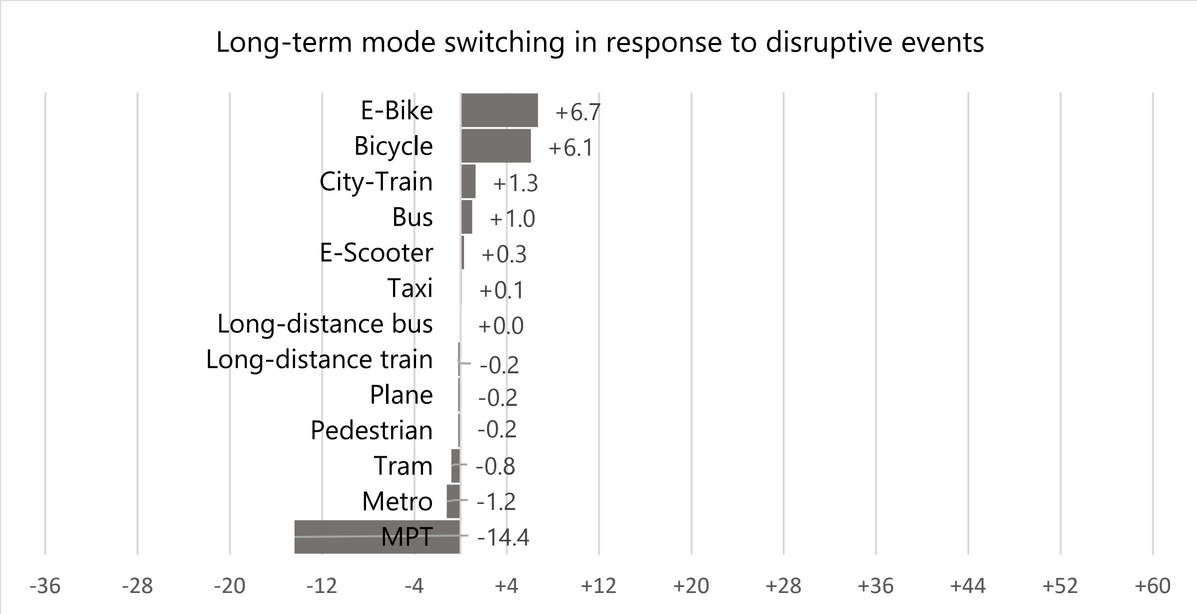

Figure 2. Long-term mode switching in response to disruptive events.

We also examined individual categories of disruptive events and their effects on modal shifts as shown in figure 3. Expansion of infrastructure caused the largest shift to the bicycle. Negative personal financial changes, job changes and the pandemic lead to significant shifts to the bicycle as well. Temporary breakdowns of a private means of transport as well as positive changes in public transport services lead to a small mode shift away from the bicycle. Unfortunately, due to small sample sizes, mode shift patterns regarding other categories of disruptive events are not statistically representative.

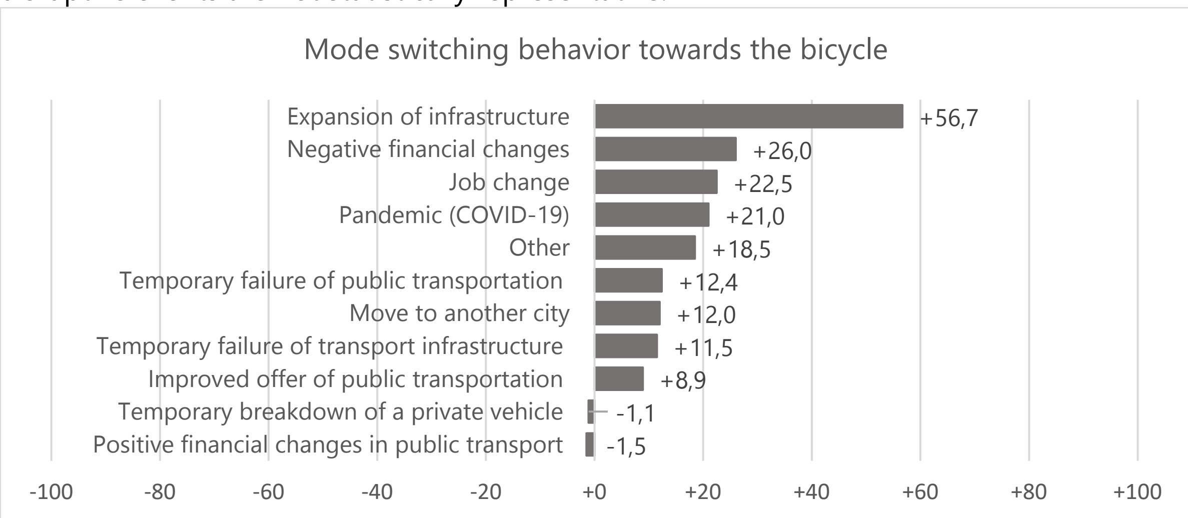

Figure 3. Mode switching behaviour towards the bicycle over different categories of disruptive events.

CONCLUSIONS

Despite various disruptive events that affect mode choice and mobility habits, motorized private transport remains a persistent mode of transport. However, such events can also induce significant shifts towards the bicycle as a preferred mode of transport among those who experience them. Therefore, we suggest that cycling can be a key element of adaptive transport systems for urban planning. Our results imply that investing in cycling infrastructure can be an effective strategy for enhancing urban resilience.

References

Bucsky, P. (2020). Modal share changes due to COVID-19: The case of Budapest. In Transportation Research Interdisciplinary Perspectives (Vol. 8, p. 100141). Elsevier BV. https://doi.org/10.1016/j.trip.2020.100141

Lara, D.; Pfaffenbichler, P.; Da Rodrigues Silva, A. (2023): Modeling the resilience of urban mobility when exposed to the COVID-19 pandemic: A qualitative system dynamics approach. In: Sustainable cities and society 91, S. 104411. DOI: 10.1016/j.scs.2023.104411.

Müggenburg, H.; Busch-Geertsema, A.; Lanzendorf, M. (2015): Mobility biographies: A review of achievements and challenges of the mobility biographies approach and a framework for further research. In: Journal of Transport Geography 46, S. 151–163. DOI: 10.1016/j.jtrangeo.2015.06.004.

Developing customized cargo bike routes based on individual preferences and vehicle specifics

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Abstract

BACKGROUND

Providing adequate routing is crucial for all road users traveling varying tours. Existing routing algorithms focus on cars and conventional bikes that are used privately. These offer customized settings based on the users' needs. To date, there is no tailored solution offering optimal cargo bike routes taking into account special requirements and preferences of commercial cargo bike users.

GOAL

We aim to fill this gap and develop a solution determining specific cargo bike routes in urban areas, possibly improving route efficiency and driver satisfaction. In addition, we aim to answer the following research questions: What influence do factors such as vehicle type and infrastructure have on the route choice of cargo bike drivers? To what extent can personalized navigation solutions increase the efficiency of cargo bike use?

METHODS

Our approach combines various methods and uses data from different sources to generate routes for commercial cargo bike users. The approach builds on data from empirically collected cargo bike trips. These are 30,000 cargo bike routes that have been recorded under real world conditions by users of various economic sectors, such as logistics, construction and manufacturing (craftsmen), service industries, retail, and the public sector. Trip data includes additional information, such as the characteristics of the used type of cargo bike. In addition, we use infrastructural and spatial parameters derived mainly from OpenStreetMap, such as bike infrastructure, street type, steepness/slope, urban green, connectivity, share/repair facilities. Parameters further include route characteristics of specific relevance for cargo bikes, such as stairs or narrow passages.

Using an in-house routing algorithm (Strazoon, developed by 7P), as well as common routing engines such as Google Maps, we create a set of alternative routes for each tracked route. Discrete (route) choice models are then used to derive influencing factors for cargo cyclists' route choices. Potential influencing factors in the model are travel time, street type, type of bike infrastructure, surface, motorized traffic as well as vehicular and person-related factors. Quantitative outputs are then validated qualitatively by conducting ride-alongs with cargo bikes couriers and interviews with experts. Based on the results the routing algorithm is enhanced considering personalized input.

RESULTS AND CONCLUSION

Results show routing preferences of users of various cargo bikes in commercial use. The contribution offers up to date scientific results for cargo bike route choice. The routing solution developed helps to increase the economic potential and the acceptance of the use of cargo bikes in commercial use.

Development of a bicycle route choice model for greater Gothenburg area

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Keywords
Bicycle; route choice; map-matching; uncertainty; Pasi-size Logit

Challenge Addressed / Research Problem Investigated
We illustrate that uncertainty from noisy GPS data can have a strong impact on the estimation of bicycle route choice model. We also capture the effects of width of a separated bike lane, providing possibility to conduct ex-ante evaluation of investment on widening existing separated bike lane.

Abstract
INTRODUCTION
Map-matching GPS data to the underlying bicycle network is the first step in the development of a bicycle route choice model. Bierlaire and Frejinger (2008) discussed the impact of measurement error caused by inaccuracy in map-matching on the route choice model. They pro-posed to explicitly include a measurement equation in the route choice model. The measurement equation is interpreted as the probability of having a specific inferred path given the GPS sequence observation. However, in real-world applications, the potential inaccuracy in map-matching is often ignored due to its complexity in considering the measurement error explicitly. The study aims to explore to what extent a combination of noisy GPS data and high-resolution network leads to uncertainty in the map-matching and how this affects route choice model estimation. Furthermore, the study also aims at exploring effects of policy relevant variables which are less investigated in previous studies of this type, e.g., a widening of existing bike path which is the most common bicycle policy measure at least in Sweden.

METHODOLOGY
Map-matching
In this study, a Hidden-Markov model (HMM) based map-matching algorithm is adopted (Li et al., 2013; Vosloo and Joubert, 2019) illustrated in Figure 1. Given a sequence of GPS points

representing one bicycle trip, for each GPS point P_n in this sequence, a set of candidate nodes (denoted c_n^i) within a maximum search distance in the bicycle network are proposed to which the given GPS point should be matched. The problem of the map-matching then is transformed into finding an "optimal" path in the candidate graph.

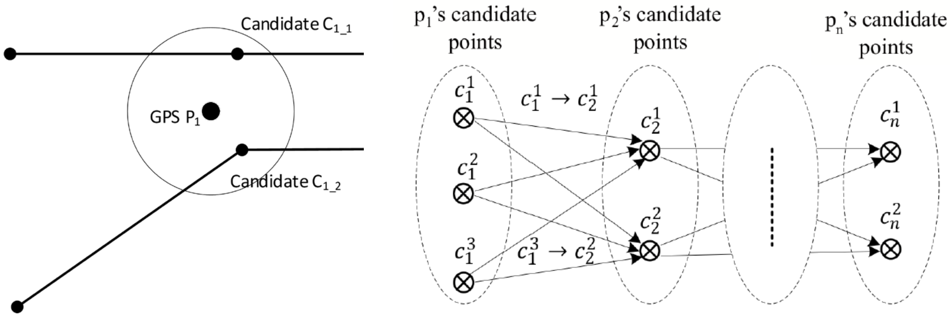

Figure 1. Illustration of path finding in the candidate graph (Vosloo and Joubert, 2019)

Alternative path generation
A combined data-driven path identification method (DDPI) and repeated path-search method are adopted for the alternative path generation. DDPI is first proposed by Ton et al. (2018) where observed bicycle trips with similar origin and destination are clustered. Unique paths within each cluster can be considered as path alternatives for any given path in the same cluster and the unique paths within the same cluster are added into the choice set. Three repeated path-search methods are also tested: 1. Breadth-first search on link elimination (BFS-LE); 2. Doubly stochastic generation function (DSGF); 3. Labelling approach.

Path-size Logit model
The standard path-size Logit model approach is adopted. A similar formulation as so-called Value-of-Distance space (Meister, et al., 2023) is adopted. An effort was made to estimate travel time and use that in the model estimation. Effects of intersection/turn are captured in the form of intersection delay. Thus the model is estimated in Value-of-Time space.

1. Data and case study description
The GPS data was collected from a dedicated research project using a travel diary mobile application called TravelVU. The data consists of 4.6 million GPS points from 13521 cycling trips from 430 cyclists. An example of the problem with "parallel bike path" is found during the validation of map-matching results. Figure 2 illustrates this problem. The link (green) is a separated bicycle path alongside the mixed traffic link (red) while GPS trajectories (blue) traverse half the way on the green link and half the red link, making it hard to determine the which link should be matched. To overcome this issue, a link attribute "primary usage" is considered in the map-matching. This attribute denotes the primary usage of the link for the type of mode: car, walk and bike. If the primary usage of the link is for bicycle traffic, then the probability of the link being selected in the map-matching increases. As a result, this study produces two sets of map-matched paths, considering and not considering "primary usage = bike".

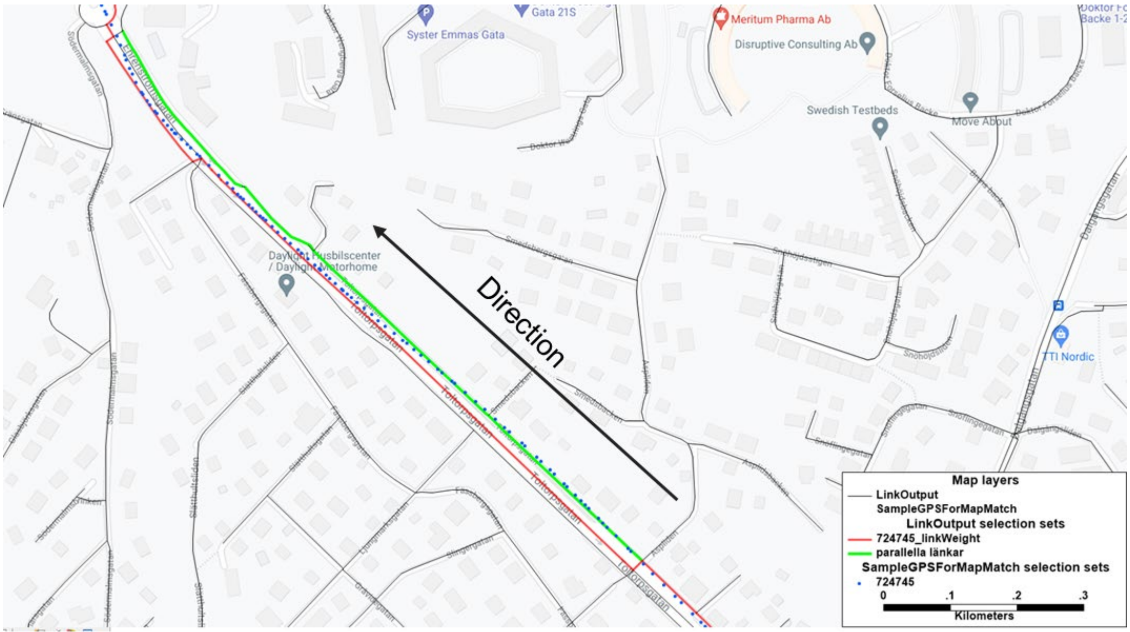

Figure 2. Illustration of parallel link problem in map-matching.

2. model estimation results

The estimation results show unexpected discrepancies between the cases considering or not considering "primary usage = bike" in the map-matching process. When not considering "primary usage = bike", the effect of separated bike path produces "wrong" sign, indicating that a considerable share of mixed traffic links in the "parallel link" situations are matched instead of the links with primary usage as bike.

This results also found significant effects of the width of separated bike path, type of road surface (gravel or paved) and lighting, apart from the variables used in most studies. The model identifies the effect of the width of a separated bike path where the separated bike path with width >2m has a stronger effect than that with width <=2m. Lighting has a positive effect. In fact, road with lighting is also an indication that this is a primary or secondary road. The effect of intersection/crossing also is found prominent. Delays at signalized intersection and crossing light rail have strong negative effects effect of commuters avoiding signalized intersection is strong.

CONCLUSIONS

The study demonstrates that a combination of high-resolution network and noisy GPS data causes uncertainties in map-matching which can lead to misleading results in route choice model estimation. When it comes to the policy implications, this study estimates the impact of width of bike path, lighting together with other variables. The use of travel time rather than distance allows for smooth integration with existing cost-benefit analysis tools and enable relevant analysis for projects such as widening existing bike paths.

References

Bierlaire, M., Frejinger, E., 2008. Route choice modeling with network-free data. Transportation Research Part C: Emerging Technologies 16, 187–198. https://doi.org/10.1016/J.TRC.2007.07.007.

Li Y, Huang Q, Kerber M, Zhang L., Guibas L, 2013, Large-scale joint map matching of GPS traces, 21st ACM SIGSPATIAL International Conference on Advances in Geographic

Information Systems, pp. 214{223, ACM SIGSPATIAL, ACM Digital Library, Orlando, Florida.

Meister, A., Felder, M., Schmid, B., & Axhausen, K. W. (2023). Route choice modeling for cyclists on urban networks. Transportation Research Part A: Policy and Practice, 173, 103723. https://doi.org/10.1016/J.TRA.2023.103723.

Ton, D., Duives, D., Cats, O., Hoogendoorn, S., 2018. Evaluating a data-driven approach for choice set identification using GPS bicycle route choice data from Amsterdam. Travel Behaviour and Society 13, 105–117. https://doi.org/10.1016/j.tbs.2018.07.001.

Vosloo, J.B, Joubert, J.W., 2019. Development of a map-matching algorithm for dynamic-sampling-rate GPS signals to determine vehicle routes on a MATSim network, ORiON, 35(1): 1-31.

Quantitative modelling of cyclists' route choice behaviour based on revealed preference data: a literature review

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Challenge Addressed / Research Problem Investigated

To summarise, analyse, and synthesise the existing literature on the topic, identify research gaps, and formulate future research directions.

Abstract

INTRODUCTION

Bicycle travel contributes to positive impacts on the environment (Brand et al. 2021), makes cities more liveable (Te Br¨ommelstroet et al. 2017), and improves individual health (Oja et al. 2011). One of the aspects to consider when encouraging other road users to shift to bicycle is analysis of route choice behaviour of the current cyclists. Since the first bicycle route choice study based on revealed preference data (Menghini et al. 2010), a considerable number of studies have been published on this topic. This paper reviews, analyses, and synthesises studies applying quantitative methods to model the bicycle route choice problem on revealed preference data, identifies research gaps, and formulates future research directions. It comprises 26 studies estimating at least one statistical choice model based on revealed preference data, and published in peer-reviewed journals in English language.

SELECTED INSIGHTS

Cycling GPS data Bicycle research increasingly benefits from large-scale, crowdsourced datasets that leverage modern smartphone technology. These datasets present an opportunity of large sample sizes, and high spatial and temporal coverage (Nelson et al. 2021). On the other hand, rapidly increasing data volumes can pose practical challenges, such as limited access or availability of hardware resources, or long analysis and computation times. The majority of bicycle route choice studies make use of data from smartphone applications, mostly designated for other projects or campaigns. Utilising crowdsourced datasets for bicycle route choice modelling research slowly becomes a common practice, and a substantial increase in the sample size for modelling can be observed, with up to several thousands observations in the recent studies.

Bicycle network Existing digital networks for cities might lack minor streets or paths open to bicycle traffic (Berjisian & Bigazzi 2022). The Open Street Map (OSM) network is a free editable map of the world that relies on crowdsourced data and manual edits from millions of private users. Even though the level of quality can vary from city to city, it has a high coverage and provides a good basic network in most cities also for bicyclists (Nelson et al. 2021). The vast majority of the bicycle route choice studies utilise the network from OSM, mostly enriching it with external sources. Some of the studies obtain the network information from authorities or private companies, or use official city GIS networks.

Map matching Inferring spatial patterns from the GPS data in relation to the underlying network requires an intermediate step in the analysis called map matching. In the bicycle route choice literature, there is no rigorous consensus about the best map matching algorithm to apply for bicycle traffic and the methodology in many of the algorithms is unclear. As reviewed by a recent study (Berjisian & Bigazzi 2022), map matching for cycling trips is more complex than for car trips, and matching the routes based on GPS data from active travel modes poses several challenges. The authors propose a set of modifications to the existing algorithms, which constitutes a very solid foundation towards generic solutions, tackling the issues in the map matching algorithms for active travel data.

Choice set generation Prediction ability of choice models, with respect to the actual choice, depends on the heterogeneity and reliability of the choice sets (Prato & Bekhor 2007). Just as for the map matching algorithm, there is yet no best common practice about how to generate a choice set to allow most reliable estimations, and the researchers apply different approaches based on data and resource availability. With computational advancements and increasing data availability, there is also a growing interest in alternative approaches, such as sampling methods, data-driven methods, or route choice methods that allow for omitting the choice set generation step.

Model attributes Network attributes are the most represented type of attributes in bicycle route choice models. Figure 1 summarises the representation of network attributes in the bicycle route choice literature. In some cases, the models account also for external circumstances in the moment of choice, such as weather, or type of bike used, or information about individual characteristics of cyclists. These variables are usually interacted with network attributes to understand the relationship between them.

Methods The vast majority of bicycle route choice studies employ path-based models, ranging from the traditional MNL model to extensions of the MXL model. Alternatively, link-based methods allow for taking the entire network into account and thereby avoid predefining choice sets. Moreover, another advanced methods for modelling behaviour, such as classifiers or spatial models, have recently been gaining interest among bicycle researchers. Despite providing a different perspective and effective approaches to the problem, they lack the link to economic theories of the original multinomial logit model, reducing the interpretability and comparability with other studies.

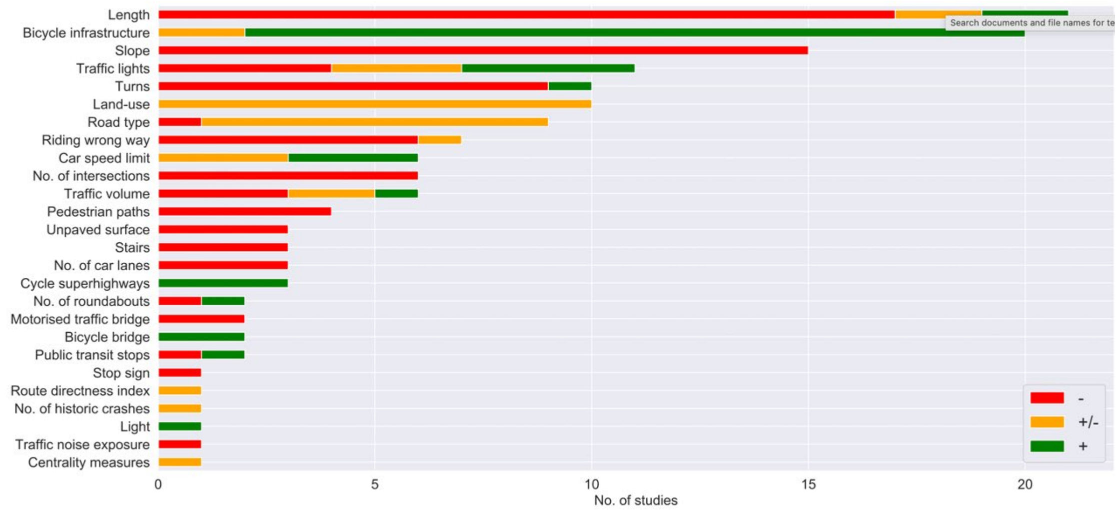

Fig. 1: Network attributes in bicycle route choice studies. '+': positive influence, '-': negative influence, '+/-': influence diverse, unclear or dependent on other variables.

Model evaluation and validation Existing bicycle route choice studies serve mostly the explanatory purpose and the models are evaluated in-sample, with traditional goodness-of fit measures, such as pseudo-R-squared or log-likelihood. Parady et al. (2021) discuss and criticise the sole reliance on the in-sample measures and call for a need to validate the model results on a new set of observations. Only six bicycle route choice studies performed a validation on a holdout sample, and they achieved satisfactory and repeatable results. However, and there is yet no established method in the bicycle route choice literature to uniformly assess the models and compare the results between studies.

OUTLOOK

Conclusions from the studies included in this review will be discussed in the light of three topics from the bicycle research field: i) utilising large-scale cycling GPS data, ii) quantifying cyclists' route choice preferences and formulating policy implications for cycling, and iii) capturing heterogeneity in behaviour. Technological developments bring further opportunities to utilise large data sources to study cyclists' behaviour, which in turn opens the door for many research ideas. Accounting for the multi-level heterogeneity in bicycle route choice models should become a standard and the related results will provide more detailed conclusions translated into more target-oriented measures to promote cycling. Finally, future research should encompass a wider range of cities and countries for a better knowledge transferability.

References

Berjisian, E. & A. Bigazzi (2022). "Evaluation of map-matching algorithms for smartphone-based active travel data". In: IET Intelligent Transport Systems.

Brand, C., T. Götschi, E. Dons, R. Gerike, E. Anaya-Boig, I. Avila-Palencia, A. de Nazelle, M. Gascon, M. Gaupp-Berghausen, F. Iacorossi, et al. (2021). "The climate change mitigation impacts of active travel: Evidence from a longitudinal panel study in seven European cities". In: Global Environmental Change 67, p. 102224.

Menghini, G., N. Carrasco, N. Sch¨ussler, & K. W. Axhausen (2010). "Route choice of cyclists in Zurich". In: Transportation research part A: policy and practice 44.9, pp. 754–765. doi: 10.1016/j.tra.2010.07.008.

Nelson, T., C. Ferster, K. Laberee, D. Fuller, & M. Winters (2021). "Crowdsourced data for bicycling research and practice". In: Transport reviews 41.1, pp. 97–114.

Oja, P., S. Titze, A. Bauman, B. De Geus, P. Krenn, B. Reger-Nash, & T. Kohlberger (2011). "Health benefits of cycling: a systematic review". In: Scandinavian journal of medicine & science in sports 21.4, pp. 496–509.

Parady, G., D. Ory, & J. Walker (2021). "The overreliance on statistical goodness-of-fit and under-reliance on model validation in discrete choice models: A review of validation practices in the transportation academic literature". In: Journal of Choice Modelling 38, p. 100257.

Prato, C. G. & S. Bekhor (2007). "Modeling route choice behavior: how relevant is the composition of choice set?" In: Transportation Research Record 2003.1, pp. 64–73.

Te Br¨ommelstroet, M., A. Nikolaeva, M. Glaser, M. S. Nicolaisen, & C. Chan (2017). "Travelling together alone and alone together: mobility and potential exposure to diversity". In: Applied Mobilities 2.1, pp. 1–15.

Comparative Study on Route Choice Models for Cyclists

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Abstract

A central element of modern transport-planning software used for the design of urban cycling networks, are sophisticated route choice models. This study presents the results of a comparison among three different modelling approaches applied to a Zurich scenario. We compare two conventional path-based models with different choice set generation techniques (BFSLE [1] and Metropolis-Hastings [2]), as well as a link-based recursive model [3] that does not require the generation of a choice set.

The models are estimated on approx. 3.600 GPS trajectories recorded through-out the MOBIS project [4]. The trajectories are map-matched to an OSM-based network of the Zurich agglomeration, which includes approx. 220.000 links. The estimation results for the three different models are shown in the Table 1 below. All models were estimated using the same dataset, of which 80% is for training and 20% for validation. The generated results are comparable; expect for traffic signals, all parameters have the expected signs across the three models, resulting in a consistent, mostly intuitive, behavioral interpretation.

Table 3. Estimation results

	PSL_{BFSLE}		PSL_{MH}		RL	
	est.	std.	est.	std.	est.	std.
length [km]	-1.35^{***}	0.11	-1.52^{***}	0.18	-0.074^{***}	0.004
bike path [km]	1.04^{***}	0.07	3.17^{***}	0.71	0.021^{***}	0.001
bike lane [km]	1.73^{***}	0.06	2.60^{**}	0.86	0.007^{***}	0.001
speedlimit 30 [km]	0.19^{***}	0.04	0.13^{*}	0.53	0.009^{***}	0.001
traffic signals [-]	0.03^{***}	0.01	-0.03^{***}	0.02	-0.089^{*}	0.057
slope 2-6% [km]	-0.39^{***}	0.15	-2.78^{***}	1.22	0.012^{***}	0.001
slope 6-10% [km]	-3.95^{***}	0.42	-14.76^{***}	2.21	-0.035^{***}	0.002
slope >10% [km]	-6.03^{***}	0.50	-20.80^{***}	3.24	-0.106^{***}	0.002
path size [-]	-1.50^{***}	0.16	2.97^{***}	0.09	-	-
u-turn [-]	-	-	-	-	-9.385^{**}	3.921
parameters	9		9		9	
final LL	-11471.8		-5340.61		-53.90	
AIC	22961.59		10699.23		125.81	
BIC	23016.98		10755.32		181.99	
rho2	0.26		0.54		-	

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$ using robust standard errors.

The length parameter is negative and significant in all models, which we consider as an important indicator for the behavioral validity. The parameters for cycling infrastructure have a positive sign and are significant in all models, however with relative differences between the two infrastructure types. The BFSLE model indicates a stronger preference for unprotected bike

lanes (painted on regular streets, i.e. mixed traffic), while both other models show a stronger preference for bike paths separated from motorized traffic. The parameters for speed limit up to 30 kmph are positive and significant in all models. The parameter for traffic signals is significant across the models, but positive in the BFSLE model and negative in both others. In our case, the traffic signals serve as indicator for large complex intersections, making a respective positive effect on utility rather counter-intuitive.

The estimates for the different slope values are all significant and show an intuitive pattern in all models, however, with slight magnitude differences. The first gradient level has negative estimate in both path-based models and a positive one in the RL model. The relative increase in effect size over the different gradient levels is, however, rather consistent across the three models. The path size terms are both significant, while having a positive estimate in the BFSLE model, and a negative one in the MH model. This is due to the differences in the choice set composition, where the MH choice sets have substantially more overlapping, i.e. correlated, routes. The U-turn parameter in the link-based RL model imposes a penalty on the U-turn behaviors to avoid potential self-loops. The estimate has the excepted sign and is significant.

The out-of-sample validation was performed with the hold-out subset for all three models. Following [5] we use the First Preference Recovery (FPR) as central evaluation criteria for the predictive performance of the models. The FPR is the percentage of correct predictions assuming that the predicted choice is the one with the highest choice probability. For route choice models, the FPR is typically plotted against the overlap threshold. Said threshold defines the minimal share of an observed route that needs the be present in the predicted route in order to be considered a successful prediction. Figure 1 shows the resulting curves of the three model as well as a shortest-path reference model.

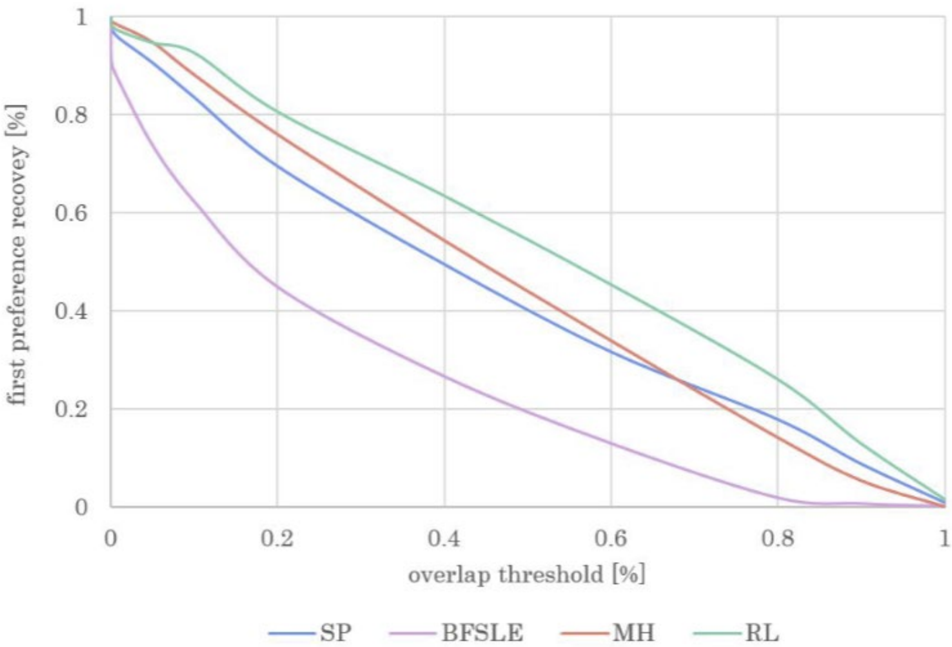

Figure 1. FPR-overlap dependency

The results show that the RL model clearly outperforms the others, while the BFSLE model performs the worst. The MH model behave similar to the shortest-path reference. Two commonly evaluated overlap thresholds are the 100% and 80% level, also listed in the Table

2. It can again be seen that the RL model outperforms the others w.r.t. to both levels. It further indicates that both path-based models perform worse than the shortest-path reference.

Table 4: FPR values

	SP	PSL_{BFSLE}	PSL_{MH}	RL
$FPR_{100\%}$	0.009	0.0	0.001	0.014
$FPR_{80\%}$	0.178	0.017	0.142	0.259
$FPR_{\text{link-level}}$	0.38	0.219	0.427	0.491
$FPR_{\text{link-level, length-weighted}}$	0.431	0.249	0.456	0.537

It should be noted that all models perform relatively bad on a 100%-level, i.e. correctly predicting the route link by link. This is due to the underlying network that has a high network density (see [6] for discussion of implications on map-matching and consecutive modelling). The majority of published cyclist route choice models are used for behavioral inference, hence only few have performed an out-of-sample validation. For a 100% threshold, [hood2011gps] reports values of 15%, [casello2014modeling] reports values of 46/65% and [sobhani2019metropolis] reports values of around 85% also using the MH algorithm for choice set generation, but a much coarser network representation.

Considering $FPR_{100\%}$ and $FPR_{80\%}$ both thresholds, it seems like the SP and RL model perform best. However, one needs to consider which requirement arise when using the model for different prediction use cases. In the case of traffic assignment problems, and given a certain level of aggregation, it might be more important to have good average forecast of flows rather than perfect predictions of each route. The bottom section of the Table 2 shows the FPR on a link-level, i.e. considering every link in every observed route as individual choice observation (which is aligned with the general concept of link-based models). In a path-based context, the values can somewhat be interpreted as average accuracy. FPR(link-level) is the average of an indicators that take the value of 1 if link i was predicted correctly and 0 otherwise, FPR(link-level, length-weighted) takes the length-weighted average of the above. Considering these metrics, the RL model still outperforms the others. Also the MH model performs better than the SP model, while the BFSLE model still performs the worst.

References

[1] Rieser-Schüssler, N., M. Balmer and K. W. Axhausen (2013) Route choice sets for very high-resolution data, Transportmetrica A: Transport Science, 9 (9) 825–845.

[2] Flötteröd, G. and M. Bierlaire (2013) Metropolis–hastings sampling of paths, Transportation Research Part B: Methodological, 48, 53–66.

[3] Fosgerau, M., E. Frejinger and A. Karlstrom (2013) A link based network route choice model with unrestricted choice set, Transportation Research Part B: Methodological, 56, 70–80.

[4] Molloy, J., A. Castro, T. Götschi, B. Schoeman, C. Tchervenkov, U. Tomic, B. Hintermann and K. W. Axhausen (2022) The mobis dataset: a large gps dataset of mobility behaviour in switzerland, Transportation, 1–25.

[5] Parady, G., D. Ory and J. Walker (2021) The overreliance on statistical goodness-of-fit and under-reliance on model validation in discrete choice models: A review of validation practices in the transportation academic literature, Journal of Choice Modelling, 38, 100257.

[6] Meister, A., K. W. Axhausen, M. Felder and B. Schmid (2022) Route choice modelling for cyclists on dense urban networks, Available at SSRN 4267767.
[7] Hood, J., E. Sall and B. Charlton (2011) A GPS-based bicycle route choice model for San Francisco, California, Transportation Letters, 3 (1) 63–75.
[8] Casello, J. M. and V. Usyukov (2014) Modeling cyclists route choice based on gps data, Transportation Research Record, 2430, 155–161.
[9] Sobhani, A., H. A. Aliabadi and B. Farooq (2019) Metropolis-hasting based expanded path size logit model for cyclistsâ route choice using gps data, International journal of transportation science and technology, 8 (2) 161–175.

Ontology-based Approach for Harmonizing Metrics in Bike Network Evaluations

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Keywords
Bike network, evaluation metrics, applied ontology.

Challenge Addressed / Research Problem Investigated
The lack of a formal and consistent framework for the variety of existing bike network evaluation metrics and criteria used across different approaches and domains, which hinders the comparability and transparency of such evaluations.

Abstract
The global imperative to mitigate CO_2 emissions from transportation has spurred the adoption of micro-mobility solutions (Reck et al., 2023). Specifically, bicycling has witnessed a remarkable surge in bike network developments and associated promotion initiatives. For example, in Switzerland a referendum advocating for 50 km of new bike paths in Zürich has recently been passed successfully (Rerat & Ravalet, 2023). At the same time, there continues to be a challenge in determining the optimal placement of new bike trails, pragmatically balancing between enhancing city cycling potential and minimizing adverse effects on other forms of transportation, while also addressing potential cyclists' concerns regarding safety, efficiency, accessibility, or comfort. While high quality cycling infrastructure can motivate people to cycle, it is unclear how to measure the quality of bike networks (Weikl & Mayer, 2023). Thus, the proliferation of such developments calls for effective evaluation and analysis tools.

Since the goodness of the bike network can be measured in many ways, a plethora of evaluation approaches are available, exhibiting varying degrees of establishment. While some of the evaluation metrics in these approaches are commonly accepted (Kazemzadeh et al., 2020), others are actively researched within specific domains, such as city planning (Rybarczyk & Wu, 2014), geographic information science (Winters et al., 2023), transport planning (Grigore et al., 2018), public health (Lowry & Loh, 2017) and network sciences (Reza et al., 2022). Similarly, these evaluation frameworks often are tailored for individual cities and research objectives (Grigore et al., 2018), while others are utilized across multiple cities (Cervero et al., 2019). Additionally, several popular Python libraries and software plug-ins (Boeing, 2017) are widely used for network evaluation.

The abundance of diverse evaluation approaches poses several challenges. One primary challenge is the variation in utilized metrics, as each evaluation often uses domain-specific terminology and employs a carefully selected and uniquely formalized set of metrics to assess the quality of city bike networks. For example, while land-use mix is considered to increase bike mode choice and is commonly used to measure bike network quality, different proxies or network edge buffer values are used across individual approaches (Prato et al., 2018).

Consequently, the evaluation of a bike network can vary depending on the chosen metrics and is hardly comparable.

Furthermore, while several classifications of related metrics exist available (Weikl & Mayer, 2023; Cervero et al., 2019), there is no shared consensus on what constitutes a good bike network across domains. This leads to ambiguous interpretations which undermines the clarity of quantitative and qualitative evaluation frameworks and can result in poorly informed planning decisions. Such concerns have been expressed in literature (Knight & Marshall, 2015). Therefore, we argue that a more structured and explicit formulation of bike network evaluation metrics is needed to address existing syntactic and semantic inconsistencies and to improve transparency, reproducibility, and comparability of different bike network evaluation approaches.

This research presents an ontology-based approach as a comprehensive guiding principle for harmonizing and comparing diverse frameworks and metric sets when assessing bike networks. We aim to ease the comparability of evaluation methods utilized for assessing bike networks across various domains, including public health, urban design, transport planning, and network sciences. The idea of using ontologies to structure and improve the transparency of evaluation frameworks has been adopted in other fields, such as sustainable development and urban planning (Binder et al., 2020).

We describe our methodology in two steps. First, we established the scope of our ontology by formulating the following competency questions: (1) Is a specific metric formulation consistent across relevant evaluations? (2) What type of criteria a specific metric measures? (3) Which metrics are included in a specific evaluation approach? Second, we conducted a comprehensive literature review of existing bike network evaluation approaches and their associated metric sets. Third, we proposed a classification system, capturing key attributes of evaluation metrics and generated a machine-readable knowledge base containing metrics from 25 evaluation approaches, enabling a descriptive meta-analysis. We also adopted existing Ontology of Units of Measure (OM) (Rijgersberg et al., 2013) and a Foundation Ontology for Global City Indicators (Fox, 2015).

The encountered metrics can be structured in five key thematic categories: *Topological, Morphological*, *Contextual, Modal,* and *Infrastructural* metrics. Topological metrics primarily refer to typical centrality measures. Morphological metrics relate to the geometric configuration of the network. We classify land-use mix, accessibility, or noise pollution as contextual metrics. Modal metrics formalize dynamic traffic features such as volume. Infrastructural metrics encompass network properties, e.g., bike lane type. We suggest a *Composite* category to address the emergence of novel combined metrics (Sarlas et al., 2020). Other formally defined related evaluation components, namely *EvaluationMethod, EvaluationCriteria, MeasurementScale, AggregationFeature*, *WeightingSystem* and *ScoringScale,* can be explicitly linked to metrics via ontology object properties. The analysis results of the generated knowledge base highlight the diversity of bike network evaluation metrics: out of 276 encountered metrics, of which 174 are distinct, only a handful of metrics occur frequently. Similarly, although the consensus regarding the links between metrics and criteria varies, we observe distinct relations. For example, infrastructural metrics primarily evaluate safety and comfort, contextual metrics – accessibility and attractiveness, and morphological metrics – connectivity.

While our introduced ontology-based principle to describe evaluation metrics make existing metric discrepancies explicit and enhances clarity of network evaluation metrics and interpretability of what the constituents of a high-quality bike network are, we recognize our approach infancy. For example, dynamic factors, such as cycling culture, individual behavior, and technological developments, like electric batteries, should be integrated in the future. Furthermore, the list of encountered metrics is not exhaustive and should be extended.

In summary, we have proposed an ontology-based formulation of bike network evaluation metrics in response to a crucial concern that revolves around the need for a comprehensive and unified approach to evaluating bike networks. The main contributions of our research include the classification and establishment of an ontological structure for bike network metrics. This approach can guide transparent, reproducible, and comparable metric selection when considering various network evaluation approaches. We envision two future tasks: 1) involving domain experts in ontology validation, and 2) demonstrating a practical applicability of our ontology by utilizing it to guide the selection of evaluation metrics to develop a GIS-based evaluation tool for an optimal bike network design in Zurich, as a part of E-Bike City project (Axhausen, 2022).

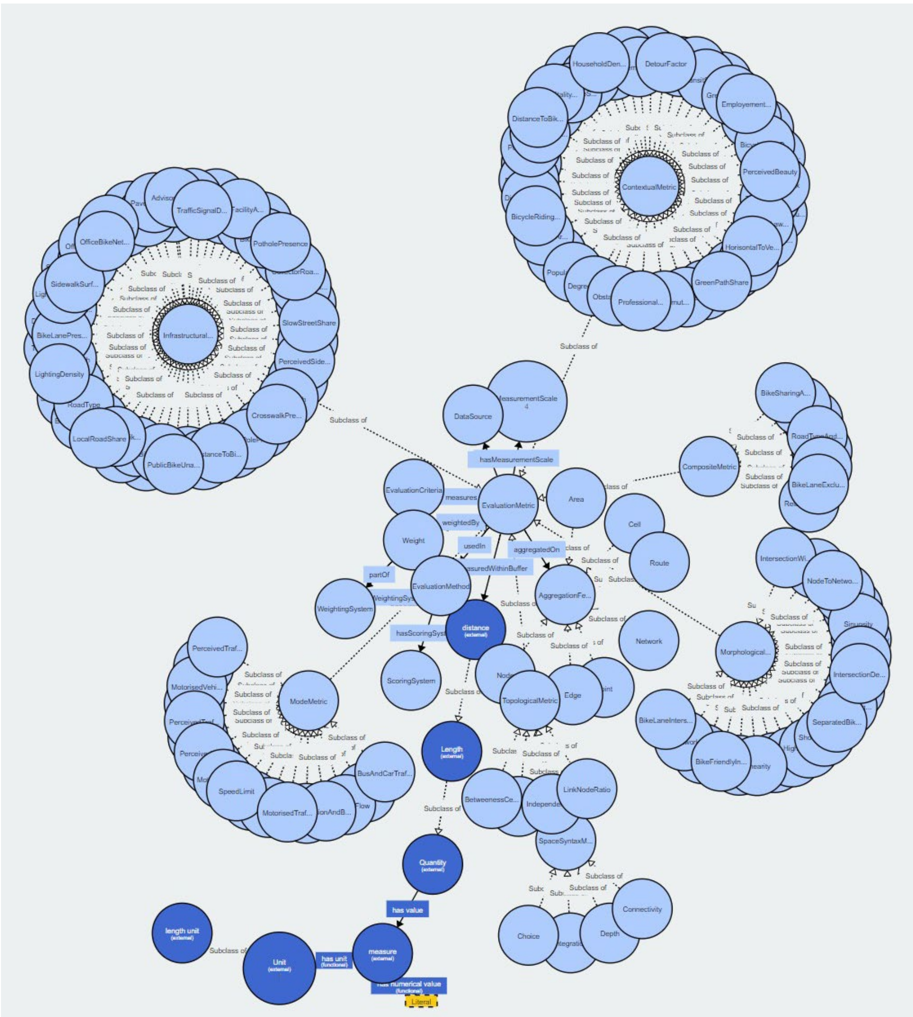

Figure 1. The initial bike network evaluation metric ontology (NEMO) concept network.

References

Axhausen, K. W., 'Can we capture the effect of an e-bike city?: Idea and challenges', Nov. 2022, doi: 10.3929/ETHZ-B-000579993.

Binder, C. R., Wyss, R., and Massaro, E., Eds., 'Sustainability Assessment of Urban Systems', 1st ed. Cambridge University Press, 2020, doi: 10.1017/9781108574334.

Boeing, G., 'OSMnx: New methods for acquiring, constructing, analyzing, and visualizing complex street networks', Comput. Environ. Urban Syst., vol. 65, pp. 126–139, Sep. 2017, doi: 10.1016/j.compenvurbsys.2017.05.004.

Cervero, R., Denman, S., and Jin, Y., 'Network design, built and natural environments, and bicycle commuting: Evidence from British cities and towns', Transp. Policy, vol. 74, pp. 153–164, Feb. 2019, doi: 10.1016/j.tranpol.2018.09.007.

Fox, M. S., 'The role of ontologies in publishing and analyzing city indicators', Comput. Environ. Urban Syst., vol. 54, pp. 266–279, Nov. 2015, doi: 10.1016/j.compenvurbsys.2015.09.009.

Grigore, E., Garrick, N., Fuhrer, R., and Axhausen, K. W., 'Bikeability in Basel', 2018, doi: 10.3929/ETHZ-B-000283763.

Kazemzadeh, K., Laureshyn, A., Winslott Hiselius, L., & Ronchi, E., 'Expanding the Scope of the Bicycle Level-of-Service Concept: A Review of the Literature', Sustainability, 12(7), 2944, 2020, https://doi.org/10.3390/su12072944.

Knight, P. L., and Marshall, W. E., 'The metrics of street network connectivity: their inconsistencies', J. Urban. Int. Res. Placemaking Urban Sustain., vol. 8, no. 3, pp. 241–259, Jul. 2015, doi: 10.1080/17549175.2014.909515.

Lowry, M., and Loh, T. H., 'Quantifying bicycle network connectivity', Prev. Med., vol. 95, pp. S134–S140, Feb. 2017, doi: 10.1016/j.ypmed.2016.12.007.

Prato, C. G., Halldórsdóttir, K., and Nielsen, O. A., 'Evaluation of land-use and transport network effects on cyclists' route choices in the Copenhagen Region in value-of-distance space', Int. J. Sustain. Transp., vol. 12, no. 10, pp. 770–781, Nov. 2018, doi: 10.1080/15568318.2018.1437236.

Rérat, P., and Ravalet, E., 'The politics of velomobility: Analysis of the vote to include cycling in the Swiss Constitution', Int. J. Sustain. Transp., vol. 17, no. 5, pp. 503–514, May 2023, doi: 10.1080/15568318.2022.2068388.

Reck, D. J., Martin, H., and Axhausen, K. W., 'Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility', Transp. Res. Part Transp. Environ., vol. 102, p. 103134, Jan. 2022, doi: 10.1016/j.trd.2021.103134.

Reza, S., Ferreira, M. C., Machado, J. J. M., and Tavares, J. M. R. S., 'Road networks structure analysis: A preliminary network science-based approach', Ann. Math. Artif. Intell., Sep. 2022, doi: 10.1007/s10472-022-09818-x.

Rybarczyk, G., and Wu, C., 'Examining the Impact of Urban Morphology on Bicycle Mode Choice', Environ. Plan. B Plan. Des., vol. 41, no. 2, pp. 272–288, Apr. 2014, doi: 10.1068/b37133.

Sarlas, G., Páez, A., and Axhausen, K. W., 'Betweenness-accessibility: Estimating impacts of accessibility on networks', J. Transp. Geogr., vol. 84, p. 102680, Apr. 2020, doi: 10.1016/j.jtrangeo.2020.102680.

Weikl, S., and Mayer, P., 'Data-driven quality assessment of cycling networks', Front. Future Transp., vol. 4, p. 1127742, Mar. 2023, doi: 10.3389/ffutr.2023.1127742.

Winters, M., Brauer, M., Setton, E. M., and Teschke, K., 'Mapping bikeability: a spatial tool to support sustainable travel', Environ. Plan. B Plan. Des., vol. 40, no. 5, pp. 865–883, 2013, doi:10.1068/b38185.

Methodology for Planning and Designing Bicycle Lanes Networks in Small Cities

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Keywords

Mobility, planning, design, bicycle lane, microsimulation

Challenge Addressed / Research Problem Investigated

Absence of a systematic methodology for planning and designing bicycle lane networks in small cities.

Abstract

In comparison to intermediate and large cities, small cities offer significant advantages for developing strategies and projects aimed at mitigating the impact of greenhouse gas emissions generated by urban mobility. In this comparative context, sustainable urban mobility projects in small cities may require lower financial resources and shorter project development time. The primary goal of this study is to present an effective methodology for the planning and design of bicycle lanes networks in small cities. This methodology aims to facilitate decision-making, be replicable, save time and resources, and result in a bicycle lanes network that meets quality standards for users and generates benefits in various areas of societal development.

In the literature review, no methodological work was found that systematically outlines the procedure for planning and designing bicycle lanes in small cities. Therefore, this research sets out to address this challenge with the premise that its methodology can be replicated in similar cities. This work entails the development of a methodological proposal for planning and designing bicycle lanes networks in small cities, prioritizing potential user demand. The proposed methodology involves six steps, including the identification of trip attractors, the delineation of an analysis area, route planning, the creation of a road inventory, geometric design development, and the evaluation of levels of service to measure the impact on vehicular traffic on the affected streets.

The process of identifying trip attractors involves classifying destinations into six distinct categories: recreational, meetings, work, health, education, and transfer. To delimit the analysis area, focused spaces are established based on the concentration of these attractors, taking into account delimiters representing zoning barriers or limits. The layout of the bicycle lanes network is carried out by creating direct connections from access points to the analysis area to exits, with a special emphasis on covering destinations related to work, education, health,

and transfer. The road inventory to be modified provides specific details about identification, sections, directionality, surface, road geometry, and hierarchy of each road included in the layout. The geometric design of the bicycle lanes network carefully considers the redistribution of space in roadways, sidewalks, and medians, seeking safe possibilities and alternatives that contribute to calming the streets through safety, comfort, coherence, attractiveness, and complementary facilities. To assess the impact of implementing bicycle lanes on levels of service, two traffic simulations are performed at selected intersections within the network. These intersections are chosen based on criteria such as proximity to attractors, traffic volume, or crossings of different hierarchies, and are conducted using specialized software. The first simulation employs vehicular traffic flow during peak demand hours with the current road geometry obtained from the road inventory, while the second simulation uses the same vehicular traffic flow and the proposed design geometry. Subsequently, the results are compared. Following the proposal of the bicycle network, a quality assessment is conducted using a weighting matrix for each lane in the network. The criteria considered at the time of proposing the layout are rated in greater detail, providing valuable information to identify potential deficiencies in the network and assign a quality rating.

This research presents a methodology for the planning and design of bicycle lanes networks in small cities, representing a contribution to urban planning, promoting sustainable mobility, and aiding in the fight against climate change. To implement this methodology, it is recommended to develop a socialization plan, use precision equipment for designing safer intersections, address deficiencies found in the evaluation of bicycle lanes, provide parking facilities, collaborate on projects related to pedestrian mobility, blue and green infrastructures, safe area development, vehicle parking organization, and the reduction of motor vehicle traffic lanes, among other measures.

Planning regional cycling networks - an example from the state of Baden-Wuerttemberg

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Keywords
Cycling network, Separated cycling infrastructure, Model, Planning data, Prioritization

Challenge Addressed / Research Problem Investigated
We developed an objective, data-based approach to the question of where new cycleways are needed outside urban areas in a statewide cycling network.

Abstract
Due to the limited range of distances in cycling, research on network planning focuses on urban networks (Gerike und Parkin 2016) (Boisjoly und El-Geneidy 2016) (Reggiani, et al. 2022). However, regional network planning is an important step towards bicycle-friendly transport systems. In densely populated, polycentric regions like in many parts of Europe, distances between cities and towns are often bikeable. Nevertheless, depending on the local administrative structure and cycling tradition, bicycle infrastructure is often missing outside urban areas. On top of that, with the growing number of pedelecs, also the cycling distances tend to grow which is why inter-city and regional cycling infrastructure gains more and more importance.

In order to efficiently close missing links on regional routes, it is necessary to build a network first. This is a complicated task on a regional level, because additionally to road infrastructure such as regional, state and federal roads there are also touristic routes e.g. along non-asphalted service roads. Therefore, the state of Baden-Wuerttemberg commissioned a research study for building a state-wide network and defining a project list for the planning of new cycle ways. As the state of Baden-Wuerttemberg is only responsible for bicycle infrastructure along federal and state roads outside urban areas, the study is limited to this type of bicycle infrastructure. However, the methodology in general is not limited to this case.

The infrastructure data used stems from three different sources:

- A model of all classified roads including information on traffic volumes, speed limits and the existence of separated cycling paths outside urban areas
- An existing cycling network for Baden-Wuerttemberg, that has been developed since 2014 but covers primarily central places of high and middle order. In this network, infrastructure standards are higher than for normal cycling routes. ("RadNETZ BW", hereafter referred to as "high quality routes").

- A touristic cycling network, containing information on the surface material (hereafter referred to as "touristic routes")

A node-link-model was built from these three networks to achieve an integrated and holistic overview of all available routing options for cyclists.

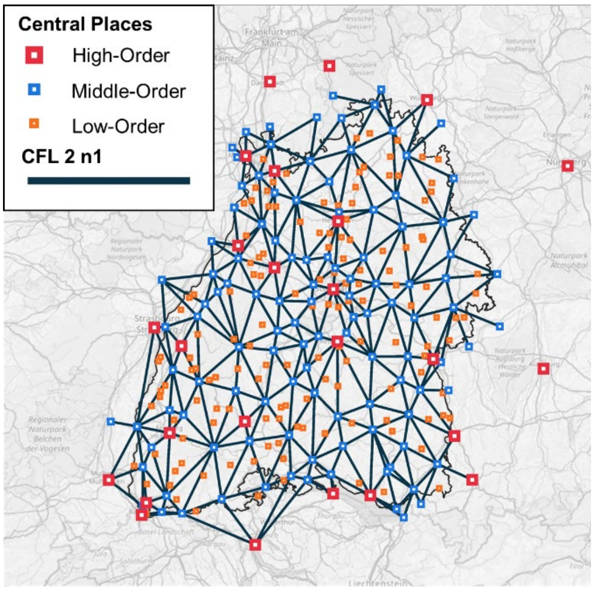

Figure 1: Central places and relations of connectivity function level 2 to the nearest neighbor (background map: © OpenStreetMap contributors).

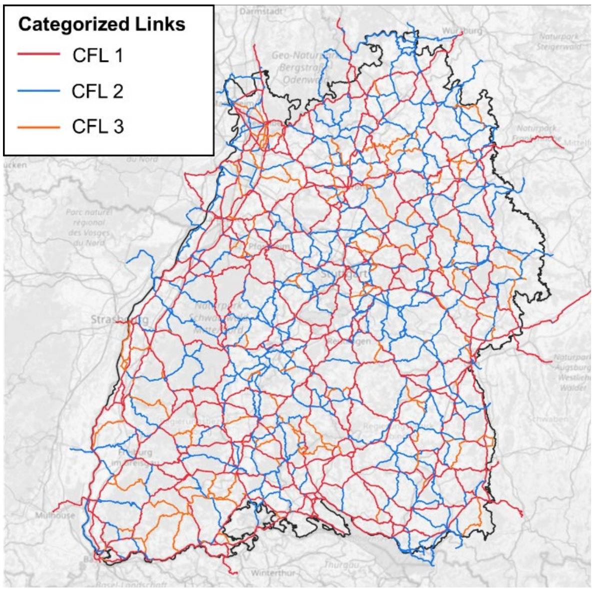

Figure 2. Map of the resulting categorized links with level of connectivity function 1 to 3 for cycling in Baden-Württemberg (background map: © OpenStreetMap contributors).

NETWORK BUILDING AND CATEGORIZATION

For building the bicycle network, a method for categorizing transport networks according to their function in the context of spatial planning described in the German guidelines for integrated network design (RIN) (Forschungsgesellschaft für Straßen- und Verkehrswesen 2008) was used. In the first step, the connections between the central places in Baden-Württemberg and their nearest and second nearest neighboring central place are built. Figure 1 shows the central places considered in the study, as well as the connectivity function level 2 to the nearest neighbor, which connects the middle-order centers. The links in the network are categorized according to their connectivity function. To determine the connectivity function, a route selection for all the considered relations must take place. In an all-or-nothing traffic assignment, routes are searched for each relation with a connectivity function. The high-quality routes as well as state and federal roads were prioritized in this step over touristic routes. The connectivity function of the relation is then assigned to the links of the resulting route.

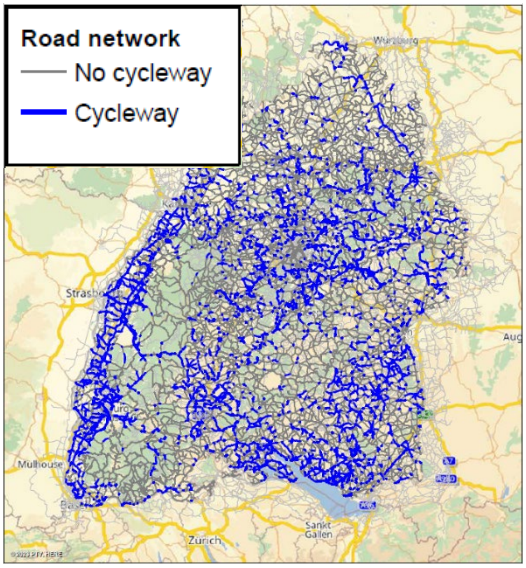

Figure 3. State and federal roads with and without separated cycle ways (background map: Here maps).

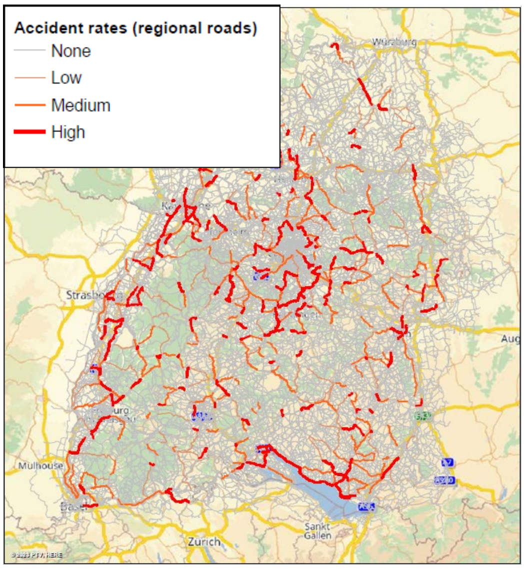

Figure 4. Categorization of the network links regarding traffic accident density (background map: Here maps)

Table 1. Indicator set and corresponding weights for assessing the relevance of a separated cycle way in a given network link.

Indicator	Weight
Connectivity function level	0,15
Bicycle traffic volume (actual)	0,1
Bicycle traffic volume (forecast 2030)	0,1
Relevance for school trips (Number of schools in distance of max. 3 km of link)	0,1
Feeder function for fast bicycle routes (predicted bicycle traffic volumes on link connecting to a planned fast bicycle route)	0,1
Yearly accident rate (accidents with cyclists involved from 2017 to 2019 divided by three years and the link length)	0,25
Motorised traffic volume	0,2 (The maximum rating of all three aspects is used)
Heavy traffic volume	
Speed limit	

ASSESSING THE RELEVANCE FOR SEPARATED CYCLE WAYS

In order to prioritize between potential links for new cycle ways, we defined a set of indicators that describe the relevance of a separated cycle way on a given link (see Table 1). One indicator is the connectivity level function derived from the first step. Another important indicator is the expected bicycle volume. Using a methodology described in the guidelines for potential assessment of fast cycle routes (Lange und Malik 2019), we estimated the bicycle demand in the entire network. This was done for the current network using modal split data from the mobility survey "Mobility in Germany" from 2017 (Bundesministerium für Verkehr und digitale Infrastruktur 2017). On top of that, a forecast for 2030 was developed, accounting for Baden-Wuerttembergs goal to increase the share of bicycle trips to 20% of all trips by the year 2030. Furthermore, we analyzed traffic accidents with cyclists involved. Also, the relevance for commuter and school trips was evaluated by analyzing the spatial location of schools and planned fast cycle routes.

DEFINITION OF GAPS TO BE CLOSED

Finally, in the network of all categorized links, links without appropriate infrastructure had to be identified. Appropriate infrastructure was defined as a separated cycle way or a road with low traffic volumes and speed limits in accordance with the German design guidelines for bicycle infrastructure (Forschungsgesellschaft für Straßen- und Verkehrswesen 2010). Infrastructure gaps were automatically defined for the entire network. Due to the high number of links showing missing infrastructure, only links with a rating of 60 % or higher (in relation to the maximum possible rating) from the step before were analyzed more closely. For these links, it was checked whether parallel routes using other road types are appropriate alternatives. In this case, a certain infrastructure standard along this route will have to be established, but it is not necessary to build a new cycle way. Otherwise, a new cycle way is necessary, i.e. the link will be part of the infrastructure project list. This check had to be done manually.

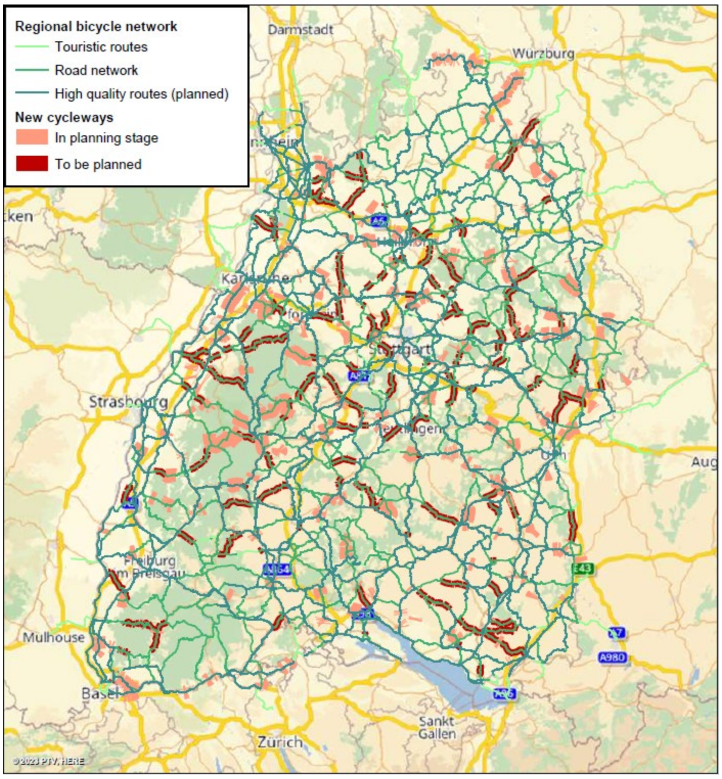

Figure 5. The resulting cycling network and the needs for cycle way construction.

As a second source of information, the 44 district administrations in Baden-Wuerttemberg were asked to report missing cycle ways in their territory. All reported gaps lying on a categorized link were added to the resulting list of infrastructure projects. Reported missing links outside the network were added, if they improved the service quality of the regarded connectivity function levels.

CONCLUSION

The methodology used in the research project allows for a long-term, transparent and objective infrastructure planning of regional cycle ways outside urban areas. Baden-Wuerttemberg had already been planning the construction of 840 km new cycle ways until 2030. As an outcome of the research project, another 1200 km are planned until 2040, which will contribute to building a closed state-wide network. The rating of all network links provides a basis for an objective selection of projects and their prioritization. Furthermore, the network model that was built gives a complete overview of the current data base on this planning level for the state of Baden-Wuerttemberg.

References

Boisjoly, Geneviève, et al. Bicycle network performance through directness and connectivity measures, a Montreal, Canada case study." *Transportation Research Board 95th Annual Meeting.* Washington, 2016.

Bundesministerium für Verkehr und digitale Infrastruktur. „Mobilität in Deutschland." 2017.

Forschungsgesellschaft für Straßen- und Verkehrswesen. *Empfehlungen für Radverkehrsanlagen.* Köln: FGSV-Verlag, 2010.

Forschungsgesellschaft für Straßen- und Verkehrswesen. *Richtlinien für integrierte Netzgestaltung.* Köln: FGSV Verlag, 2008.

Gerike, Regine, and John Parkin. „Strategic planning of bicycle networks as part of an integrated approach." In *Cycling Futures: From Research into Practice*, 115-136. Routledge, 2016.

Lange, Peter, and Jan Malik. *Radschnellverbindungen. Leitfaden zur Potenzialanalyse und Nutzen-Kosten-Analyse.* Bergisch Gladbach: Bundesanstalt für Straßenwesen, 2019.

Reggiani, Giulia, et al. „Bicycle network needs, solutions, and data collection systems: A theoretical framework and case studies." *Case Studies on Transport Policy* 10, Nr. 2 (2022): 927-939.

Evaluating willingness-to-pay for cycling infrastructure in Switzerland

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Challenge Addressed / Research Problem Investigated

While it is clear which elements of cycling infrastructure is generally preferred by most cyclists, quantifications of willingness-to-pay for these infrastructures are rare and necessary for building up modelling, evaluation and prioritization methods for cycling infrastructure.

Abstract:

The quality of cycling infrastructure is known to play an important role for cycling rates and cycling route choices. In this study, the preferences of cyclists concerning route choice is examined in a stated-preference (SP) experiment. The differential of this study is that it forces study participants into a trade-off between travel times and infrastructure quality, thus allowing the es-timation of willingness-to-pay (WTP) values, in terms of travel times, for quality improvements of cycling infrastructures. The elements varying in the SP experiment are:

- Street type (neighborhood vs. main streets)
- Cycling infrastructure (lane or path)
- Cycling infrastructure width
- Cycling infrastructure marking for neighborhood streets (coloring, symbols)
- Car parking available or not
- Speed limits
- Car traffic volumes

The experiment was first conducted as part of the EBIS (E-Biking in Switzerland) study and while still ongoing, already encompasses over 3'000 respondents over all regions of Switzerland (be-sides Ticino) and e-bikers as well as conventional cyclists. Since the sample is strongly biased towards frequent cyclists, other participants were recruited through a polling institute to also in-clude individuals who do not cycle frequently.

Methodologically speaking, the choices were analyzed with discrete choice models, namely mul-tinomial logit models (MNL), mixed logit models (MIXL), to understand the variability of pref-erences as well as latent class models (LC), to understand how preferences vary across different groups of cyclists. The LC models will only become truly relevant when embedding the responses from the second wave as well.

The results so far encompass participants of the first wave consisting predominantly of frequent cyclists. The results of first MNL and so far, are in line with the existing literature in terms of the elements that are valued the most in the cycling infrastructure. The highest WTP values in main streets are found for the following elements (in decreasing order): physically separated cycling lanes, wide cycling infrastructure and absence of parking.

For neighborhood streets, which have no separated cycling infrastructure from cars, particularly high WTP's are found for the following elements (in decreasing order): lower car traffic volumes, absence of car parking and on-street paint and symbology. Also, generally, neighborhood streets are preferred against main streets. In sum, as in the literature, the results show that the highest preferences are in place for elements that separate cyclists from car traffic the most.

The most interesting findings are the differences between the different user groups, which show significant results. S-Pedelec (45 km/h) have the least preferences for improved cycling infra-structure, followed by conventional cyclists and E-Bikers (25 km/h). The latter are the most sen-sitive to improved cycling infrastructure. This is mostly related to the sociodemographics of this group though. The preferences and needs of these different groups are especially relevant in Swit-zerland given the fast and wide spread of E-Bikes in general and fast S-Pedelecs in particular.

In the next months the work will focus on understanding the differences between the different cycling (and non-cycling) groups based not only on mobility tool ownership, but also on wider sociodemographic characteristics. Latent class models and mixed logit models will be the main tools used for producing the relevant findings. These results will the be presented and discussed at the CRB meeting.

The radical monopoly of cars and its alternatives: Athens amidst other European metropolises

Orestis Paschalinas

Challenge Addressed / Research Problem Investigated

Examine if the extent of public (rail) transport availability of European megalopolises, in comparison to Athens, influences motorisation rates and sets a precedent for developing a cycling infrastructure or not.

Abstract

Previous studies show that public transport availability inversely correlates with car dependency in European metropolises. A dense network of supplied public transport infrastructure and services creates a cultural precedent for citizens and policy-makers. This cultural precedent makes it easier to prove the feasibility of a cycling infrastructure that takes urban space from the private car. In general, it makes a better case for promoting cycling as a viable and trustworthy means of mobility. In this study, Athens, Greece, is used as a case study of a European metropolis where no successful challenge took place of the radical monopoly during the postwar dominance of cars and motorcycles.

Today, Athens stands out from all European metropolises with its extreme motorisation rate of cars and motorcycles. This is proven by comparing Athens to more than 40 European cities with over one million people in terms of (a) public rail transport availability, (b) urban density, (c) motorisation rates per population and surface area, examining correlations between the former (a) and the latter (c). In addition, other cultural norms are briefly examined as possible determinants.

This study re-emphasises the importance of 'efficiency' in public discourse in cities that suffer from the aforementioned social ill of a radical monopoly of cars as a distorted affluent status. The study strives to point out something that is not a given: that non-motorised mobility provides an average sustainable speed for most citizens, and this can be an efficient way of mobility, especially from and to workplaces.

This is not to negate the notion that mobility should invoke the Homo ludens in us, mobility as play and as a celebration of autonomy. The notion of mobility as a common good is the broader understanding that some academics have rightly envisioned, but this, one could argue, came to fruition from a critique of an older antithesis where two poles existed: car mobility on one side and a sound system of public transportation with a cycling infrastructure on the other. That is not a given situation in some cities of Europe.

This "old" idea contradicts the speed and efficiency of the automobile within the city with another alternative (the bicycle for this study) on the same grounds. For some cities, the initial stage of relative truth, of just displaying the antithesis with two ends (where one is nonexistent, like cycling infrastructure and a significant cycling modal share in Athens), is the gate to a broader truth that is already clear in the academic realm. The second stage of this more general

truth comes to fruition as a sublation superseding the discussion around instantaneous speed and efficiency. Still, it preserves an aspect that is reasonable in higher thought.

It is demonstrated that this is a crucial factor for changing human behaviour in European cities with lower purchasing power and weaker economies but still affluent to maintain a high motorisation rate. Those cities do not suffer from an excess of AI models, autonomous cars, bicycle highways, guidelines, manuals, and sophisticated algorithms that are efficient in any way whatsoever. They suffer from a lack of an organised state setting a vision to meet the expectation of mobility demands of its own citizens. A policy beyond letting the city work on the grounds of 'every individual for himself'. A policy beyond having an invisible state which compensates for its inefficiency by being lenient to citizens' unlawful behaviour. Inefficiency, which in itself, then becomes the breeding ground for the prevalence of anti-social individualistic mindsets and practices.

Cities like Athens suffer not so much from efficiency but from the lack of development of any kind of urban mobility policy planning that envisions anything else but trying to control and contain mobility chaos. This reality of mobility is, in a peculiar sense, mobility of play, autonomy, and anarchy. It is a notion of doing whatever one wants by himself regardless of law or corporate restrictions and spending time in the street as much as one desires. Mediated, however, not by sustainability and the right of the slowest but via a most tragicomic perverse form, by the rule of the strongest, i.e., the car and the motorcycle, at the expense of everyone else.

In the above line of thought, this study revisits the proposed urban cycling scheme of 226 km lanes (which has yet to be implemented) by the Athens cycling community and peer-reviewed by academics (2012). It adds insights as a viable alternative on the grounds of speed and efficiency during business rush hours in Athens. The study shows a comparative dataset of time spent during rush hour to cover numerous routes of the network. Along with the data analysis of European cities in different categories of indicators, using sources from national and regional statistical agencies, Google Maps / Citymapper estimated times, crowdsourced application data and on-site data collection via cycling with a conventional and an e-bike.

References

Dimitris Milakis, Konstantinos Athanasopoulos, Evangelos Vafeiadis, Konstantinos Vasileiadis, Thanos Vlastos, (2012). Planning of the Athens Metropolitan Cycle Network using Participative Multicriteria Gis Analysis. *Procedia - Social and Behavioral Sciences*, Volume 48, pp. 816-826.

Pedram Saeidizand, Koos Fransen, Kobe Boussauw, (2022). Revisiting car dependency: A worldwide analysis of car travel in global metropolitan areas. *Cities*, Volume 120, 103467.

Ali Enes Dingil, Joerg Schweizer, Federico Rupi, Zaneta Stasiskiene, (2018). Transport indicator analysis and comparison of 151 urban areas, based on open source data. *European Transport Research Review*. Volume 10, Issue 2, 58.

Thalia Verkade, Marco te Brömmelstroet, (2022). *Movement: how to take back our streets and transform our lives*. Scribe Publications.

Ivan Illich, *Energy and Equity*, (1974). Thessaloniki, Greece: Nissides publications (in Greek, 2019).

Cost benefit analysis and bicycle infrastructure investments are friends

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Abstract

INTRODUCTION

Cost-benefit analysis (CBA) is a decision tool for infrastructure assessment intended to express all relevant societal effects in monetary terms. The framework simplifies the process of comparing projects and streamlines the task of prioritizing them. Despite the criticisms regarding its limitations in capturing unquantifiable project benefits, CBA remains the prevailing method used by policy makers to assess and evaluate transport infrastructure projects (e.g., Beukers et al., 2012).

Although CBA of bicycle infrastructure projects are still rare (Brown et al., 2016; Paulsen & Rich, 2023b), studies such as Chapman et al. (2018), Paulsen & Rich (2023a), Rich et al. (2021), and Sælensminde (2004) suggest that the socio-economic performance and, in particular, efficiency of bicycle infrastructure projects is extremely high, indicating that they are likely to largely outperform infrastructure investments for other transport modes. This is primarily rooted in limited investment needs (costs) and the health benefits associated with them.

This leads to the discussion point we would like to raise at the conference, namely that cycling infrastructure and CBA are friends. While certain effects, such as urban liveability, perceived safety, and boundary effects, may not be adequately captured in CBA, investments in bicycle infrastructure tend to exhibit positive outcomes that are often systematically better than those for other transport projects when evaluated on similar terms.

METHODOLOGY AND DATA

As stated in Paulsen & Rich (2023a,b), the Net Present Value (NPV) summarising the absolute societal profit can be calculated for any set of upgraded network segments u as follows:

$$\mathrm{NPV}(\boldsymbol{u}) = \overbrace{\left(\sum_{t=2}^{50}\kappa^t\right)\sum_{\omega\in\Omega}\zeta_\omega\frac{D_\omega(\boldsymbol{u})+d_\omega^0}{2}\left(x_\omega^0-X_\omega(\boldsymbol{u})\right)}^{\text{Consumer surplus}} + \overbrace{\left(\sum_{t=2}^{50}\kappa^t\right)\sum_{\omega\in\Omega}\xi_\omega\left(D_\omega(\boldsymbol{u})\Lambda_\omega(\boldsymbol{u})-d_\omega^0\lambda_\omega^0\right)}^{\text{Health benefits}}$$
$$+\overbrace{\kappa^{50}\sum_{b\in\mathscr{B}}c_b u_b}^{\text{Scrap value}} - \overbrace{\kappa^1\sum_{b\in\mathscr{B}}c_b u_b}^{\text{Construction costs}} - \overbrace{\left(\sum_{t=2}^{50}\kappa^t\right)\sum_{b\in\mathscr{B}}m_b u_b}^{\text{Maintenance costs}}. \quad (1)$$

Due to space restrictions we cannot describe all the used notation, for which we refer to Paulsen & Rich (2023b). Instead we summarise that the NPV includes i) the consumer surplus, ii) health benefits which are proportional to the total kilometres ridden by bicycle, iii) the scrap

value representing the residual worth of investments, iv) the construction costs of selected network segments, and v) the corresponding annual maintenance costs. All costs follow Incentive (2018) (and Paulsen & Rich, 2023a,b) and benefits are based on the model in Hallberg et al. (2021) (and Paulsen & Rich, 2023a), in which the function D_{ω} expresses the induced cycling demand for origin-destination pair ω resulting from changes to the infrastructure.

By adapting the official Danish guidelines for transport project appraisal, we conduct calculations to determine the NPV and the Internal Rate of Return (IRR) for 49 proposed cycle superhighway routes in and near Greater Copenhagen. Whereas the NPV measures the absolute welfare, the IRR indicates the relative socio-economic efficiency (the higher, the better). We compare the key performance indicators with those of 50 other transport infrastructure projects related to either road traffic or public transport.

RESULTS

As seen in Figure 1, the proposed bicycle infrastructure projects are generally considerable less expensive than road and public transport projects. Consequently, investing in bicycle infrastructure projects generally entails a lower risk due to the relatively low maximum potential loss involved. However, because projects are less capital intensive, the absolute welfare gain measured as NPV are also smaller. On the other hand, compared to the size of the investments, the projects are often relatively better, i.e. more efficient, as reflected per the IRR as seen in Figure 1 below.

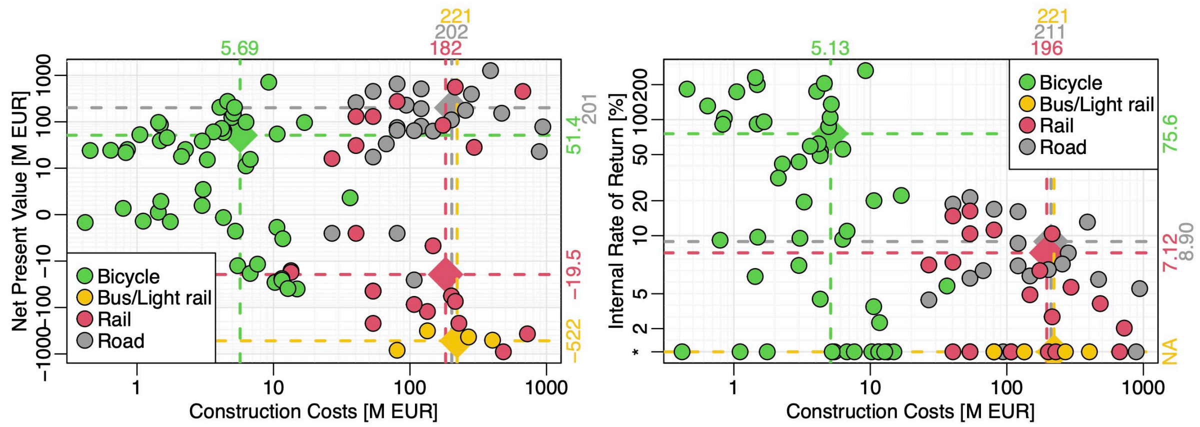

Figure 1: Performance measures NPV (left) and IRR (right) of 99 proposed Danish transport infrastructure projects. Diamonds and dashed lines represent average values per mode. All axes are non-linear. *IRR is unknown or lower than 1%. These projects are excluded from the calculation of averages for the IRR plot.

To maximize the overall socioeconomic impact (NPV), it can be advantageous to consolidate smaller projects into packages of projects that achieve a scale similar to larger projects. When doing this, it is relevant to consider which projects to include, as choosing the wrong projects can considerably undermine the socioeconomic performance as demonstrated in Paulsen & Rich (2023a,b).

Adding the NPV's of the 49 individual bicycle projects predicts a combined NPV of 2.71 bn EUR (not shown in the plot). However, properly evaluating the combined effect of building all projects jointly, yield an NPV of 3.28 bn EUR revealing synergistic effects worth 0.57 bn EUR. When only including the projects deemed to lead to positive welfare gains according to the model framework in Paulsen & Rich (2023a,b), the combined NPV increases by an additional 0.28 bn EUR leading to a total of 3.58 bn EUR.

CONCLUSIONS AND OUTLOOK

This abstract shows that, although CBA may not be able to include all welfare benefits of cycling infrastructure, such projects often performs well in standard cost-benefit evaluations. Synergistic effects are found when considering projects jointly. When combined with an optimal order of investments as proposed in Paulsen & Rich (2023a,b), a welfare gain of more than 3.5 bn EUR in NPV can be achieved.

For future research, it will be relevant to gather socio-economic efficiency measures of additional transport projects, for instance from other countries where e.g. health benefits per km differ and the market share of cycling is lower, in order to investigate to which degree the findings are transferable across countries.

Conclusively, the study shows that when bicycle infrastructure investments are measured by the same standards as other infrastructure investments, there is no contradiction between bicycle infrastructure investments and economic efficiency. In fact, quite the contrary; if decision makers aim for high efficiency, low risk of public funds, and fast execution, bicycle infrastructure projects should be accelerated further in the coming years. Hence, although there indeeed are fair points of criticism to raise against the CBA methodology, we want to bring to the conference that there are also solid arguments for why the cycling community should embrace the CBA framework for evaluation purposes. It ensures that concrete data and evidence are presented, making it challenging for politicians to bypass or avoid such investments.

References

Beukers, E., Bertolini, L. & Te Brömmelstroet, M. (2012). "Why Cost Benefit Analysis is perceived as a problematic tool for assessment of transport plans: A process perspective". Transportation Research Part A: Policy and Practice 46.1, pp. 68–78.

Brown, V., Diomedi, B. Z., Moodie, M., Veerman, J. L. & Carter, R. (2016). "A systematic review of economic analyses of active transport interventions that include physical activity benefits". Transport Policy 45, pp. 190–208.

Chapman, R., Keall, M., Howden-Chapman, P., Grams, M.,Witten, K., Randal, E. & Woodward, A. (2018). "A Cost Benefit Analysis of an Active Travel Intervention with Health and Carbon Emission Reduction Benefits". International Journal of Environmental Research and Public Health 15.5, p. 962.

Hallberg, M., Rasmussen, T. K. & Rich, J. (2021). "Modelling the impact of cycle superhighways and electric bicycles". Transportation Research Part A: Policy and Practice 149, pp. 397–418.

Incentive (2018). Samfundsøkonomisk analyse af supercykelstierne. Technical report.

Paulsen, M. & Rich, J. (2023a). Optimal bicycle network expansions with endogenous demand. Presentation at the 11th Symposium of the European Association for Research in Transportation (hEART), Zurich, Switzerland.

Paulsen, M. & Rich, J. (2023b). "Societally optimal expansion of bicycle networks". Transportation Research Part B 174, p. 102778.

Rich, J., Jensen, A. F., Pilegaard, N. & Hallberg, M. (2021). "Cost-benefit of bicycle infrastructure with e-bikes and cycle superhighways". Case Studies on Transport Policy 9.2, pp. 608–615.

Sælensminde, K. (2004). "Cost-benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic". Transportation Research Part A: Policy and Practice 38.8, pp. 593–606.

Analysing Regression Methods to Estimate Network-Wide Bicycle Traffic Volumes Based on Crowdsourced GPS-Data

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Challenge Addressed / Research Problem Investigated

To estimate network-wide average daily bicycle traffic volumes using crowd-sourced GPS-data, permanent counter data and various regression methods.

Abstract

BACKGROUND

Cycling is considered as an environmentally friendly mode of transport which can help to reach CO2 saving goals (Buehler & Pucher 2011). Especially the trend towards more ebikes and the interconnected potential for longer trips can help to reduce CO2 emissions from traffic. To enhance the cycling mode share and the amount of travelled kilometres more and safe infrastructure is needed. Building processes, especially those with larger environmental impacts and/or higher costs need a solid prediction of future potentials in the planning process and a brief evaluation of the built infrastructure afterwards. For these tasks, it is crucial to have data regarding the bicycle travel demand. Since automatic permanent counting stations can only provide data for a few points in the cycling network, a combination with crowdsourced data is necessary. The German cycling campaign CITYCYCLING was carried out in more than 2,500 cities in 2022 and about 300,000 participants recorded more than 5 million rides. This data provides a very good network coverage and, in combination with the automatic counting stations, can predict the average daily bicycle (ADB) volumes across the whole network. Our contribution relies on the project MoveOn and will focus on new statistical methods and a dataset of more than 500 counters all across Germany to predict nationwide ADB volumes for planning purposes.

RELATED RESEARCH

So far, similar approaches to estimate network-wide ADB volumes are mostly limited to smaller planning areas as single cities (Hochmair et al. 2019; Lin & Fan 2020). The number of automated counting stations as reference values for the actual ADB at certain points in the network is generally low. In order to estimate ADB based on crowdsourced GPS-data and automated count data regression models are used. Previous studies widely use linear (Livingston et al. 2021) or Poisson (Dadashova et al. 2020) regression models to estimate ADB from crowdsourced GPS data. Dadashova uses the Random Forest algorithm to determine the importance of Variables in a preceding step (Dadashova et al. 2020). In terms of model validation and evaluation few studies consider out-of-sample errors (Livingston et al. 2021). Most often, the error analysis is carried out for the same dataset that is used to build the regression models. Therefore, high correlation coefficients are obtained. But at the same time the informative value of these error analyses is strongly limited regarding the model's capability to estimate ADB at other points in the overall network than used in the provided dataset.

METHOD AND DATA

Although linear and Poisson regression can produce good results in estimating ADB, they are often limited by their requirements. Linear regression assumes linearity between predictor and response variables. Furthermore, real data is often overdispersed (Berk & MacDonald 2008), violating the assumption of equality of expected value and variance of the Poisson distribution in a Poisson regression. Accordingly, it is necessary to consider further regression models for prediction and compare their model scores and errors. For our purposes, Gradient Boosting and Random Forest are selected as treebased regression models. They both handle numerical and categorical data naturally. Additionally, they are robust to outliers, but hard to interpret. As a further model Support Vector regression is used, it has excellent generalization capability and high prediction accuracy. Unfortunately, there are many tuning hyperparameters that greatly affect the performance of the model. To combine the advantages of different models stacking ridge regression is used, which combines all or some of the beforementioned. In stacking regression the greatest improvement occurs when dissimilar models are combined (Breiman 1996), subsequently we stack Poisson, Support Vector and Random Forest regression. Our current data set contains n = 146 data points with all available automatic counting stations in the federal state of Hessia, (Germany) as response variable. The predictor variables are aggregated trajectory data from the CITYCYCLING campaign and information about the location of the automatic counting stations and the type of cycling infrastructure on the associated roads. After pre-processing the data for each model individually, we use a k-fold cross-validation to assess the generalization ability of each model. For k = 10 the estimate of prediction error is almost unbiased (Simon 2007). For hyperparameter tuning a grid search is used to maximize R2. To compare the models, we calculate R2 and the negative mean absolute error (NMAE).

RESULTS

With linear regression we obtained R2 = 0.54, NMAE= −213.54 and with Gradient Boosting R2 = 0.59, NMAE= −206.03. Figure 1 shows the performance of Random Forest, Support Vector, Poisson and Stacking regression. The performance of Poisson, Random Forest and Gradient Boosting regression differed only marginally. Support Vector regression has achieved better results in NMAE. Stacking regression outperformed all further tested models for both R2 and NMAE. Figure 1 visualizes that the predictions of Random Forest, Support Vector, Poisson and Stacking regression Predictions were more accurate for values less than the threshold $\theta := 1000$ than for values greater than θ. In addition it shows the lower density of data points with values greater than θ.

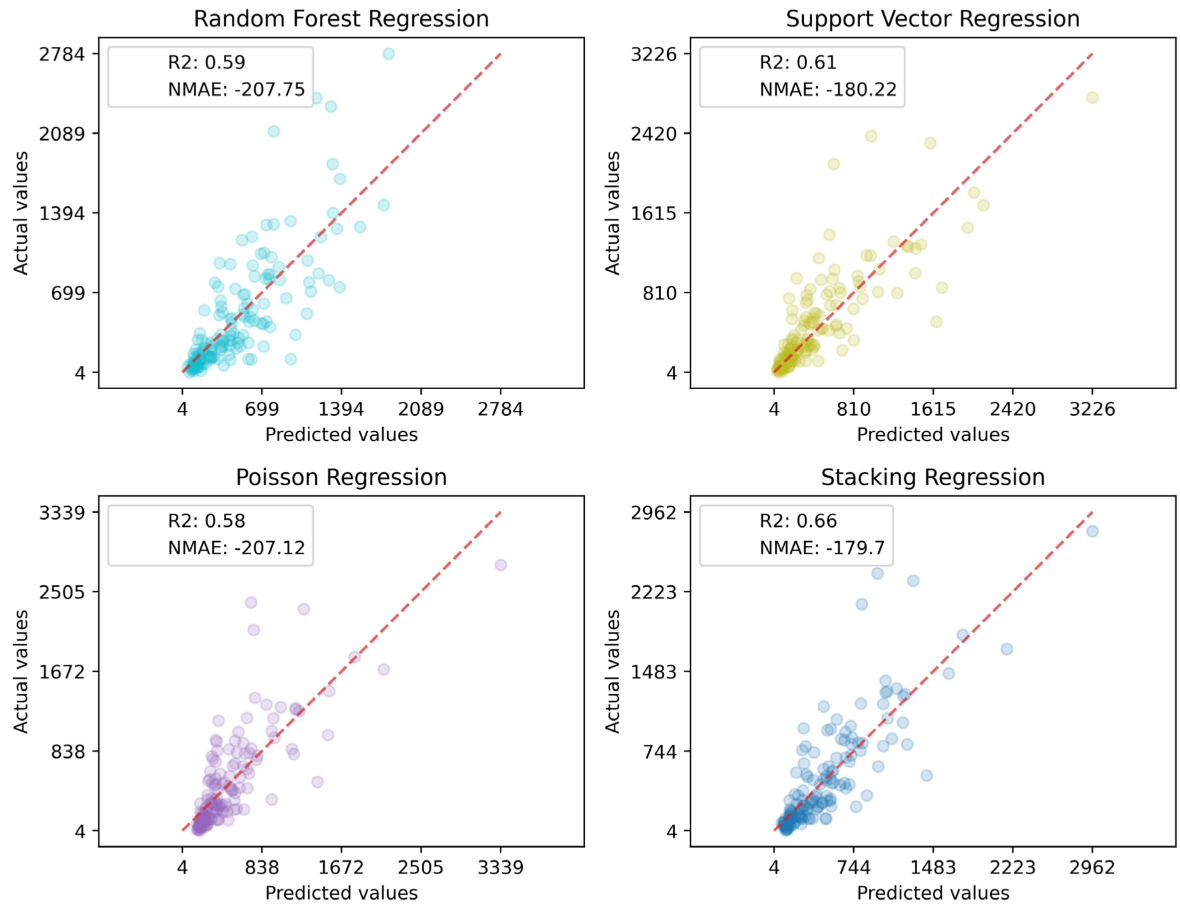

Fig. 1. Visualized cross-validated predictions and evaluated model scores with 10-fold cross-validation for different regression models

OUTLOOK

Until the end of 2024, we will collect and process further data and, in this way, continuously expand the data basis of our models. This will enable us to adapt and improve models after each new iteration of the CITY CYCLING campaign. Our goal is to provide ADB maps for the whole of Germany and integrate them into an online platform that provides planning data for municipal administration. We will gradually include more variables that describe, for example, the spatial distribution of cycling volumes in cities and their dependencies. In addition, we will extend our methodology in such a way that it will be possible to generate difference maps between two data years depending on variables such as the number of participants in the campaign or the weather. This will enable municipalities to monitor the success of cycling measures against fixed criteria.

References

Berk, R. & J. M. MacDonald (2008). "Overdispersion and Poisson regression". In: Journal of Quantitative Criminology 24, pp. 269–284.

Breiman, L. (1996). "Stacked regressions". In: Machine learning 24, pp. 49–64.

Buehler, R. & J. Pucher (2011). "Sustainable transport in Freiburg: lessons from Germany's environmental capital". In: International Journal of Sustainable Transportation 5.1, pp. 43–70.

Dadashova, B., G. P. Griffin, S. Das, S. Turner, & B. Sherman (2020). "Estimation of average annual daily bicycle counts using crowdsourced strava data". In: Transportation research record 2674.11, pp. 390–402.

Hochmair, H. H., E. Bardin, & A. Ahmouda (2019). "Estimating bicycle trip volume for Miami Dade county from Strava tracking data". In: Journal of transport geography 75, pp. 58–69.

Lin, Z. & W. D. Fan (2020). "Modeling bicycle volume using crowdsourced data from Strava smartphone application". In: International journal of transportation science and technology 9.4, pp. 334–343.

Livingston, M., D. McArthur, J. Hong, & K. English (2021). "Predicting cycling volumes using crowdsourced activity data". In: Environment and Planning B: Urban Analytics and City Science 48.5, pp. 1228–1244.

Simon, R. (2007). "Resampling strategies for model assessment and selection". In: Fundamentals of data mining in genomics and proteomics, pp. 173–186.

Modeling Bicycle Traffic – Influencing Factors and Parameterization

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Keywords
Literature review, use case, data collection concept, status quo analysis, target catalog

Challenge Addressed / Research Problem Investigated
There is a big potential to enhance the database used for modeling mode choice and route choice of cyclists regarding quality and quantity of data as well as the integration of bicycle transport in transport demand models.

Abstract
The bicycle is seen as playing an important role in realizing the mobility transition. Politicians promote bicycle traffic through funding programs, strategic plans and infrastructural investments. For example, goals stated within the framework of the National Cycling Plan include 1. an increase in the average number of trips made by bicycle, 2. an increase in the average length of these trips, and 3. a simultaneous improvement in road safety (BMDV, 2021). In recent years, one can indeed observe a modal shift towards more cycling, especially in urban areas (Mason & Yanocha, 2021).

The enhancement of data-driven transport planning tools is an additional field of action to accelerate the transition towards sustainable mobility. These tools enable transport planners and municipalities to identify infrastructural needs and to build demand-oriented cycling infrastructure. However, in the status quo, the explanatory power of transport demand models is lower for bicycle traffic than for motorized vehicle traffic. A main reason is that necessary data to model bicycle traffic in a realistic way is not available (Huber et al., 2019). Besides, many municipal administrations mentioned that they do not have sufficient personnel and technical resources to develop and improve databases and models (ibid.). As a result, urban planners and transport modelers often use simplified approaches to model bicycle traffic (Pillat & Manz, 2021) or they do not model it at all. For example, models are based on aerial distances rather than actually chosen routes and detour factors or average speeds instead of speed distributions by user groups are assumed (ibid.). For a more realistic and easy adaptable

modeling of bicycle traffic within current and future transport models, planners require further data and parameters describing the behavior of cyclists.

The objective of our contribution is to present a joint work on:

1. the factors influencing mode and route choice from previous empirical research,
2. the prioritization of the influencing factors from the perspective of transport modeling,
3. the comparison of the identified influencing factors with the database in the status quo as well as with existing consideration in transport models,
4. a use case to derive parameters to model bicycle traffic from the results of the literature review and a reproduction of these results in a transport demand model,
5. and an innovative survey concept to collect missing data.

We identified influencing factors separately for mode choice and route choice based on existing literature. Therefore, we examined 63 publications on mode choice and 47 publications on route choice by bicycle. In the first step, we compiled 383 statements on determinants of mode choice and 423 statements on determinants of route choice by bicycle. In the second step, we categorized the results. Factors influencing mode choice include socio-demographic and -economic characteristics, mode availability, cost components, temporal and spatial characteristics, weather, trip-related and subjective factors. Factors influencing route choice by bicycle include socio-demographic and -economic characteristics, bicycle types, temporal characteristics, spatial characteristics, weather, and subjective factors. All findings were prioritized from a modeling perspective in an online workshop and discussed with modeling experts.

Afterwards, we analyzed the models created by PTV Group in recent years with regard to the integration of bicycle traffic. The models analyzed include e.g., the multimodal transport demand models of Dresden, Augsburg, Munich and the national passenger transport model of Switzerland. In addition, we considered one research project and one master thesis. For each of the models, we collected the parameters used and evaluated still missing parameters. Supplementary, we added the data availability for each parameter.

Regarding mode choice, we summarized the effects (positive, negative, not significant) for each determinant. Since it is not possible to determine generalizing effects for route choice, quantifiable effects from the publications are given as examples. This data can be used to determine the parameters of transport models in such a way that they reflect the results of the publications. Therefore, a use case was developed and implemented. The determinant of the use case was topography. The empirical results of six publications provided the database for the use case (table 1).

Table 5: Publications evaluated within the use case regarding topography

Publication	Effect
Menghini et al. (2010)	Increase of maximum slope by 1% is perceived as increase in distance by 115 m
Prato et al. (2018)	Factors for calculating the perceived length from the longitudinal slope
Broach et al. (2012)	Factors for calculating the perceived length from the longitudinal slope
Motoaki et al. (2015)	Choice probability of a route as a function of its gradient differentiated by two classes of cyclists. Route A: 20 min, low traffic volume and gradient of X %. Route A: 10 min, high traffic volume and slope of 10%.
Hood et al. (2011)	The average cyclist avoids riding up a 10 m hill as long as the detour is less than 0.59 km.
Huber (2022)	For two identical routes, each with a 50% choice probability, increasing the proportion of route segments with a longitudinal slope > 2% by 10% causes the choice probability to decrease by 2.7%.

In the use case, three approaches to implement the influence of topography on bicyclists' route choice in transport demand models were observed. There parameters were calibrated to reflect the empirical results of the surveys. The resulting parameter sets can be compared and defined as ranges that can be used for future transport demand models. Based on interviews with experts and research on the state of the art of survey methods, we developed an innovative survey concept to collect missing data, which is necessary to determine further parameters for bicycle models.

Our results show that additional research is needed on the influence of personal and household characteristics, especially on income and education. With regard to transport modes, the existing data is not yet sufficient to model quantities of pedelecs and cargo bikes. Furthermore, it is not sufficiently evaluated whether pedelec riders spread their routes more widely and react less sensitively to certain parameters, such as topography, than users of conventional bicycles. The greatest need for research exists for time-related influencing variables, e.g.:

- The actual travel time for bicycling is unknown and is derived using routing engines.
- How large is time loss for cyclists at intersections?
- What are bicycle access times esp. at large bicycle parking facilities?
- How consistent is route choice? (No comparative data available)

Research is also needed on spatial influencing variables and the built environment, e.g.:

- How can differences in the network model and terrain model be detected?
- How can the influence of nature (green spaces, etc.) be quantified?

References

BMDV (2021). 2030–A cycling nation, National Cycling Plan 3.0, Berlin, Germany. https://bmdv.bund.de/SharedDocs/DE/Anlage/StV/nationaler-radverkehrsplan-3-0-en.pdf?__blob=publicationFile.

Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. Transportation Research Part a: Policy and Practice, 46(10), 1730–1740. https://doi.org/10.1016/j.tra.2012.07.005.

Hagen, T., Sunder, M., Lerch, E., & Saki, S. (2021). Effekte der COVID-19-Pandemie auf Mobilität und Verkehrsmittelwahl. Straßenverkehrstechnik (1), 7–14.

Hood, J., Sall, E., & Charlton, B. (2011). A GPS-based bicycle route choice model for San Francisco, California. Transportation Letters, 3(1), 63–75. https://doi.org/10.3328/TL.2011.03.01.63-75.

Huber, S. (2022). Analyse des Routenwahlverhaltens von Radfahrenden auf Grundlage GPS-basierter Daten zum real beobachteten Verkehrsverhalten, https://tud.qucosa.de/api/qucosa%3A79035/attachment/ATT-0/.

Huber, S., Lißner, S., & Francke, A. (2019). Utility of GPS data for urban bicycle traffic planning in germany: Potentiality, limitations and prospects. International Journal of Transport Development and Integration, 3(1), 1–14. https://doi.org/10.2495/TDI-V3-N1-1-14.

Mason, J., & Yanocha, D. (2021). Cycling Is Booming and Not Just Where You Think. https://www.itdp.org/wp-content/uploads/2021/09/CyclingisBoomingST33092021.pdf.

Menghini, G., Carrasco, N., Schüssler, N., & Axhausen, K. W. (2010). Route choice of cyclists in Zurich. Transportation Research Part a: Policy and Practice, 44(9), 754–765. https://doi.org/10.1016/j.tra.2010.07.008.

Motoaki, Y., Daziano, R., (2015). A hybrid-choice latent-class model for the analysis of the effects of weather on cycling demand, Transportation Research Part A 75 (2015) 217–230 . https://www.sciencedirect.com/science/article/abs/pii/S0965856415000592.

Pillat, J., & Manz, W. (2021). Modelle des Personenverkehrs. In D. Vallée, B. Engel, & W. Vogt (Eds.), Stadtverkehrsplanung Band 2 (pp. 273–339). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-59695-1_9.

Prato, C. G., Halldórsdóttir, K., & Nielsen, O. A. (2018). Evaluation of land-use and transport network effects on cyclists' route choices in the Copenhagen Region in value-of-distance space. International Journal of Sustainable Transportation, 12(10), 770–781. https://doi.org/10.1080/15568318.2018.1437236.

Modelization of cycling share heterogeneity between the center and the suburbs of French urban areas.

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Keywords
Cycling, Suburb, French urban area, Modelization, Spatial heterogeneity

Challenge Addressed / Research Problem Investigated
Quantify the respective weigths of factors of different kinds on the spatial heterogeneity of cycling between center, inner suburbs and outer suburbs of French functional urban areas.

Abstract

INTRODUCTION

For forty years, cycling, as a daily mode of transport, has been evolving in a very heterogeneous way within French urban areas. Cyclists have been more and more numerous in the centre parts but not in the inner suburbs where cycling has been decreasing, and in the outer suburbs where its decrease is very substantial[1]. The aim of my work is to enlighten the causes of the spatial heterogeneity of cycling in French urban areas. I mainly question the role of factors influencing cycling and I quantify their respective weights to explain the current opposition between the very low cycling suburban rates and the higher cycling rates in the centre. It resonates with a growing corpus of studies which try to enlighten characteristics of spatial context that favours cycling with model-based methodologies (Mertens et al., 2017; Gao et al. 2018, Koglin et al., 2022). However, many of these studies take place in the central part of urban areas where cycling is yet a significant part of the modal share (mainly cities of northern Europe) (Handy et al. 2014; Ledsham et al., 2022).

METHODOLOGY

Thus, I built a multivariate model with data mainly coming from travel surveys of five French functional urban areas (Toulouse, Strasbourg, Lyon, Tours and Nantes). I tested the relationship between a variable of interests (Did the individual surveyed take a trip by bicycle or not the day before?) and around thirty explanatory variables corresponding to factors that were highlighted as determinant to cycling according to the scientific literature. The explanatory variables depict characteristics of built and natural environment surrounding individuals' residences, characteristics of individuals' trips and their socio-demographic features. The first aim of the model is to point out the factors that are twinned with a higher probability for individuals to be cyclists. The second aim is to enlighten the role of these factors in the cycling rate gap between centre and suburbs. This gap can be fuelled by component effects (suburb

[1] In this study the components of the French urban area called « centre », « inner suburb » and « outer suburb » refer to the foreign classification of the French statistical institute (INSEE) that divided French urban areas in three parts according to morphological critters and according to a proportion of daily work commuters in a municipality

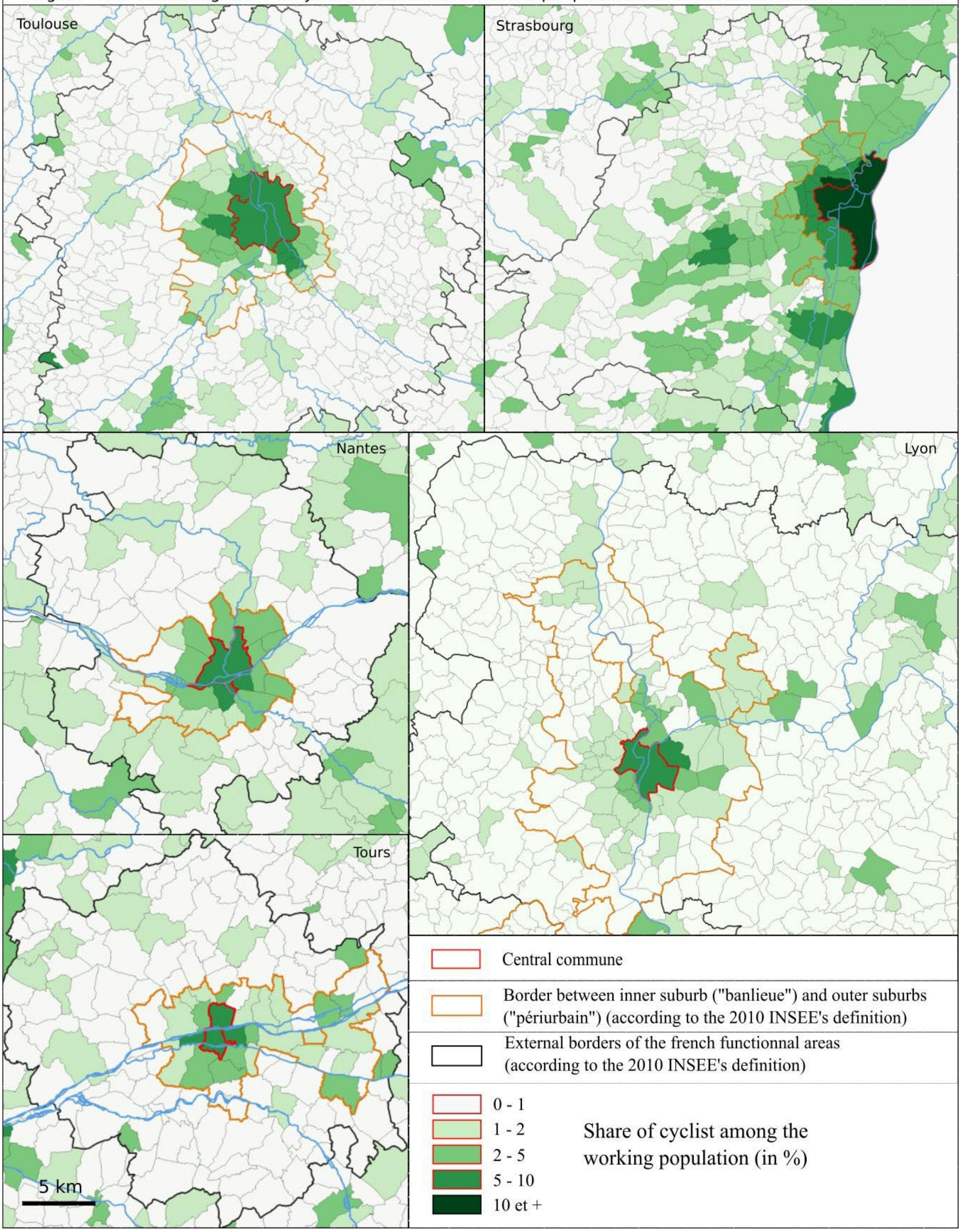
cycling rate is lower because there are less “bikeable” spaces in suburbs or because there is a smaller proportion of people who have features, or trip features, favouring cycling in suburbs than in the center), or by interaction effects (factors hindering cycling only act in the suburbs for instance).

MAIN RESULTS

Most of the explanatory variables tested in this model act as expected, but not with the same intensity according to the urban area considered. For instance, in Nantes and Toulouse, someone that lives in a neighbourhood where there is a high density of cycling infrastructures, has around 40% and 60% more chances, respectively, to be a cyclist compared to someone that doesn’t have any cycling infrastructures around his home. This advantage is not significative for the other three urban areas. Higher occupational groups and men have a higher probability to be cyclists than lower occupational groups and women in all the urban areas except Lyon where cyclist’s socio-demographic features seem to be more balanced. This model highlights above all the impact of people’s trips’ characteristics and the proximity to a bikeshare station: those who do little trips during a usual day and those who live close to a bikeshare station have a higher probability to be a cyclist in the five urban areas.

The results of my analysis show that the spatial distribution of cyclists in the five functional urban areas follows a decrease from the centre to the peripheries (Figure). The model results confirm that this decrease comes from a combination of factors that favors or disfavors cycling and that are unevenly distributed in the different parts of the functional urban areas. Among these factors, cycling spatial inequity in the functional urban areas is mainly associated with an unequal repartition of cycling infrastructures and services. Bike share services of Nantes, Lyon and Toulouse in particular, located in the very center of these urban areas, are associated with a great part of the heterogeneity between center and other parts of the urban area but also between the downtown and the rest of the urban area’s core. A second major result is that characteristics of trips for inner or outer suburb residents are less favourable for cycling than for center residents but for different reasons. In outer suburbs, the main issue is that there is a greater part of people that have too long and complex trips to be made by bike compared to the center. In the inner suburb, it’s less the trip distance than the greatest part of people that move between inner suburb and other parts of the urban area that seems to be the explanation of its lower cycling rate compared to those of the center. It’s especially true for Toulouse or Lyon where there are two complete ring roads dividing the inner suburb and the center. These results show the cycling potential of the inner suburbs, that have trip lengths not as unfavourable for cycling as in the outer suburbs but need specific measures to improve the crossing of the urban motorways in particular.

Figure : The decreasing share of cyclists from the center to the peripheries of five french functionnal urban areas



References

Gao, J., Kamphuis, C. B., Dijst, M., & Helbich, M. (2018). The role of the natural and built environment in cycling duration in the Netherlands. *International journal of behavioral nutrition and physical activity*, *15*, 1-16.

Handy, S., Van Wee, B., & Kroesen, M. (2014). Promoting cycling for transport: research needs and challenges. *Transport reviews*, *34*(1), 4-24.

Koglin, T., Alvanides, S., & Fields, B. (2022). Overview of special issue on urban cycling: Rationalities, justice, safety, and geographical analysis. *Transportation Research Interdisciplinary Perspectives*, 100713.

Ledsham, T., Zhang, Y., Farber, S., & Hess, P. (2022). Beyond downtown: factors influencing utilitarian and recreational cycling in a low-income suburb. *International Journal of Sustainable Transportation*, 1-22.

Mertens, L., Compernolle, S., Deforche, B., Mackenbach, J. D., Lakerveld, J., Brug, J., Roda C., Feuillet T., Oppert J-M., Glonti K., Rutter H., Bardos H., De Bourdeaudhuij I. & Van Dyck, D. (2017). Built environmental correlates of cycling for transport across Europe. *Health & place*, *44*, 35-42.

Happiness is in the journey: A different view on accessibility in the cycling city

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Keywords
Accessibility, mobility, urban planning, spatial data science, well-being

Challenge Addressed / Research Problem Investigated

Current accessibility metrics view mobility solely as a disutility, and disregard how pleasurable experiences during the trip to a destination may positively influence our perception of its accessibility.

Abstract

Accessibility-oriented planning has emerged as a leading paradigm in urban transport planning. It is based on the idea that the ultimate goal of the transport system is not to provide people with the ability to move per se (i.e. mobility), but rather with the ability to reach their desired destinations (i.e. accessibility). Prioritising accessibility is widely regarded to enhance sustainability in cities, and promote the uptake of active transport modes such as cycling.

However, in the way in which we currently think about and measure accessibility, the trip towards the destination has no value in itself. It is reduced to nothing more than a demand derived from the need to reach the destination. That is, mobility is solely seen as a cost that should be minimised. Usually, this cost is expressed as travel time, although several scholars have stressed the need to include different types of monetary, societal and environmental costs as well. But in any case, it remains a disutility. Recent research has challenged this dominating view of mobility as a disutility, and proposed alternative narratives that instead underpin the benefits of mobility: a way to experience positive mental states, to socially interact, to develop senses of place and belonging, and to increase well-being (Te Brömmelstroet et al, 2022). Hence, mobility is something that has value in itself, and can provide us with many different pleasurable experiences. This is especially true when you walk or cycle, since the interaction you have with your environment is much stronger than when travelling by car, allowing you to actively develop your core human capacities (Ferdman, 2021).

We believe that these alternative narratives should be integrated in the way we think about accessibility, and how we measure it. If mobility is more than just a disutility, it may actually positively influence our perceptions of accessibility. Our hypothesis is that pleasurable experiences during the trip to the desired destination can make the destination itself be perceived as more accessible. If this holds true, it means that we can improve accessibility by designing streets in a way that fosters such experiences (e.g. through green, shared

spaces with many possibilities for social interactions), even if this means that it may take longer to reach the desired destinations than if we would design the street in a way that prioritises fast and efficient travel (e.g. bicycle highways).

Ongoing developments in data collection and data analysis tools have made it a realistic goal to integrate these alternative views into quantitative frameworks that assess accessibility. For example, by combining quantitative emotion sensing with qualitative questionnaires in mixedmethod approaches, we are able to measure how people experience different environments they move through. Augmented reality can extend this into computer-generated environments that do not yet exist in the real world. Furthermore, with bottom-up simulation models of human movement we may assess how different street designs are fostering social interactions. In a next step, automated interpretation of (generated) imagery through GeoAI can help us to evaluate planning scenarios based on the developed insights.

Considering the above, we hope to spark a fruitful discussion dealing with the following two core questions. Can pleasurable experiences during a cycling trip influence how accessible we perceive the destination to be? How can data science be of use as a tool to integrate such influences into quantitative frameworks that assess accessibility?

References

Ferdman, Avigail. 'Well-Being and Mobility: A New Perspective'. Transportation Research Part A: Policy and Practice 146 (2021): 44–55. https://doi.org/10.1016/j.tra.2021.02.003.

Te Brömmelstroet, Marco, Miloš N. Mladenovic, Anna Nikolaeva, İdil Gaziulusoy, Antonio Ferreira, Kaisa Schmidt-Thomé, Roope Ritvos, Silvia Sousa, and Bernadette Bergsma. 'Identifying, Nurturing and Empowering Alternative Mobility Narratives'. Journal of Urban Mobility 2 (2022): 100031. https://doi.org/10.1016/j.urbmob.2022.100031.

Can crowdsourced large-scale near-crash data replace crash data? A comparison of models using both sources

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Keywords
Bicycle near-crash, Crowdsourced data, Bicycle crash, Police data.

Challenge Addressed / Research Problem Investigated
Conventional bicycle crash data are underreported thus large-scale (near-) crash data are necessary to identify unrevealed crash-prone locations

Abstract
INTRODUCTION
Cycling is increasingly gaining attention as a sustainable transport alternative and bicycle safety is recognized as a main barrier for increasing cycling demand (Buehler & Pucher, 2022). To explore the hotspots and potential causes of bicycle crashes, most studies used crash data recorded by police or hospitals. However, such crashes mostly involve severe injuries or insurance claims, whereas many minor crashes are often unreported (Laureshyn et al., 2017). To overcome the issue of underreporting, bicycle near-crashes, which are incidents that do not cause or only cause slight injuries (S. Springer et al., 2020), has been suggested to be surrogate measure for analyzing crash risks (Puchades et al., 2018). With sensors embedded in bicycles becoming more universal, large amounts of near-crash/ crash data can be collected (e.g., (Gupta et al., 2022)), making crowdsourced data a robust source to have precise and profound insights into bicycle safety studies (Karakaya et al., 2020). However, there is still a lack of understanding of the characteristics of bicycle near-crashes, and only few studies conducted a comparative analysis between bicycle crashes and near-crashes (e.g., (Strauss et al., 2017) and (Poulos et al., 2017)). Therefore, this study aims to compare occurrence rates of crashes and near-crashes and to analyze their variation across different infrastructure types.

DATA AND METHODOLOGY
Data sources
Two datasets were used in this study. One is crowdsourced bicycle near- crash data from Hövding - a head protection airbag for cyclists worn around the neck (Hövding, 2022). A sensor in the helmet tracks the movement and acceleration of cyclists and continuously determines the current safety state. Safety states include *normal state* and three levels of *near-crashes* (i.e., to what extent the helmet is about to deploy). Overall, 129,818 near-crashes were recorded from 2019 to 2021 in Metropolitan Copenhagen. The other data source is crash data from the police, which contains conventional crashes reported to the police involving cyclists. Overall, 4,220 crashes were recorded in the same area and period.

Statistical models of bicycle near-crash and crash

To understand the risk of (near) crashes and which infrastructure features affect the (near) crashes risk, occurrence rates of (near) crashes on each road segment were calculated by dividing the frequency of (near) crashes by the total bicycle traffic (i.e., exposure). For Hövding near-crashes, the exposure was directly obtained from the users (i.e., we know where each Hövding user has traveled), making the risk assessment more precise (Saad et al., 2019; Vanparijs et al., 2015). For police crashes, however, we do not have such information available, and thus we approximate cyclist flows from a traffic model (Paag et al., 2019). We then use a negative binomial (NB) model to model the (near-) crash rate. We chose to use a NB model since using a Poisson model caused overdispersion issues. Equation 1 shows the specification of the NB regression model, where the logarithm of occurrence rate is modeled by a linear combination of explanatory variables.

$$log(Rate_i) = log(\frac{10^5 \times (Near)Crash\ frequency_i}{Annual\ bicycle\ traffic_i \times Length_i}) = \beta_0 + \boldsymbol{\beta_1} \times \mathbf{Infrastructure_i} + \varepsilon_i \quad (1)$$

Here Occurrence $Rate$ denotes how many crashes or near-crashes that occur per 100,000 bicycle-kilometer traveled on each road segment i per year. $\mathbf{Infrastructure}$ denotes column vectors of infrastructure variables, including 15 road types, 4 surface types, and 8 point-based infrastructure types. β_0 denotes the intercept, and $\boldsymbol{\beta_1}$ is a row vector containing coefficients for infrastructure and ε_i is the residual.

RESULTS AND DISCUSSION

Overall, we modeled Hövding near- crash rates and police crash rates. To address which infrastructure features that cause higher occurrence of near-crashes and crashes, we calculated the expected annual frequency of Hövding near-crashes and Police crashes shown in Figures 1a and 1b, respectively, by multiplying estimated (near-) crash rates with exposures. Generally, the expected number of near-crashes is far higher than the expected number of crashes, identifying risky locations. Compared to crashes, more near-crashes occurred on the small paths or roads that are mostly pedestrian-oriented. This tendency is especially obvious in the southern part of the city center. This might be because cyclists have a higher chance of having near-crashes with pedestrians on such paths or roads, while crashes were not severe enough to be reported to the police. Compared to near-crashes, crashes occurred more often at signalized intersections and roundabouts, which could be due to more cyclists-vehicle conflicts. Overall, bicycle near-crashes and crashes have different occurring patterns, emphasizing the value of stand-alone bicycle near-crash research.

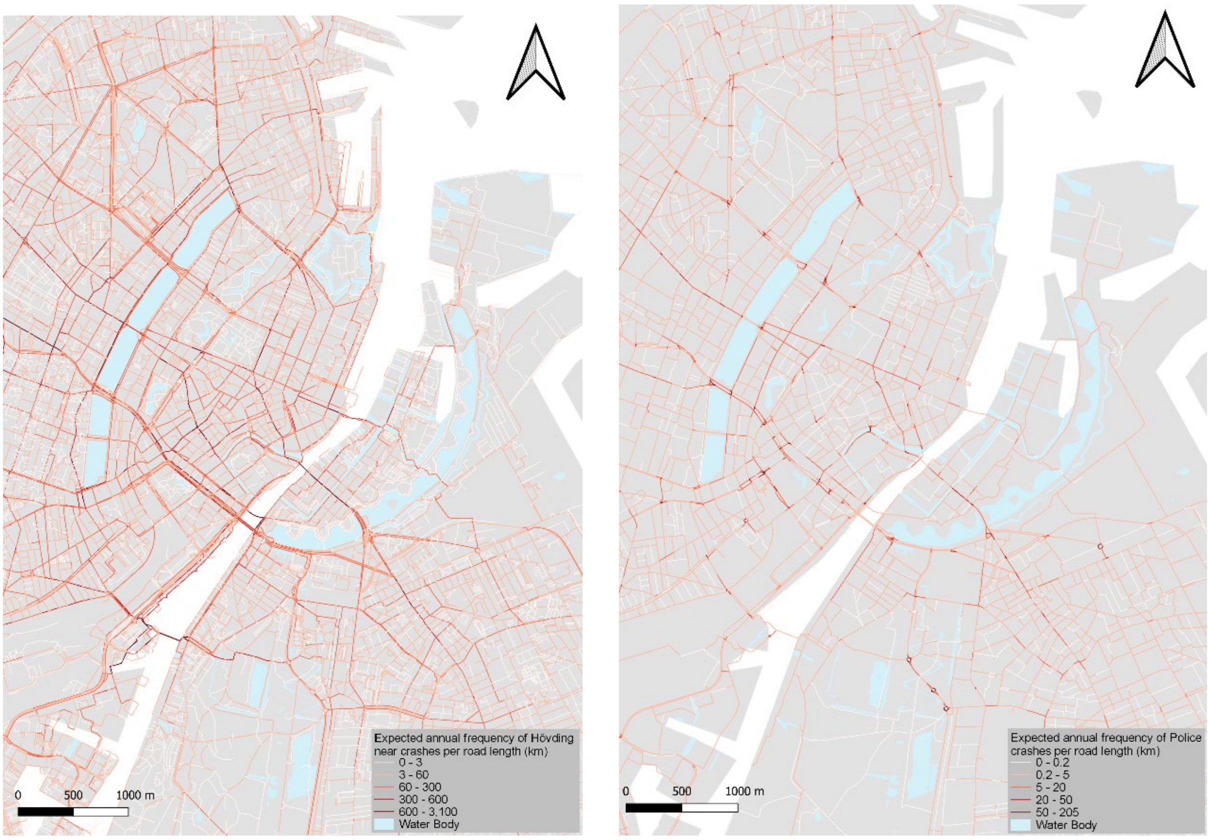

Figure 1. Expected Annual frequency of (a) Hövding near-crash and (b) Police crash per road length

CONCLUSIONS

We used large-scale crowdsourced and conventional crash data to explore and compare how different infrastructure features affect the frequency of both bicycle near-crashes and bicycle crashes. We found that the considerable number of bicycles near-crashes available in the data can be used to reveal risky or uncomfortable locations that cannot be identified solely by crash data from police. It is well-known that conventional crash data lacks information about specific types of crashes, e.g., solo-crashes, due to underreporting. In this study, we found that near-crashes occurred frequently on pedestrian-oriented roads, while crashes occur frequently at intersections. Therefore, this study filled gaps in existing studies regarding bicycle near-crashes by focusing on modeling bicycle near-crashes across places with different infrastructure features and identifying unrevealed risky locations. Overall, this study concludes that bicycle crowdsourced near-crashes data and conventional crash data can be used complementarily to effectively disclose crash-prone hotspots remaining unrevealed, making near-crashes valuable measures for policymakers to improve cycling safety.

References

Buehler, R., & Pucher, J. (2022). Cycling through the COVID-19 Pandemic to a More Sustainable Transport Future: Evidence from Case Studies of 14 Large Bicycle-Friendly Cities in Europe and North America. *Sustainability*, *14*(12), 7293. https://doi.org/10.3390/su14127293.

Gupta, S., V, R., & A, S. (2022). Fall Accident Detection System for Bicycle Riders using Support Vector Machines. *2022 IEEE 11th International Conference on Communication Systems and Network Technologies (CSNT)*, 392–397. https://doi.org/10.1109/CSNT54456.2022.9787665.

Hövding. (2022). *Hövding's official website | Hövding—Airbag for urban cyclists*. https://hovding.com/.

Karakaya, A.-S., Hasenburg, J., & Bermbach, D. (2020). SimRa: Using crowdsourcing to identify near miss hotspots in bicycle traffic. *Pervasive and Mobile Computing*, *67*, 101197. https://doi.org/10.1016/j.pmcj.2020.101197.

Laureshyn, A., Goede, M. de, Saunier, N., & Fyhri, A. (2017). Cross-comparison of three surrogate safety methods to diagnose cyclist safety problems at intersections in Norway. *Accident Analysis & Prevention*, *105*, 11–20. https://doi.org/10.1016/j.aap.2016.04.035

Paag, H., Kjems, S., & Hansen, C. O. (2019). COMPASS: Ny trafikmodel for Hovedstadsområdet. *Proceedings from the Annual Transport Conference at Aalborg University*, *26*(1), Article 1. https://doi.org/10.5278/ojs.td.v26i1.5077.

Poulos, R. G., Hatfield, J., Rissel, C., Flack, L. K., Shaw, L., Grzebieta, R., & McIntosh, A. S. (2017). Near miss experiences of transport and recreational cyclists in New South Wales, Australia. Findings from a prospective cohort study. *Accident Analysis & Prevention*, *101*, 143–153. https://doi.org/10.1016/j.aap.2017.01.020.

Puchades, V. M., Fassina, F., Fraboni, F., De Angelis, M., Prati, G., de Waard, D., & Pietrantoni, L. (2018). The role of perceived competence and risk perception in cycling near misses. *Safety Science*, *105*, 167–177. https://doi.org/10.1016/j.ssci.2018.02.013.

S. Springer, M. Kreusslein, & J.F. Krems. (2020). Shedding Light on the Dark-Field of Cyclists' Safety Critical Events: A Feasibility Study in Germany. *Proceedings of 9th International Cycling Safety Conference ICSC 2021. Lund, Sweden*.

Saad, M., Abdel-Aty, M., Lee, J., & Cai, Q. (2019). Bicycle Safety Analysis at Intersections from Crowdsourced Data. *Transportation Research Record*, *2673*(4), 1–14. https://doi.org/10.1177/0361198119836764.

Strauss, J., Zangenehpour, S., Miranda-Moreno, L. F., & Saunier, N. (2017). Cyclist deceleration rate as surrogate safety measure in Montreal using smartphone GPS data. *Accident Analysis & Prevention*, *99*, 287–296. https://doi.org/10.1016/j.aap.2016.11.019.

Vanparijs, J., Int Panis, L., Meeusen, R., & de Geus, B. (2015). Exposure measurement in bicycle safety analysis: A review of the literature. *Accident Analysis & Prevention*, *84*, 9–19. https://doi.org/10.1016/j.aap.2015.08.007.

Enhancing Urban Cycling Safety: Understanding the Effects of Safety Measures

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Keywords
Sustainable Urban Mobility, Urban Cycling; Objective Safety, Vulnerable Users, Urban Transport Safety

Challenge Addressed / Research Problem Investigated
Prioritizing and investing in cycling safety measures is essential to encourage more people to embrace cycling, create a safer environment for cyclists, and unleash the full potential of cycling as a sustainable and efficient mode of urban transportation.

Abstract
Urban cycling play is crucial in addressing urban mobility challenges in rapidly growing cities. It contributes to reducing traffic congestion, improving air quality, and promoting physical activity (Pucher & Buehler, 2018). Research has shown that cities with prioritized cycling infrastructure experience significant decreases in congestion and associated costs. Investing in cycling infrastructure and fostering a cycling-friendly culture is essential for creating sustainable and livable cities (Litman, 2019). However, the lack of safety is a major obstacle to the widespread adoption of cycling as a regular mode of transportation, often linked to inadequate infrastructure (Félix et al., 2017).

Cycling safety represents a significant barrier that hampers the widespread adoption of cycling as a transportation mode. Concerns about road safety for cyclists can deter individuals from choosing bicycles as their primary means of urban mobility. Enhancing cycling safety through measures such as dedicated cycling infrastructure, improved road design, and traffic calming interventions can significantly increase cycling rates (Heinen et al., 2019). By prioritizing cycling safety and implementing appropriate measures, cities can create a safer environment that encourages more individuals to embrace cycling as a sustainable mode of urban transportation (Pucher et al., 2010).

Improving cycling safety requires well-designed and purposeful cycling infrastructure that considers both perceived and actual safety. This work aims to summarize the current knowledge on the effects of road safety measures in an easily accessible manner. These measures encompass a range of technical devices or programs designed to enhance road

safety, targeting elements such as land use patterns, roads, road furniture, traffic control devices, motor vehicles, police enforcement, and road user behavior (Elvik et al., 2009).

This comprehensive work encompasses various measures to improve cycling safety, totaling 46 measures. It is important to note that there is no universally standardized scientific definition for improving cycling safety. In this context, it refers to reducing the anticipated number of accidents, minimizing accident or injury severity, or lowering the rate of accidents or injuries per kilometer of travel. The objective is to implement measures that contribute to creating a safer environment for cyclists and mitigating potential risks associated with cycling.

For our case study, we will focus on the city of Lisbon. In this study, we have access to a comprehensive georeferenced database comprising approximately 500 accidents involving cyclists and other vehicles since 2015. This database serves as a valuable resource for analyzing and understanding the factors contributing to cycling-related accidents in the city. Furthermore, we have conducted a thorough review of various measures that can be implemented to improve cycling safety. These measures encompass a wide range of interventions, including infrastructure enhancements, educational initiatives, legal frameworks, and enforcement strategies. To assess the effectiveness of these measures, we will employ a modeling approach to analyze both the severity and frequency of accidents. By examining the relationships between different variables and accident outcomes, we aim to identify key factors influencing the occurrence and severity of cycling accidents. This research endeavor will contribute to developing evidence-based recommendations for enhancing cycling safety.

The evaluation of intervention effects aims to quantitatively estimate the impact of implementing a corrective intervention on the expected frequency of accidents or casualties. Existing knowledge about the effects of road safety interventions primarily relies on studies evaluating previous interventions (before-after studies). The most common way to quantify the effect of a corrective intervention on safety is through the percentage reduction in accidents resulting from it (also known as the accident reduction factor). It is crucial to assess the effectiveness of safety measures by predicting their potential to reduce accidents.

Due to the diverse nature of road safety measures and the limitations of empirical studies, there are various ways to evaluate their efficiency. Thus, it is possible to estimate the effect values of implementing a corrective intervention in three distinct ways (ROSEBUD, 2004): based on meta-analysis, based on literature review, and based on known relationships between risk factors and accidents.

The most appropriate way to synthesize the results of studies evaluating the effects of a particular intervention is through meta-analysis (ROSEBUD, 2005). This technique provides a weighted estimate of the average effect of the intervention and a confidence interval for that estimate (typically using a 95% confidence interval). As a result of the conducted bibliographic analysis, a significant number of studies and relevant results regarding the effects of implementing a wide range of corrective interventions involving cycling safety have been identified.

The research has been conducted on various types of cycling infrastructure, including cycle lanes, roundabouts, crossing facilities, advanced stop lines, shared-use paths, and cycle tracks. In conclusion, while cycling infrastructure has a role to play in improving road safety for cyclists, it should not be used in isolation. A range of interventions, including marketing, education, legislation, and enforcement, should be employed to improve the culture of road sharing and road user behavior.

References

Elvik, R., Høye, A., Vaa, T., Sørensen, M. (2009). The Handbook of Road Safety Measures. Second Edition. Elsevier Science, Oxford.

Félix, R., Moura, F., Clifton, K.J., (2017). Typologies of urban cyclists: Review of market segmentation methods for planning practice. Transportation Research Record 2662, 125–133.

Heinen, E., Panter, J., Mackett, R., & Ogilvie, D. (2019). Changes in mode of travel to work: A natural experimental study of new transport infrastructure. International Journal of Behavioral Nutrition and Physical Activity, 16(1), 51.

Litman, T. (2019). Evaluating Active Transport Benefits and Costs: Guide to Valuing Walking and Cycling Improvements and Encouragement Programs. Victoria Transport Policy Institute. Retrieved from https://www.vtpi.org/tdm/tdm103.pdf

Pucher, J., & Buehler, R. (2018). Cycling towards a more sustainable transport future. Transport Reviews, 38(6), 689-694.

Pucher, J., Buehler, R., & Seinen, M. (2010). Bicycling renaissance in North America? An update and re-appraisal of cycling trends and policies. Transportation Research Part A: Policy and Practice, 45(6), 451-475.

ROSEBUD (2005). WP5: Recommendations. European Community R&TD Project, 5th Framework Programme "Competitive and Sustainable Growth", Project "ROSEBUD" Road Safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision-Making.

The image of a comfortable overtaking manoeuvre differs qualitatively between motorists and cyclists

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Keywords
overtaking, rural road, bicycle, motor vehicle, qualitative methods

Challenge Addressed / Research Problem Investigated
Understanding whether cyclists and motorists have a common picture of what a comfortable overtaking manoeuvre implies.

Abstract
The most frequent encounter between cyclists and motorists on rural roads is the overtaking manoeuvre. It is characterised by the fact that the motorist has most control over how the manoeuvre is executed, while the cyclist is the more vulnerable part.

Most of the research on overtaking is of quantitative nature and consists of modelling approaches that describe how different, often infrastructure-related factors influence the mean clearance between the cyclist and the overtaking vehicle (e. g. Beck et al., 2019; Mehta et al., 2015; Nolan et al., 2021). A few studies consider how this is experienced by the cyclist (Beck et al., 2021; Garcia et al., 2020; Rasch et al., 2022). Questionnaire-based research identified driver aggression during overtaking manoeuvres as one of the major factors preventing people from cycling at all or on certain roads (Fernández-Heredia et al., 2014; Heesch et al., 2011; Kaplan & Prato, 2016).

In several countries, regulations around overtaking of cyclists have been changed and adapted with the purpose to provide more protection for cyclists (Kircher et al., 2022). In Sweden, the government proclaimed that cycling should increase and be made safer in the whole country (Regeringskansliet, 2017). As there is a large network of rural roads, overtaking is an important aspect in this endeavour, and the government commissioned the Swedish Transport Agency to investigate suggestions for a new overtaking rule, amongst other possible rule changes (Regeringen: Infrastrukturdepartementet, 2021).

The current research is intended to cast more light on how the situation of today is experienced by Swedish drivers and cyclists who travel on rural roads.

METHOD
Three datasets are included, henceforth called Quest-Panel, Quest-Link and Quest-Cyclists. Quest-Panel and Quest-Link included the same questions but differ in the way they were

distributed. Quest-Cyclists had a slightly different, but comparable content and an additional purpose and was distributed in a similar way as Quest-Link.

Quest-Panel was distributed to a panel representative of Swedish inhabitants. Inclusion criteria were that respondents should be adult, live in Sweden and travel on rural roads with either a motor vehicle or a bicycle at least sometimes. The goal was to achieve 1000 responses. In total, 1009 responses were collected.

Quest-Link was distributed via social media such as Facebook groups, LinkedIn, etc., including an encouragement to spread the link. These 439 respondents were self-selected and not representative of the Swedish population.

Quest-Cyclists was spread as Quest-Link. Its main purpose was to find participants for an experiment on overtaking of cyclists. Therefore, questions resembling those in the other questionnaire were asked. All respondents to Quest-Cyclists cycled on rural roads. No information was collected about their driving of motorised vehicles (see Table 1).

Table 6. Type of vehicle used by the respondents to the different questionnaires.

	Quest-Panel	Quest-Link	Quest-Cyclists
bike only	86 (8.5 %)	36 (8.2 %)	unknown
car only	666 (66.0 %)	101 (23.0 %)	0 %
both bike and car	257 (25.5 %)	302 (68.8 %)	unknown
total	1009	439	330

The representative sample (Quest-Panel) showed that one third of all adult inhabitants of Sweden who travel on rural roads also use a bicycle to do so. More than 90 percent use a motor vehicle at least sometimes. Quest-Link was therefore skewed towards the cyclist side, even though the percentage of non-drivers was similar.

ANALYSIS

A thematic analysis was conducted, starting out with Quest-Panel. This will be compared to findings from Quest-Link and Quest-Cyclists. Specifically, all answers to two free-text questions were analysed:

1. Describe what makes you feel uncomfortable during overtakings when you are cycling on rural roads (only answered by respondents who cycle, and who indicated that they at least sometimes experience overtaking manoeuvres as uncomfortable, 280 responses from Quest-Panel).
2. Describe in your own words what would be required to make an overtaking situation between a motor vehicle and a bicyclist feel comfortable (all respondents).

The answers were read and sorted into themes. The results presented here are a first, preliminary analysis of the identified higher-level topics in Quest-Panel. A more detailed analysis will be presented at the conference and in a research paper.

RESULTS

Cyclists frequently describe experiencing overtaking situations as uncomfortable due to a low clearance and/or high speeds of overtaking vehicles, but these seem to be the overt symptoms of a feeling of inferiority. A threat emanating from the presence of the bigger and heavier vehicles is described, in combination with having nowhere to escape to. A feeling of lack of control is assigned both to being on the receiving end in the interaction, and to aggravating circumstances like wind, bad road surfaces, debris, and bad visibility, which predominantly affect the cyclist. Another factor mentioned was that one could not know about the state and intention of the driver, and drivers were described as taking chances, not accepting to wait behind the cyclist, and demonstrating their power through aggressive behaviour by overtaking closely on purpose. Lack of knowledge about the breadth of one's vehicle and therefore unwittingly exposing cyclists to danger was also mentioned.

Drivers and cyclists tended to come to different conclusions on how to make overtaking manoeuvres comfortable. A general trend was that drivers required free space and unhindered progress. This could be reflected in a wish for spacious infrastructure or separated bicycle lanes, but it could also be phrased as a demand for cyclists not to be on rural roads at all. If they were, they should make themselves small and visible, by sticking to the right, riding single file, keeping a straight line, and wearing high-viz. There was a tendency to use derogative language when referring to cyclists on rural roads – they were described as "nuisance" and "in the way", implying that cyclists did not have equal rights to the road. However, there were also opinions showing respect of cyclists, in that they should be given space and only be overtaken when visibility was good and no oncoming traffic in sight.

Drivers who also cycled tended to phrase their answers more from a cyclist's perspective, similar to those who only cycled. This group put the main responsibility on the drivers, asking for respect and attention, for patience to wait for a good opportunity, and for giving cyclists adequate space. The right of motorists to the road was not questioned, but motorists could be described as bullies, dangerous and aggressive.

References

Beck, B., Chong, D., Olivier, J., Perkins, M., Tsay, A., Rushford, A., . . . Johnson, M. (2019). How much space do drivers provide when passing cyclists? Understanding the impact of motor vehicle and infrastructure characteristics on passing distance. *Accident Analysis & Prevention*, *128*, 253-260. https://doi.org/https://doi.org/10.1016/j.aap.2019.03.007.

Beck, B., Perkins, M., Olivier, J., Chong, D., & Johnson, M. (2021). Subjective experiences of bicyclists being passed by motor vehicles: The relationship to motor vehicle passing distance. *Accident Analysis & Prevention*, *155*, 106102. https://doi.org/https://doi.org/10.1016/j.aap.2021.106102

Fernández-Heredia, Á., Monzón, A., & Jara-Díaz, S. (2014). Understanding cyclists' perceptions, keys for a successful bicycle promotion. *Transportation Research Part A: Policy and Practice*, *63*, 1-11. https://doi.org/https://doi.org/10.1016/j.tra.2014.02.013.

Garcia, A., Llorca, C., & Serra-Planelles, J. (2020). Influence of peloton configuration on the interaction between sport cyclists and motor vehicles on two-lane rural roads. *Journal of Transportation Safety & Security*, *12*(1), 136-150. https://doi.org/10.1080/19439962.2019.1591557.

Heesch, K. C., Sahlqvist, S., & Garrard, J. (2011). Cyclists' experiences of harassment from motorists: Findings from a survey of cyclists in Queensland, Australia. *Preventive Medicine*, *53*(6), 417-420. https://doi.org/https://doi.org/10.1016/j.ypmed.2011.09.015.

Kaplan, S., & Prato, C. G. (2016). "Them or Us": Perceptions, cognitions, emotions, and overt behavior associated with cyclists and motorists sharing the road. *International Journal of Sustainable Transportation*, *10*(3), 193-200. https://doi.org/10.1080/15568318.2014.885621.

Kircher, K., Forward, S., & Wallén Warner, H. (2022). *Cycling in rural areas : an overview of national and international literature* (03476030 (ISSN)). (VTI Rapport, Issue. http://urn.kb.se/resolve?urn=urn:nbn:se:vti:diva-18557.

Mehta, K., Mehran, B., & Hellinga, B. (2015). Evaluation of the Passing Behavior of Motorized Vehicles When Overtaking Bicycles on Urban Arterial Roadways. *Transportation Research Record*, *2520*(1), 8-17. https://doi.org/10.3141/2520-02.

Nolan, J., Sinclair, J., & Savage, J. (2021). Are bicycle lanes effective? The relationship between passing distance and road characteristics. *Accident Analysis & Prevention*, *159*, 106184. https://doi.org/https://doi.org/10.1016/j.aap.2021.106184.

Rasch, A., Moll, S., López, G., García, A., & Dozza, M. (2022). Drivers' and cyclists' safety perceptions in overtaking maneuvers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *84*, 165-176. https://doi.org/https://doi.org/10.1016/j.trf.2021.11.014.

Regeringen: Infrastrukturdepartementet. (2021). Uppdrag att analysera regelfrågor så att andelen som reser med cykel kan öka [Regeringsbeslut]. *Regeringsbeslut*. https://www.regeringen.se/4ab0fa/contentassets/2503a77aec384c39bd17312d74041aa1/uppdrag-att-analysera-regelfragor-sa-att-andelen-som-reser-med-cykel-kan-oka.

Regeringskansliet. (2017). En nationell cykelstrategi för ökad och säker cykling – som bidrar till ett hållbart samhälle med hög livskvalitet i hela landet. In Näringsdepartementet (Ed.), (Vol. N2017.19). Stockholm: Näringsdepartementet.

Insights from the Road: Promoting Safe Cycling through Real-life Accident Data Analysis

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Keywords
traffic accident data, GIDAS, conflict situation, scenario, cycling safety

Challenge Addressed / Research Problem Investigated

By delving into the depths of accident data, we can uncover patterns and trends, comprehend the root causes of accidents, and formulate effective strategies to prevent future incidents.

Abstract

1 OBJECTIVE

Ensuring the safety of cyclists on the road is a matter of great concern for numerous institutions worldwide. Our focus lies in examining comprehensive accident data to enhance cyclist safety. Through the utilization of data analytics and evaluations of accident scenarios, we can support the creation of safe infrastructure, implement suitable vehicle safety systems, and ultimately reduce bicycle accidents. Our objective is to inspire innovative ideas and approaches that will ultimately contribute to the overall safety of public roads for everyone involved.

2 DATA SOURCE

This analysis relies on data obtained from the German In-Depth Accident Study (GIDAS) database. Since 1999, GIDAS gathers information on personal injury accidents within two investigation areas in Germany (Dresden and Hanover) and their surrounding regions. Each accident is documented in high detail by investigators, capturing approximately 3,500 specific data points at the accident site and in medical facilities. Furthermore, the entire accident sequence is reconstructed with meticulous attention to detail, beginning from the initiation phase of the incident and the reactions of those involved, all the way through the collision and the final positions of the participants. Essential variables such as braking behavior, initial and collision speeds of the individuals on the road are determined. A comprehensive sketch of the accident scene is created, and the participants are interviewed with their consent. Through the application of a weighting procedure, GIDAS data can be regarded as representative for the German accident scenario. For the analysis we used the GIDAS database as of 31 December 2022, which encompasses 13,692 accidents where at least one bicycle was involved.

3 DESCRIPTIVE ANALYSIS OF HIGHLY DETAILED ACCIDENT DATA

The present study offers valuable insights into bicycle accident occurrences utilizing GIDAS. Our objective is twofold: firstly, to uncover the causes of bicycle accidents through detailed data analysis, and secondly, to minimize the severity of injuries in unavoidable accidents.

3.1 ACCIDENT CAUSATION

In order to prevent accidents, our study focuses on investigating the causes behind them. Leveraging the rich and comprehensive information available in the GIDAS dataset, we are able to analyze the behavior of both cyclists and other road users. We aim to shed light on the most frequently encountered conflict situations involving bicycles.

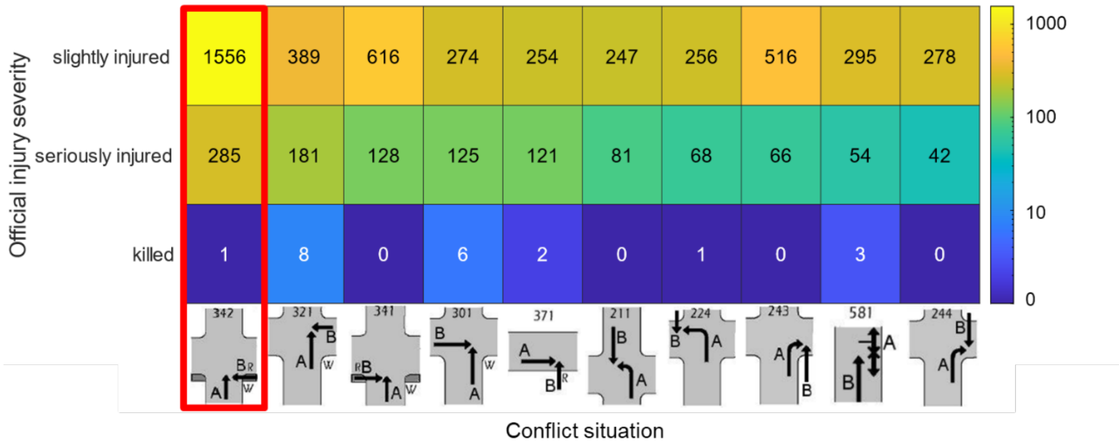


Figure 1: The top-ten conflict situations plotted against the injury severity of the cyclist.

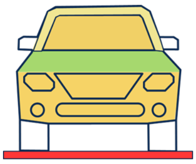
Specifically, we have examined the most prevalent conflict situation: instances where a cyclist approaching from the right on a bicycle lane or pavement interacts with another road user. In many cases, the cyclist is observed using the bicycle lane in the opposite direction. Notably, only 45% of the participants were found to be aware that they were violating traffic regulations by using the wrong side of the road. By employing a detailed descriptive analysis, we are also able to analyze accident causations and patterns in the data.

Around 16% of the bicycle accidents in GIDAS are single bicycle accidents, which have increased in frequency in the last years. We examine reasons by looking at the share of pedelecs, the type of road surface and the road conditions and further accident causations.

3.2 INJURY CAUSATION

On the passive safety side, the information in GIDAS allows us to analyze the impacts of the cyclist. The most frequent opponent of cyclists in accidents are passenger cars. In addition to the position on the car, the causes of the injuries can also be precisely determined. Figure 2 is showing typical injury patterns, thus the effected body regions, of the cyclist and their injury causing parts for AIS3+ injuries.

Body region (AIS3+)	%
other trauma	0%
head	39%
face	2%
neck	1%
thorax	27%
abdomen	2%
spine	6%
upper extremities	3%
lower extremities	20%



Body region (AIS3+)	Street/ environment	Front hood	Surrounding structure	A-pillar	Windshield	Other/ unknown
head	52%	2%	3%	18%	22%	3%
thorax	42%	11%	14%	6%	19%	8%
spine	45%	3%	5%	5%	18%	25%
lower extremities	41%	11%	39%	0%	4%	5%

Figure 2: Analyze typical injury patterns of the cyclist and injury causing parts for AIS3+ injuries

This knowledge shows possibilities to optimize vehicle front shapes and structures as well as protective cycling equipment/clothing to minimize the risk of severe cyclist injuries.

Overtakings in rural roads – cyclists & motorists' perspective

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Keywords
cyclist, driver, overtaking, rural road, perceived safety

Challenge Addressed / Research Problem Investigated
Today, there is no knowledge about how many people cycle on rural roads or how often overtakings occur - and understanding of rural road overtaking experiences from different road user perspectives is missing.

Abstract
INTRODUCTION
Most countries have large networks of rural roads where cyclists and motorists meet during overtaking maneuvers. A description of safe overtakings from the perspective of all road users is needed, that is easy to understand and interpret for human traffic participants, driver support systems and future automated vehicles.

Knowledge on exposure for rural road overtakings is fundamental to establish a safe overtaking definition that is meaningful. Today, knowledge on how many people cycle on rural roads, how often overtakings happens, and the understanding of experiences from overtakings in different road user perspectives are missing.

The aim of this study is to create awareness of the magnitude of car-to-cyclist overtaking situations in rural roads. A second aim is to provide input to the design of systems that enable safe interactions between motorists and cyclists, by:

- describing characteristics of rural road cyclists and their experience from overtaking situations
- describing characteristics of rural road drivers with and without cycling experience, and differences in their view on overtakings.

METHOD
<u>Data</u>
Two datasets were collected: Quest-Panel and Quest-Link that included the same questions.

Quest-Panel provided a representative sample for Sweden in terms of age, gender, and geographical regions. Inclusion criteria were adult persons living in Sweden. Out of 1173 respondents, 119 did not operate on rural roads and 45 used rural roads only as pedestrians, see Figure 1. A majority, 614 respondents, travelled on rural roads only as motorists and 309

did so either as motorists or as cyclists/pedestrians (145 motorist+cyclist+pedestrians, 112 motorist+cyclists, 52 motorist+pedestrians). Remaining 86 used country roads as cyclists, where 29 of them did so as both cyclists and pedestrians.

Respondents that did not operate on rural roads at all or used rural roads only as pedestrians were screened out from the rest of the survey.

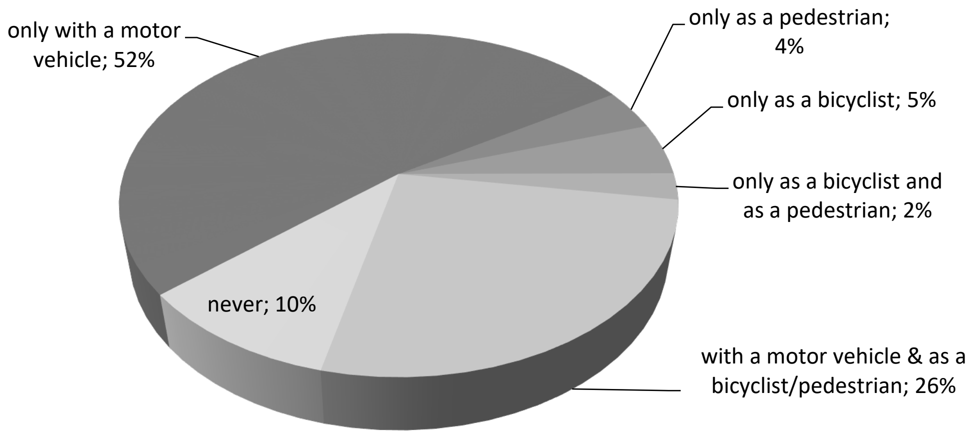

Figure 1. Road users in Quest-Panel

Quest-Link was distributed via cyclist societies and via social media. The 439 respondents were self-selected and not representative of the Swedish population.

<u>Analysis</u>

The Quest-Panel sample and screen-outs during data collection were used to calculate proportions of rural road users in Sweden.

Descriptive statistics reported combined cyclists responses from Quest-Panel and Link-Panel.

Motorist road user categories, i.e.:

- motorists only (M) and
- both motorists and bicyclist/pedestrians (M+C)

were summarized using descriptive statistics on Quest-Panel data. Demographics, awareness and perceived safety were investigated using chi-square and Fisher’s exact tests.

Demographics of respondents are presented in Table 1 along with percentages for gender, age and region for the adult Swedish population 2021 (SCB, n.d.).

Table 1 Demographic Characteristics

Demographic Characteristics	Swedish population	Quest-Panel: Total sample, n=1009	Quest-Panel, Motorist road user category: Motor vehicle drivers only (M), n=614	Quest-Panel, Motorist road user category: Both motor vehicle drivers and cyclists/ pedestrians (M+C), n=309	Quest-Panel: Cyclists, n=343	Quest-Link: Cyclists, n=338
	%	%	%	%	%	%
Gender						
Female	49,2	50	49,2	49,2	49,9	60,4
Male	50,8	50	50,8	50,8	50,2	39,6
Age						
18-24	11,1	12,4	13	8,7	11,7	0,9
25-64	72,7	74	73,1	76,4	78,1	95
65-75	16,2	13,6	13,8	14,2	10,2	4,1
Region						
Upper Norrland	5,1	6	6	6,5	5,8	5
Central Norrland	3,6	3,7	2,9	6,2	3,5	4,7
North Midsweden	8,1	9,3	9,1	10,7	10,8	5,9
East Central Sweden	16,7	16,9	17,4	17,1	17,2	26
Stockholm	23,5	20,2	21,8	14,9	16,9	21
West Sweden	20	18,6	19,1	18,5	11,1	7,1
Småland, Gotland, Öland	8,3	9,6	8,9	10,7	18,1	8,6
Southern Sweden	14,8	15,8	14,7	15,5	5,8	5,03
Highest educational level						
None completed		0,5	0,5	0	0,6	
Primary school		4,9	5,4	2,9	4,7	1,78
High school		45,1	46,7	39,8	41,4	26,63
University		48,8	46,7	56	52,8	69,23
Prefer not to state		0,8	0,7	1,3	0,6	2,37
Income from Employment						
Up to 700 000 SEK		59,8	60,1	54,4	58,9	36,09
More than 700 000 SEK		27,1	27,5	30,4	27,7	46,45
Prefer not to state		13,2	12,4	15,2	13,4	17,46

Results

Rural road usage and car-to-cyclist overtaking situations

Out of all respondents to the panel survey, 38% use rural roads (at least sometimes) as cyclists or pedestrians, see Figure 1. 10% never use rural roads and remaining 52% only use rural roads as motorists.

73% of the cyclists say they use rural roads for commuting purposes, to get to a specific goal, e.g., work, seeing a friend or visit the store. 60% of cyclists use rural roads when cycling for recreation or for exercise.

42% of all motorists face overtaking situations with cyclists either "Basically every time" or "At least every second or third time" they drive on a rural road. When motorists only (M) answered the question "What is the reason you don't cycle on country roads?", 31% said that they don't want to cycle on rural roads, even if they cycle in other places, and 43% would like to cycle in rural roads, see Figure 1. Out of the respondents that would like to cycle in rural roads, 25% dare not because of the risks in traffic.

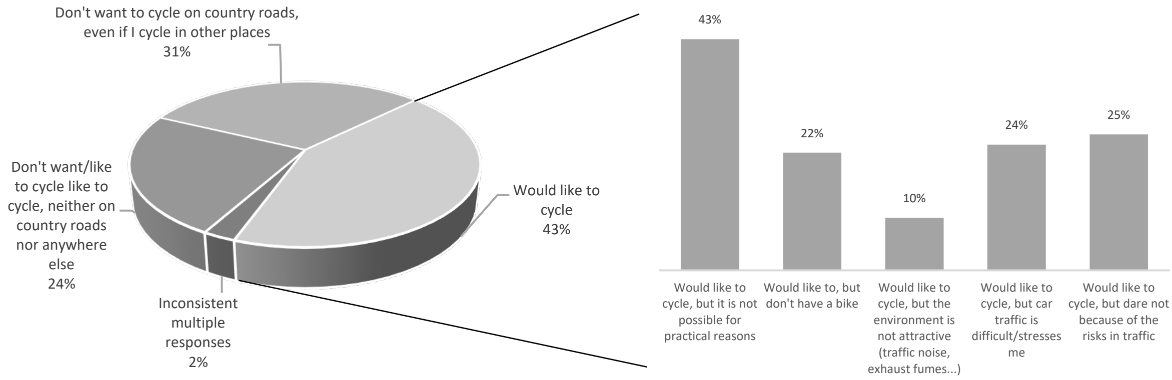

Figure 2. Motorists only's (M) reasons for not cycling on country roads, n=614.

Rural road cyclist experiences

Cyclist's rural road experiences were investigated in Quest-Panel + Quest-Link. When comparing responses from the two datasets, some differences appear, e.g., in Quest-Link more cyclists target recreation or exercise, avoid certain roads and experience unsafe overtakings regularly, see Table 2.

All cyclists exemplified things they do to influence how they get overtaken. Most common were the intention to keep out of the way: 89% of cyclists go as close to the right edge as possible, and 35% cycle on a trail when in pairs/groups. 34% uses reflective clothing and reflective/hi-viz equipment.

To the question on how often they feel that overtaking does not feel "reassuring", 2/3 of all cyclists replied "Often, basically on every bike ride", "Often, at least every second or third bike ride" or "Quite regularly".

45% of rural cyclists state that they have chosen not to cycle in specific roads to avoid being overtaken in an unsafe manner.

Table 2. Cyclist's rural road experiences.

	Cyclists in both Quest-Link and Quest-Panel, n=681	Cyclists in Quest-Panel, n=343	Cyclists in Quest-Link, n=338
	%	%	%
Cycling purpose (multiple answers allowed)			
Commuting purposes (go to/from work, friend, shopping)	67,5	73,2	61,8
For recreation or for exercise	75,4	59,5	91,4
When cycling on country roads - how often do you feel that overtaking does not feel "reassuring"?			
Often, basically on every bike ride	19,09	10,8	27,5
Often, at least every second or third bike ride	16,74	13,7	19,8
Quite regularly	30,25	31,8	28,7
Quite rarely, maybe every 10 bike rides or less often	21,88	25,4	18,3
Basically never	6,17	9,3	3,0
I don't know, haven't thought about it	5,87	9,0	2,7
Have you chosen not to cycle in specific roads to avoid being overtaken in an unsafe manner?			
Yes	44,6	28,9	60,7
Do you usually do anything to influence how you get overtaken? (multiple answers allowed)			
Cycle as close to the right edge as possible	81,9	88,9	74,6
Cycle more towards the center of the lane	12,3	5,5	18,9
Make body movements, e.g., waving the arm, pretending to wobble	4,9	4,7	5,0
Has lighting even during the day	16,3	11,4	21,3
Have reflective clothing and other reflective/hi-viz equipment	33,7	24,8	42,6
Cycle on a trail when in pairs/groups	34,8	27,1	42,6
Cycle next to each other when in pair/groups	15,8	2,3	29,3
Other	6,4	1,5	11,2
When cycling - do you usually do anything to know if you will be overtaken by cars? (multiple answers allowed)			
Looking over the shoulder	72,8	74,1	71,6
Using a rear-view mirror	5,1	7,0	3,3
Using a radar	6,3	2,9	9,8
Listening for overtaking vehicles (e.g. avoid headphones in both ears or have low volume)	75,3	66,5	84,3
Listening to the "behavior" of the overtaking vehicle (e.g. if the car slows down, crosses the center line, etc.)	53,5	46,4	60,7
No, I don't do anything special	5,1	7,0	3,3
Other	2,8	1,5	4,1

Rural road drivers experiences

The Quest-Panel dataset was used to investigate motorist's rural road experiences.

No relationship was found between motorist road user category (M and M&C) and gender, age group, geographical region, or income. M&B were more frequent among respondents with education from university, $\chi 2$ (4) = 10.9, p = .0027.

M&Cs were more likely to report that they regularly overtake cyclists, see Table 3, while M more often stated that they never do, or that they had not thought of this situation, $\chi 2$ (4) = 25.4, p < .001.

Out of all motorists, 60% admitted they did unsafe (to the cyclist) overtaking maneuvers, and M&C reported unsafe overtaking maneuvers more often compared to M, $\chi2$ (1) = 6.0, p = .0014. The most common single reasons for performing unsafe overtaking were narrow road (25%), cyclists next to each other (22%) and unconscious overtaking (16%), see Figure 4. On the other hand, 9% of motorists had found themselves in a traffic-dangerous situation when overtaking a cyclist.

Table 3. Motorist's rural road experiences of cyclists.

	All motorists, n=923	Motor vehicle drivers only, n=614	Both motor vehicle drivers and bicyclist/ pedestrians, n=309
	%	%	%
When you drive on a rural road - how often do you overtake a cyclist?			
Basically, every time I drive on a rural road	12,6	10,8	16,2
At least every second or third time I drive on a rural road	29,4	26,1	35,9
Rarely, maybe every 10 times I drive on a rural road	40,4	42,2	36,9
Basically never	13,1	16	7
I don't know, haven't thought about it	4,6	5,1	3,6
Have you ever overtaken a cyclist in an unsafe manner on a country road?			
Yes	59,8	57	65,4
As a motorist, have you found yourself in a dangerous situation when you overtook a cyclist?			
Yes	9,1	8,5	10,4

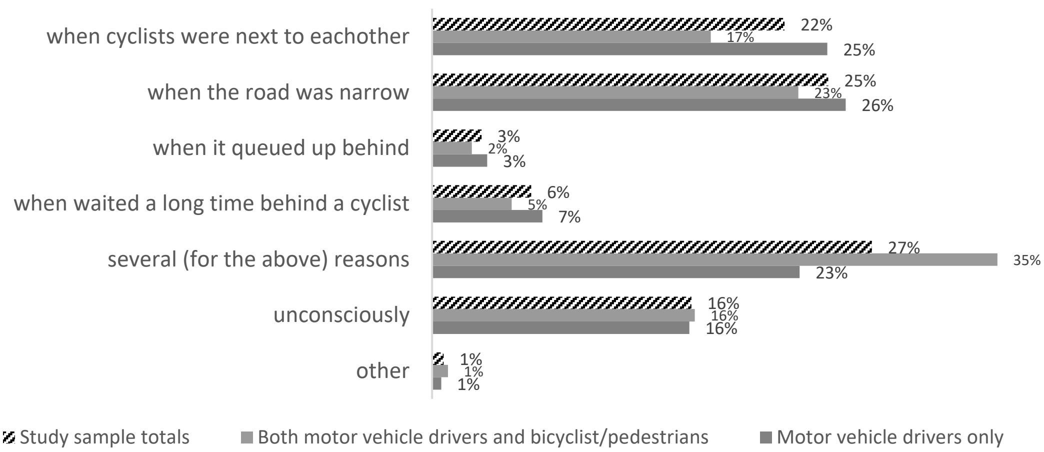

Figure 4. Reasons for performing unsafe overtakings, n=552.

DISCUSSION

The high number of cyclists using rural roads confirms the relevance of the overall research topic; almost 40% of the rural road user population travel with bicycles. Future research should, in a more precise way, quantify non-motorists exposure to overtakings in rural roads.

This study shows that experiences of overtaking maneuvers differ between cyclists and motorists as well as between motorist categories. The variety of persons and situations calls for a clear definition of what is considered as a safe overtaking. Such a definition should be used in driver coaching and in the long run to train automated vehicles on best practice in overtaking situations.

References

SCB. (n.d.). Folkmängden efter region, civilstånd, ålder och kön. År 1968 - 2022. Retrieved September 28, 2023, from https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningNy/.

The Role of Urban Green Infrastructure in Cycling Comfort

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Keywords
Cycling, Experience, Comfort, Urban Green Infrastructure

Challenge Addressed / Research Problem Investigated
To understand the role and share of Urban Green Infrastructure in contributing to the comfort of cycling experience.

Abstract
BACKGROUND
Cycling is one of the most sustainable modes of transport. Its several health, environmental, economic, and safety benefits emphasize the importance of encouraging it for future urban mobility (Banister, 2008; de et al., 2010; Gilderbloom et al., 2016; Marshall & Ferenchak, 2019; Rutter et al., 2013). Cycling infrastructure plays a fundamental role in triggering a shift toward active transportation. Cycle path characteristics such as width, accessibility to essential services in the city, connectivity and cohesion, and location are among the factors that have an impact on people's decisions for daily cycling commutes (Yang et al., 2019).

Apart from the above-mentioned factors, Urban Green Infrastructure (UGI) also contributes to this choice field (Nawrath et al., 2019). UGI encompasses several elements, such as urban trees, grass, shrubs, green roofs and facades, urban parks, and greenways. These elements all together provide a variety of benefits -known as Ecosystem Services (ES)- such as the provision of food, timber, and water, regulation of climate and microclimate, diseases and water quality, and cultural and social benefits such as contributing to the image of the city (Lynch, K., 1960) aesthetics and safety, that people can receive from these elements in cities (Jato-Espino et al., 2023).

However, what are the benefits of UGI for cycling? Looking at different transport modes available in the urban context (private cars, public transport, micro-mobility, cycling, and walking), it is evident that users of active mobility options (pedestrians, cyclists, and micro-mobility) have direct contact with their surrounding environment and, therefore, UGI has the most potential to encourage or discourage these modes.

KNOWLEDGE GAP

Previous studies have revealed several factors affecting cycling comfort. The so-called cycling grey infrastructure factors include cycle path physical characteristics such as its location, width, surface quality, signage, and traffic priority design together with larger network characteristics like providing accessibility, connectivity, urban morphology, enclosures, and safety/security. We categorize these indices under the "Built Environment" pillar. The "Natural environment" pillar includes weather, microclimate, thermal comfort, noise, air and sound pollution, shades, smell, and topography. Furthermore, any experience also has a personal dimension to it. People's memory of the place and their sense of attachment, the novelty of the location, their spiritual mood when riding a bicycle, or individual needs and habits such as perspiration, trip purpose, and allergies all make up an important part of a cycling experience that can impact mobility choices and behaviors, mentioned as "Subjective factors" in this research.

To understand the effects of UGI on the cycling experience, we need to investigate the complex of urban built environment, natural environment, and personal characteristics of people.

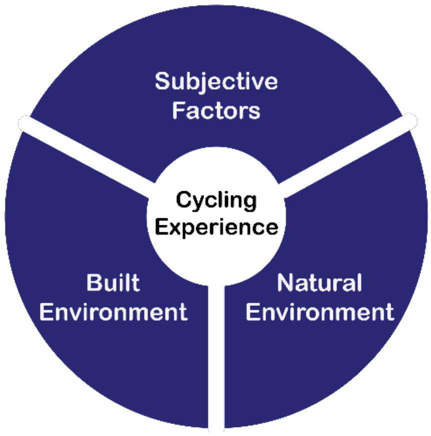

Figure 6. Components of Cycling Experience

In this trilogy of the components of the cycling experience, the third pillar, subjective factors, and their relations to the other two pillars are often overlooked due to the infinite complexity of human beings and the difficulty of capturing psychological details of movement perception in the city. Consequently, the difference in the contribution of each UGI element to the cycling experience for various people has been left undiscovered and is the knowledge gap that this research aims to address. In doing so, we introduce the User Experience data collection methods as a way of capturing the sensations and variables of cycling comfort.

METHODOLOGY

Using a mixed-methods approach, the study is shaped in the following phases:

1. **Developing Urban Street Typologies:** Initially, we assess the current situation of cycling network in the city of Munich, Germany as a case study. Based on the existing street functions in the municipality of Munich, an adapted urban street typology, ranging from Car-only streets to Active-mobility-only including width differentiations is developed.
2. **Quantitative phase**: A tailored Comfort survey for walking and cycling has been designed and distributed in Munich. Together with the data provided by previous surveys run by the City of Munich, these investigations build the quantitative phase of the research. This will reveal a general understanding of the share of comfort factors and set the ground for the next phase.
3. **Qualitative phase:** In this phase, we will pursue a qualitative approach using User Experience (UX) methods. This research starts with the social group of young adults who work or study in Munich. This group includes internationals who come from different mobility cultures and their moving to the new city acts as a life event that can trigger behavioral changes. They are either a former cyclist or a new cyclist who uptake cycling for the first time in their adulthood. Another subcategory of this group breaks

into people with or without sustainability concerns. People in this group are known to have the most agility and readiness to ride in less comfortable conditions, change their mobility behavior, and are more likely to learn and adapt to their new environment. Through the means of think-aloud protocol and voice/video recordings, participants will be asked to capture and reflect on their personal (pleasant and unpleasant) feelings during their journeys and document them as much as possible. Further open interviews will help validate the data collection and omit the researcher's interpretation from the results. A focus group workshop at the end of this phase is designed to validate the data collection and shed light on the ranking of the importance/effect of UGI elements for cycling comfort.

Expected results

The preliminary step of developing street typologies, enables the results to be expandable to other contexts outside of Munich. Comfort survey results shed light on the current state of cycling facilities and their potential pitfalls. Lastly, the outcomes of the qualitative phase will disclose the share of each three research pillars in the cycling experience.

It is expected that this research will be able to reveal the share of UGI elements and their connectivity's contribution to the daily comfort and pleasure of cycling for young adults in Munich and yield a ranking of the importance of UGI elements for an improved cycling experience as well as a comparison of the built, natural and subjective factors that affect cycling mode choice for this social group. These insights can be beneficial for future urban development policies toward facilitating more sustainable urban mobility.

References

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, *15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005.

de, H. J. J., Boogaard, H., Nijland, H., & Hoek, G. (2010). Do the Health Benefits of Cycling Outweigh the Risks? *Environmental Health Perspectives*, *118*(8), 1109–1116. https://doi.org/10.1289/ehp.0901747.

Gilderbloom, J., Grooms, W., Mog, J., & Meares, W. (2016). The green dividend of urban biking? Evidence of improved community and sustainable development. *Local Environment*, *21*(8), 991–1008. https://doi.org/10.1080/13549839.2015.1060409.

Jato-Espino, D., Capra-Ribeiro, F., Moscardó, V., del Pino, L. E. B., Mayor-Vitoria, F., Gallardo, L. O., Carracedo, P., & Dietrich, K. (2023). A systematic review on the ecosystem services provided by green infrastructure. *Urban Forestry & Urban Greening*, 127998. https://doi.org/10.1016/j.ufug.2023.127998.

Lynch, K. (1960). The image of the city. MIT Press.

Marshall, W. E., & Ferenchak, N. N. (2019). Why cities with high bicycling rates are safer for all road users. *Journal of Transport & Health*, *13*, 100539. https://doi.org/10.1016/j.jth.2019.03.004.

Nawrath, M., Kowarik, I., & Fischer, L. K. (2019). The influence of green streets on cycling behavior in European cities. *Landscape and Urban Planning*, *190*, 103598. https://doi.org/10.1016/j.landurbplan.2019.103598.

Rutter, H., Cavill, N., Racioppi, F., Dinsdale, H., Oja, P., & Kahlmeier, S. (2013). Economic Impact of Reduced Mortality Due to Increased Cycling. *American Journal of Preventive Medicine*, *44*(1), 89–92. https://doi.org/10.1016/j.amepre.2012.09.053.

Yang, Y., Wu, X., Zhou, P., Gou, Z., & Lu, Y. (2019). Towards a cycling-friendly city: An updated review of the associations between built environment and cycling behaviors (2007–2017). *Journal of Transport & Health*, *14*, 100613. https://doi.org/10.1016/j.jth.2019.100613.

What Makes a Great Cycle Superhighway? – Evaluation in the Swedish Region of Skåne

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Keywords
Cycle Superhighways, infrastructure, perceived route environment

Challenge Addressed / Research Problem Investigated
How to make Cycle Superhighways "super" – which qualities are included and how to evaluate them.

Abstract
BACKGROUND AND AIM
A region in southern Sweden, Skåne, has started to implement the concept Cycle Superhighways. The concept is inspired by the neighbouring Danish capital region and the successful work with its well renowned "supercykelstier". Region Skåne was interested in finding new ways to evaluate travel time saving and changes in route choice when new infrastructure was built or old was improved. The Swedish Cycling Research Centre at the National Road and Transport Research Institute were contacted to collaborate in an evaluation project.

During the project, several infrastructure improvements have been made. In one place, for example, the cycle path has been redrawn so that it now runs on the same side of the road, which has removed two crossings. At another place, a new cycle path was built on the outside of a residential area, removing the need to cycle through the area.

The project has two main aims. First, to evaluate improvements in infrastructure on the cycle paths and encouragement actions. Second, to develop a method that regions and municipalities can use to measure and analyse cycling on the Cycle Superhighways. Initially, the focus was to evaluate measures for travel time savings and route selection using Wi-Fi technology for crowd sourcing. However, the focus broadened during the project to also include perceived qualities in the route environment.

METHOD
The primary method to measure travel time savings and route choice was based on Wi-Fi stations deployed at around 20 locations along three of the proposed Cycle Superhighways routes. The stations were, in the preparation phase said to capture 60-70 percent of the MAC-addresses found in all devices with Wi-Fi switched on, for example mobile phones. The idea was to be able to follow one and the same MAC- address through the routes to get information

about travel times and route choices before and after interventions in the infrastructure. However, only a few percent of the cyclists were actually captured by the Wi-Fi sensors and the technology for evaluation was de-established. The project therefore took a different direction where focus was on other methods included in the project for evaluation: roadside observations and traffic counting on fixed and temporary stations. In order to answer the aim a survey with a section-divided map was developed that included questions about the route environment.

- A total of 223 cyclists answered the survey. All were older than 18 years and had cycled on at least one of the routes in the past year.
- Two focus group interviews were conducted. One group per route and these consisted of seven and eight people.
- Roadside observation studies were conducted in three different locations on six occasions. A total of 7,500 road users were observed. We noted bicycle type, gender, and other road users on the cycle path.

RESULTS

This is an ongoing research project.

The preliminary results from the survey show that interaction with other road users on the cycle path contributes to a poor social environment, for example, in some areas pedestrians have to queue in and cross the cycle path to board a bus. In the largest city along the route, Malmö, conflicts occur with car traffic at intersections and in the northernmost city, Lund, conflicts with car drivers occur at schools located near the route when parents drive their children to school.

The maintenance is in many cases poor. Bushes and branches overhanging the cycling path and root entrainment in the asphalt, reduces the "functional width" of the cycling path. Along the route there are also sharp corners that are not appreciated by the cyclists. High wind coming from the ocean along the routes is also perceived as a problem and the cyclists want protection from that.

The survey proved significant differences between some of the sections along the route. Where there was new smooth asphalt, cyclists were more satisfied with the infrastructure. In one section, the cyclists can now avoid interaction with car traffic as the cycle path runs along the same side of the road the whole route, compared to crossing the road back and forth as previously. The improvement was perceived as positive by the cyclists.

Through the roadside observations, we established that electric bicycles are the most common, and count for around 40% throughout the period and sites. About 15-20% were road bicycles. This suggests that travel speed is important. Furthermore, there are no major differences in which qualities are in demand among those who use different bicycle types, but road cyclists are more dissatisfied with the interactions with other road users and the infrastructure. Nor are there any differences between which qualities are in demand between the sexes.

In conclusion, many other qualities were pointed out as needed for the cycle paths to be experienced as super. Which brings us to the question, what qualities are there in the concept of a Cycle Superhighways and how does it differ from calling something a fast cycle path? In

Danish, the concept is called "supercykelstier" and in Swedish, "supercykelväg". Both can loosely translate to supercycle path. In the translation to English the concept might be reduced by the addition "highway". Which implies that super is equated with the qualities of a highway, where travel time savings is the dominant quality. Should the concept include more qualities? Does "super" get lost in the translation?

VISION FOR CRBAM SESSION 2023:

Using the "1,2,4 all" method, we would like to have an interactive presentation where we not only present our ongoing project but also discuss what qualities make cycling paths perceived as "super", besides time saving. The discussion would provide valuable input to the research project.

Cycling Norms for the E-Bike City – An Interplay of Policy, Engineering, and Culture

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Keywords
Infrastructure design, infrastructure design standards, law, policy, traffic culture

Challenge Addressed / Research Problem Investigated

This research aims to frame the complexity of changing cycling infrastructure design norms and to provide insights as how to best address those challenges.

Abstract

Some of the best practices for designing, constructing, and maintaining cycling infrastructure and implementing cycling-supportive policies indubitably come from the Netherlands (and Denmark), but transferring those designs and policies to other countries can prove difficult.

For example, in Switzerland, there are often legal roadblocks to implementing Dutch designs. In order to build Dutch-style cycle path crossings that have right-of-way, the laws designating how far a cycle path can be from the edge of the primary road and still receive the same level of right-of-way as that road needs to be changed (Starkermann et al., 2022). Other hindrances preventing Swiss municipalities from swiftly implementing designs that are shown to increase both objective and subjective safety, such as consistently colored cycle paths and lanes (Schnoz, 2019; Von Stülpnagel & Binnig, 2022), include directives from the Swiss Federal Department of the Environment, Transport, Energy, and Communications (UVEK) which prohibit the use of color for this purpose outside of especially dangerous intersections on priority roads (Weisung des UVEK über besondere Markierungen auf der Fahrbahn, 2013).

Beyond the intertwined nature of roadway infrastructure design and law, other challenges arise when the target country has attributes that the source country does not. For example, the cycling designs recommended by the Dutch norms do not include advice on how to accommodate cyclists safely and comfortably on roads with long, steep slopes. In much of Switzerland, the topography produces narrow, steep roads: a situation that is not addressed by Dutch design norms. A recent case study (Rieder, 2023) looked in detail at the access routes to the Hönggerberg Campus of the ETH Zurich, which is situated on a small mountain and whose access roads' average grades are 4% and whose maximum is 11%. This study revealed that the currently suggested changes to the norms for Swiss cycling infrastructure (Dörnenburg et al., 2016), do not match how cyclists and e-bikers currently ride on these steep roads – nor what they perceive as safe and desirable (Rieder, 2023). This indicates that this particular design situation – long, steep slopes on narrow roads - warrants further study.

Indeed, the fact that cycling is even being considered a plausible mode of transport by a substantial share of residents in cities with streets often having long, steep inclines is thanks to the proliferation of the pedelec (or e-bike or "e-bike 25"). However, e-bikes and their more

powerful cousins, the S-Pedelec or the "e-bike 45", pose new challenges for infrastructure design, traffic laws and transport policy. S-Pedlecs straddle the current definitions of motorized vs non-motorized. Where should such bike-motorcycle hybrids ride (drive)? Is it reasonable to allow them to mix with the much slower muscle-powered bicycles and the slower e-bikes or the same road space as cars? Roadway experts around the globe are struggling to come up with satisfying answers, because these vehicles have attributes that make it difficult to justify one action over the other. S-Pedelecs in particular, by virtue of their maximum speed of 45kmh, show a strong potential to shift people away from car use (Meyer de Freitas & Axhausen, 2022) and their riders also seem to show a preference for not mixing with (larger, heavier, faster) motorized vehicles(Meyer de Freitas, 2024). So how do we balance encouraging the use of S-Pedelecs to shift commuting and longer trips away from the car, without making cyclists and slow e-bikers less safe both objectively and subjectively?

It is not only the characteristics of the vehicles that can be disruptive to traffic flow and the real-world efficacy of roadway designs: how users behave and interact also has an impact. When comparing Swiss and Dutch roadway designs and experiencing their function "in-situ", an intangible component becomes glaringly apparent: traffic culture. While in Amsterdam motorists understand cyclists as equal traffic participants and give them due respect when passing or non-verbally negotiating right-of-way at unsignalized intersections, Zurich ranks dead last within Switzerland with regards to a respectful traffic culture (Pro Velo Schweiz, 2023). Cyclists are harassed by motorists often enough that most have a story to tell – and motorists are given voice in the press to complain about irresponsible cyclists. In such a situation, would Dutch designs that rely on traffic "interactions" instead of separating "conflicts" be accepted by the people – and would people feel (and be) safe? Could traffic culture be one reason that leads Swiss norms to consider roundabouts the most dangerous type of intersection for cyclists (Sigrist et al., 2021), while the Dutch prize it as one of the safest(fietsberaad CROW, 2016)?

This research and design project aims to address these challenges and questions. The goal is to recommend cycling infrastructure designs, laws, and policies for the transformation of Zurich, Switzerland into an E-Bike City (Ballo et al., 2023), keeping in mind the overarching goal of creating a transport network and culture that encourages safe, healthy, and environmentally friendly mobility.

The main method being used is an extensive literature review. This review encompasses the infrastructure design norms, laws, and policies in the Switzerland and the Netherlands and contrasts these with both scientific and "gray" literature on the topics of safety, traffic capacity, traffic participant preferences, and traffic culture. Furthermore, when and where available, other data sources, such as survey data (EBIS, 2023) are being integrated into the analyses underpinning the proposed designs, laws, and policies.

At the CRB conference, my goal is twofold. Firstly, I wish to present my findings and designs thus far and receive feedback from a diverse set of peers. Secondly, and more interestingly, I argue, I wish to delve more deeply into the question of "traffic culture": the way different traffic participants interact with each other. Based on the research underpinning my proposed infrastructure designs, I wish to pose questions and present hypotheses about why different places have different traffic cultures and how that affects how well different street designs work – including how the designs I propose might succeed or fail due to the traffic culture in Zurich.

References

Ballo, L., de Freitas, L. M., Meister, A., & Axhausen, K. W. (2023). The E-Bike City as a radical shift toward zero-emission transport: Sustainable? Equitable? Desirable? *Journal of Transport Geography*, *111*, 103663. https://doi.org/10.1016/j.jtrangeo.2023.103663.

Dörnenburg, K., Leonardi, G., Steiner, R., Gerber, S., Ghielmetti, M., & Frossard, J.-L. (2016). *Grundlagen für die Dimensionierung von sicheren Veloverkehrsanlagen* (Forschungsprojekt VSS 1567). Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation UVEK; Bundesamt für Strassen ASTRA; Schweizerischen Verbandes der Strassen- und Verkehrsfachleute.

EBIS, E. (2023). *EBIS - E-Biking in Switzerland—Research project* [Research Project]. https://ebis.ethz.ch/en/index.html.

fietsberaad CROW. (2016). *Design Manual for Bicycle Traffic*. CROW. https://crowplatform.com/product/design-manual-for-bicycle-traffic/

Meyer de Freitas, L. (2024, January). *How do bike types and cycling frequency shape cycling infrastructure preferences? A stated-preference survey*. 103rd Annual Meeting of the Transportation Research Board, Washington, D.C., USA.

Meyer de Freitas, L., & Axhausen, K. W. (2022). Evaluating mode-shift potentials to cycling based on individual capabilities [Application/pdf]. *Arbeitsberichte Verkehrs- Und Raumplanung*, *1763*, 19 p. https://doi.org/10.3929/ETHZ-B-000561700

Pro Velo Schweiz. (2023, July 13). *Prix Velo Städte 2021/22*. Prix Velo Städte. https://www.prixvelo.ch/de/prix-velo-staedte/2021-22.

Rieder, M. (2023). *E-Bike Campus* [Semester Project]. ETH Zurich.

Schnoz, L. (2019). *Road Safety Impact Assessment für die Radinfrastruktur*. ETH Zurich.

Sigrist, D., Starkermann, M., Walter, U., Rothenbühler, M., Maier, O., & Diem, I. (2021). *Handbuch Veloverkehr in Kreuzungen* (1st ed.). Bundesamt für Strassen (ASTRA) and Velokonferenz Schweiz.

Starkermann, M., Maier, O., Oswald, M., Thomann, S., Haefliger, R., de Jong, M., Nout, L., & Walter, U. (2022). *Entflechtung der Veloführung in Kreuzungen*. Bundesamt fuer Strassen ASTRA.

Weisung des UVEK über besondere Markierungen auf der Fahrbahn, (2013). https://www.astra.admin.ch/dam/astra/de/dokumente/abteilung_strassenverkehrallgemein/verkehrsregeln/vrv-2020/weisungen.pdf.download.pdf/Weisungen%20des%20UVEK%20%C3%BCber%20besondere%20Markierungen%20auf%20der%20Fahrbahn.pdf.

Von Stülpnagel, R., & Binnig, N. (2022). How safe do you feel? – A large-scale survey concerning the subjective safety associated with different kinds of cycling lanes. *Accident Analysis & Prevention*, *167*, 106577. https://doi.org/10.1016/j.aap.2022.106577.

Public Opinion and Cyclist Behaviour Towards Bicycle Push Buttons for Requesting Green at Intersections

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Abstract

Traffic signals are crucial for regulating road safety, but public opinions and cyclist behaviour regarding traffic signals and push buttons have sparked discussions on social media platforms. This study aimed to explore public opinions and cyclist behaviour related to traffic signals and push buttons by analysing social media data and empirical observations and provide recommendations to municipalities on both suitable push buttons, and communication with the public regarding traffic control.

To gather social media opinions, social media scrapers were used to collect the data, including posts from social media platforms and news articles published by municipalities. The analysis revealed that a significant majority (77%) of the social media posts expressed negative opinions toward traffic signals. Among the negative opinions, 52% of users believed that push buttons on traffic signals were ineffective. The main reasons cited for criticism were concerns about push button hygiene, long waiting times at traffic lights, and safety issues at intersections. Additionally, approximately 23% of negative posts did not provide specific reasons for their criticism but expressed a negative sentiment. Understanding the reasons behind these negative opinions is essential to address them effectively.

Several factors were identified as influencing the emergence of these opinions, including influential articles published by news websites and time-dependent events such as the Covid pandemic. In response to these opinions, municipalities acknowledged citizen criticisms and implemented various strategies to address concerns. Personalized approaches, actively listening to individuals, and assuring them that their criticisms would be addressed, proved to be effective in engaging with the public. Explaining the control function for specific locations also resulted in positive reactions from 65% of respondents. However, when municipalities announced improvements to intersection layout or control without a personal touch, the reactions tended to be more negative: only 50% positive reactions for layout-related announcements and 40% positive reactions for control-related announcements. Negative reactions ranged from scepticism about effectiveness to questioning why similar solutions were not implemented elsewhere.

Concurrently, an empirical study was conducted to explore the relationship between different types of push buttons and cyclist behaviour at signalized intersections. The study made use of detector data and signal data provided by the municipality of The Hague, collected from eight intersections with 3-5 bicycle movements. Each signal for these movements was equipped with loop detectors and one of three types of push buttons: bright buttons, touch buttons, or touch buttons combined with a waiting time indicator, see Fig. 1. The bright button is a simple button which must be pushed and has small feedback lights (LEDs). The touch button indicates "wait

for green" after being touched. The traffic controller of the intersection logs the data, so-called V-Log data, with which the following events can be determined per movement:

1. The start of red and green of the signals.
2. The moment the detector is occupied.
3. The moment the button was pushed or touched after the start of the red signal.
4. The number of times the button was pushed during red.
5. The duration of each button press/touch.

The buttons give feedback (the LEDs or the message “wait for green”) if pushed or touched, but also if a cyclist is detected by the loop detector, the button gives this feedback. The cyclist can still use the button after being detected by the loop detector, and the majority of cyclists will do so. For all movements at all intersections, and all buttons, on average in 0.7% of the cases only the button is used to request green, so without the loop detection. Averaged over the cycles, although the initial detection is done by the loop detector, the bright button is still pushed for 62% of the cases, The touch button is used in 85% of the cycles. It is unclear why this is higher since the touch button indicates the detection more clearly than the bright button. If the waiting time indicator is added, only in 44% of the cycles the button is still touched. There is only one movement with waiting time indicator, but it shows that when the remaining green time is clearly indicated, cyclists will use the button less.

There was no correlation found between the maximum waiting time and the number of button presses, suggesting that cyclists at these intersections do not express their impatience by pushing or touching the button more frequently. Further analysis showed that the touch button was touched for a longer duration compared to the bright button. In 85% of the cases, the bright button was pushed for less than 1 second, while only 45% touched the touch button for less than 1 second. Additionally, for the touch button (both with and without the waiting time indicator) a remarkable peak at 9 seconds was observed, with 8% of cyclists pressing the touch button for this extended duration. An explanation can be that the bright button gives clear tactile feedback when being pushed, which lacks for the touch button.

In conclusion, despite the presence of negative opinions on push buttons, cyclists continue to use them. Negative opinions expressed on social media often relate to concerns regarding hygiene, waiting times, and safety issues. The recommended approach for municipalities is to implement personalized strategies and provide information to address these concerns. The empirical study found no significant correlation between using the button and waiting time. However, clear detection feedback, the tactile feedback of the ‘push’, and a waiting time indicator is advised for enhancing user comfort and trust.

Fig 1. Left: Brightbutton, middle: Touch button, right: the Waiting Time Indicator is visible on top of an extra signal, which is close to the touch button as depicted in the middle. Figures from Vialis and Verkeerslantaarn.nl

Effectiveness of traffic signs to prevent fly parking

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Keywords
Fly parking reduction, traffic signs, bicycle parking behavior, stated preference survey, design

Challenge Addressed / Research Problem Investigated
We designed different traffic signs and investigated their effectiveness to reduce fly parking in city centers and to encourage the use of formal bicycle parking facilities.

Abstract
Bicycle use is increasing worldwide, and yet, they remain parked for most of the day. This creates the need for municipalities to provide attractive bike parking facilities with sufficient capacity to meet the growing demand. In the Netherlands, several municipalities have created indoor and outdoor formal parking spaces, but these remain underutilized. Instead, many cyclists choose for "fly parking", which is informal parking where bicycles are moored to objects on the street. This implies that bicycles are often haphazardly parked in city centers, causing inconvenience by blocking sidewalks. The discrepancy between the use of formal and informal parking spaces may be attributed to a lack of information provided to cyclists about the available formal parking options. To encourage the use of formal parking spaces, various ways of communication need to be explored.

Traffic signs are the most common form of communication in traffic. By placing these signs along individuals' routes, valuable insights into the most effective communication approach can be gained. This research focuses on investigating the effectiveness of different traffic sign designs to reduce fly parking and to encourage the use of formal parking spaces.

Currently, traffic signs that communicate this information do not exist. Therefore, new traffic sign designs have been created for this research, based on existing traffic signs to ensure familiarity and effectiveness. Three designs are proposed, reflecting hazardous communication and educative communication. Educative communication can be neutral, presenting information about formal parking options, or negative, indicating that fly parking is forbidden in a specific area. Hazardous communication also indicates that fly parking is forbidden and, more importantly, that alerts cyclists that controls are conducted and incorrectly parked bicycles are removed.

In order to understand cyclists' parking behavior, a stated preference (SP) choice experiment is conducted using an online survey. Participants were presented with images of 12 scenarios (trade-offs), each showing different parking options (formal indoor parking, formal outdoor parking and fly parking) and different traffic signs. In some scenarios, a reference case was introduced, in which no traffic signs, and thus no communication, were included. The images aimed to present the choice situations as realistically as possible without overwhelming participants with excessive information.

The scenarios also tested several other factors influencing parking behavior identified from literature. These cover parking characteristics (i.e. walking distance), trip characteristics (i.e. length of stay), and participant characteristics (i.e. gender, age, education level, work situation, bike price, and frequency of use).

Since the traffic sign designs are new, the survey was also used to their visibility (are the signs noticed?) and understandability (are the signs interpreted correctly?). To this end, the survey started with a video clip, showing from the perspective of a cyclist a trip through the city center. This video clip contained several (but not all) traffic signs, both existing and new. Participants were instructed to look for a parking space. After watching the clip, they were asked to indicate which traffic signs (shown in a list) they noticed in the video clip. After seeing the new traffic signs, participants were asked to interpret their meaning. A short explanation followed, to ensure that all participants have the same (intended) understanding of the signs.

The survey resulted in 269 useful responses. The responses were analyzed using discrete choice modelling to estimate the relative importance of the influencing factors and to identify effective traffic signs. The traffic signs with only information about the distance towards the formal parking spaces (neutral educative signs) yielded unexpected negative consequences, increasing the probability of fly parking rather than attracting users to formal parking options. An explanation for this could be that the displayed distances were considered to be too far to make the parking option attractive. The traffic signs informing that fly parking is not allowed (negative educative signs) were effective in reducing fly parking. The hazardous traffic signs (alerting that controls are performed) emerged as the most effective approach, especially for frequent bike users, which is most likely due to their dependence on bicycles for transportation and their prior experiences with bike removals. Other personal characteristics appeared to have only a marginal (if at all) additional impact on the effectiveness of the traffic signs.

The responses related to the video clips showed that participants generally had a good understanding of the traffic signs. However, only 6.3% of the participants correctly identified the signs in the video clip. This means that the good understandability and effectiveness of the traffic signs are not enough to prevent fly parking.

To sum up, the negative educative and hazardous traffic signs are effective in reducing fly parking, but extra effort is needed to make cyclists aware of these traffic signs along the bike path.

Bicycle Parking Requirements in Building Codes – A Comparison of German Cities

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Keywords
Bicycle parking, Parking requirements, Mobility management, Sustainable transportation, Urban planning

Challenge Addressed / Research Problem Investigated
Bicycle parking requirements in building codes are crucial to regulating the quality and quantity of urban parking facilities and promoting cycling, but which aspects are currently being considered, and which ones should be?

Abstract
Although the provision of secure parking increases cycling rates (Bueno et al., 2017; Hunt & Abraham, 2007), bicycle parking requirements for buildings are not comprehensive across the EU and vary even within countries (Küster & Peters, 2018). This paper uses guidelines to analyze which parking requirements building codes should ideally include, focusing on location and equipment attributes, and compares their implementation in 10 German cities.

BACKGROUND AND METHODOLOGY
Although research has shown the importance of bicycle parking facilities, most studies have focused on the infrastructure for moving traffic, such as bike lanes (Heinen & Buehler, 2019). Nevertheless, researchers have found that cyclists prefer sheds to parking racks (Lusk et al., 2014; Moskovitz & Wheeler, 2011; Yuan et al., 2017) and that bicycle parking facilities are more important than showers or lockers (Buehler, 2012; Hunt & Abraham, 2007). Cyclists are sensitive to the walking distance between parking facilities and destinations (Molin & Maat, 2015). Therefore, according to BICY, 2011, walking distances should be less than 5 m for short-term and 15 m for medium-term parking.

In Germany, bicycle parking requirements for buildings are regulated at the state level. Most states allow municipalities to set more detailed parking requirements, regulating the quantity and quality of car and bicycle parking that must be provided when a building is constructed or the use of an existing building is changed. Because the regulatory frameworks in other countries vary, we compare only German examples.

Using guidelines, we developed an evaluation scheme to compare parking requirements (primarily Barber et al., 2016; BICY, 2011; Blees et al., 2019; Department for Transport, 2020; FGSV, 2012; Meschik, 2008). To quantify accessibility, we consider the absence of barriers, the acceptable distance between the facility and the building, and the minimum space per bicycle.

RESULTS

Parking requirements vary widely between cities, as shown in Table 1. Even the ability to lock bike frames to a facility is not always mandatory. Several cities require covering, but usually only for residents. Almost all cities require easy access to parking facilities, but definitions vary, with some accepting ramps, elevators, or even stairs with push ramps. The acceptable distance between the facility and the destination also varies widely and is not even defined in half of the cities.

Also, only about half of the cities require parking facilities to provide safe standing and lighting. Differentiation between short-term and long-term parking and between visitors and permanent users is rare. While space for cargo bikes is often included, e-bike charging infrastructure is considered by only three cities.

Table 7: Comparison of bicycle parking requirements in different cities (black means included)

City		Aachen	Berlin	Bremen	Darmstadt	Dortmund	Erfurt	Göttingen	Mannheim	Münster	Potsdam
Protection	Ability to lock the bike frame		■	■	■	■	■	■	■		■
	Covering/weather protection		a)	b)	a)		c)	d)	b)	■	
Accessibility	Barrier-free access		e)	f)	f)	g)	f)	h)	f)	g)	f)
	Max. distance [m]	200		60	100	60	100				
	Space per bicycle [m²]	1		1.5	1.4	1.5	1.5	1.3	1.4	1.5	1.4
Usability	Secure standing while parking	■	■	■		■	■			■	
	Lighting			■	■	■	■				
Consideration/ Differentiation	Short-/long-term parking			■	■						
	Visitors/permanent users	■					■			■	■
	Cargo bikes		■	■	■			■	■	■	■
	E-bike charging			■	■			■			

a) 50 % for residential use
b) For residential use
c) For private users
d) If > 10 parking spaces
e) ≤ one staircase
f) Accessible on ground level without barriers or by ramps
g) Same as f), elevators also accepted
h) Same as f), stairs with push ramps also accepted

DISCUSSION AND CONCLUSION

Although the basic needs of cyclists may not differ significantly between cities, parking requirements in building codes do. Accessibility regulations are heterogeneous, and examples such as the acceptance of stairs with push ramps and access distances of up to 200 m show the unambitious nature of many parking requirements in promoting cycling. The lack of consideration for e-bike charging and cargo bikes underscores that some parking regulations are outdated. Although many European cities cannot legally use bicycle parking requirements in building codes (Küster & Peters, 2018), they are a powerful tool for cities in the long run. Therefore, more research should focus on appropriate, quantifiable regulations for the accessibility of bicycle parking facilities and the impact of such regulations on the practical implementation of parking facilities.

References

Barber, H., Arnold, T., Blackett, A., & van den Dool, D. (2016). *Bicycle Parking Facilities: Guidelines for Design and Installation.*

BICY (Ed.). (2011). *Bicycle Parking Made Easy: A guide to the construction of bicycle parking facilities.* BICY - Cities and Regions for Cycling.

Blees, V., Thiemann-Linden, J., & Müller, K. (2019). *Kommunale Stellplatzsatzungen: Leitfaden zur Musterstellplatzsatzung NRW.*

Buehler, R. (2012). Determinants of bicycle commuting in the Washington, DC region: The role of bicycle parking, cyclist showers, and free car parking at work. *Transportation Research Part D: Transport and Environment*, *17*(7), 525–531. https://doi.org/10.1016/j.trd.2012.06.003.

Bueno, P. C., Gomez, J., Peters, J. R., & Vassallo, J. M. (2017). Understanding the effects of transit benefits on employees’ travel behavior: Evidence from the New York-New Jersey region. *Transportation Research Part a: Policy and Practice*, *99*, 1–13. https://doi.org/10.1016/j.tra.2017.02.009.

Department for Transport (Ed.). (2020). *Cycle Infrastructure Design* (Local Transport Note 1/20). Norvich. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/951074/cycle-infrastructure-design-ltn-1-20.pdf

FGSV. (2012). *Hinweise zum Fahrradparken*. Köln. Forschungsgesellschaft für Straßen- und Verkehrswesen.

Heinen, E., & Buehler, R. (2019). Bicycle parking: a systematic review of scientific literature on parking behaviour, parking preferences, and their influence on cycling and travel behaviour. *Transport Reviews*, *39*(5), 630–656. https://doi.org/10.1080/01441647.2019.1590477.

Hunt, J., & Abraham, J. (2007). Influences on bicycle use. *Transportation*, *34*, 453–470. https://doi.org/10.1007/s11116-006-9109-1.

Küster, F., & Peters, M. (2018). *Making Buildings Fit for Sustainable Mobility: Comparing Regulations for Off-Street Bicycle and Car Parking in Europe.*

Lusk, A. C., Wen, X., & Zhou, L. (2014). Gender and used/preferred differences of bicycle routes, parking, intersection signals, and bicycle type: Professional middle class preferences in Hangzhou, China. *Journal of Transport & Health*, *1*(2), 124–133. https://doi.org/10.1016/j.jth.2014.04.001.

Meschik, M. (2008). *Planungshandbuch Radverkehr*. Springer.

Molin, E., & Maat, K. (2015). Bicycle parking demand at railway stations: Capturing price-walking trade offs. *Research in Transportation Economics*, *53*, 3–12. https://doi.org/10.1016/j.retrec.2015.10.014.

Moskovitz, D. A., & Wheeler, N. (2011). Bicycle Parking Analysis Using Time Series Photography. https://davidamoskovitz.files.wordpress.com/2010/08/bicycle_parking_analysis.pdf

Yuan, C., Sun, Y., Lv, J., & Lusk, A. C. (2017). Cycle Tracks and Parking Environments in China: Learning from College Students at Peking University. *International Journal of Environmental Research and Public Health*, *14*(8). https://doi.org/10.3390/ijerph14080930.

What do we do with all the bikes? Residential bicycle parking in established urban neighborhoods

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Keywords
bicycle parking, practices, mobility transition, urban space, planning

Challenge Addressed / Research Problem Investigated
How key actors create residential bicycle parking in established urban neighborhoods.

Abstract
Many residents of urban areas live in apartment buildings without sufficient bicycle parking. To create new, quality bicycle parking, space needs to be rearranged. This presents a significant challenge in urban neighborhoods where uses are well-established. Thus far, much of the existing research on processes of reallocating urban space for bicycle infrastructure has focused on road space and cycling network infrastructure, with the promise of inducing a modal shift toward cycling. But whether a user has an accessible, safe, and convenient place to store their bicycle has seen less focus.

One main difference to reallocating space for path infrastructure is that residential bicycle parking can be located in private as well as public space. While public space can be rearranged to create bicycle parking, the introduction of private space increases the complexity of what an ideal or sufficient solution for bicycle parking might be, while simultaneously increasing the number of actors involved. Furthermore, on private property, public authorities do not have ability to directly make changes. Instead, private actors decide what types of improvements to make – and whether to make them.

Both public and private actors face various factors that make planning bicycle parking infrastructure in established urban neighborhoods challenging. One aspect is that, in existing urban neighborhoods, many uses compete for the same, limited space, and existing uses are often well-established. Wherever new bicycle parking is added, some other use is displaced. Bicycle parking competes for space not only with cars, but also other public and private open space, as well as space inside of buildings. In buildings, bicycles are often stored in residual space, such as in entryways and basements. Yet, the more units in an apartment building, the less residual space is available after other required uses are accounted for (e.g. circulation space, technical buildings systems, storage). Some spaces are more negotiable than others – but almost all reallocation is contentious. The nature of historic urban fabrics is that they are layered, complex, and irregular, and are thus a challenge to navigate and modify.

Another aspect that presents uncertainty is what type of bicycle parking infrastructure to provide. There is not one single, ideal form of bicycle parking at residences. Certain qualities, such as accessibility, convenience, safety, and security, play a more or less significant role

depending on the user and their bicycles and equipment. On the one hand, there is the demand side to consider: How many bicycles are expected? Which kinds (e.g. standard adult bikes, e-bikes, cargo bikes, specialty bikes)? Then, on the supply side, it can be challenging to navigate the wide variety of bicycle parking products on the market (e.g. racks, hooks, sheds) and decide which product to use given the characteristics of the available space and anticipated users.

There is no one, uniform solution for creating residential bicycle parking in established urban neighborhoods and the processes and practices of how bicycle parking is created are varied. The aim of this research is to investigate processes and practices in order to better understand how key actors negotiate micro-scale spatial shifts to create residential bicycle parking.

The site of this research is Hamburg, Germany. In recent years, several policy instruments were introduced in Hamburg to promote the creation of bicycle parking for existing apartment buildings, including updates to the building code (applies to new construction only), the publication of a design guide (2020), the introduction of an incentive program (2022), and the development of a new bike shed scheme (piloted 2023) (ARGUS, 2020; BVM, 2023, p. 47; IFB, 2022). These policy instruments are evidence of the political will for change. Many residents still struggle to find bicycle parking that is safe from vandalism and theft, protected from the elements, and easy to access. Yet, examples of bicycle sheds, racks, and retrofitted storage facilities can be found in a variety of forms across the city, on both public and private property. Small-scale transformation is underway.

To investigate transformation processes and practices, I use a multi-case study research design. Cases are apartment buildings located within urban neighborhoods and include varied actor constellations, administrative districts, property types, and construction eras. The main sources of data collected include interviews, documentary materials, site surveys, mapping, and observations. The case study results are expected to shed light on the processes and practices of how bicycle parking is created—of what gets built and why. Investigated themes include the role of spatial form, regulations, organizational structures, and information pathways. Looking to the future, I investigate how key actors construct the path between the imagined, ideal situation and what actually gets built.

Creating additional, quality residential bicycle parking has the potential to improve the attractiveness of cycling for a large portion of the population. This research contributes to our understanding of processes of urban transformation for residential bicycle parking, and can inform research, policy, and practice. While this research is about a very specific topic — residential bicycle parking — the patterns of how varied actors navigate a simultaneous lack of clarity about what exactly should be done, who should do it, and who should pay, may in a broader sense shed light on processes of small-scale spatial transformation that are necessary to move toward a more sustainable urban future.

References

ARGUS Stadt und Verkehr Partnerschaft mbB & Gössler Kinz Kerber Kreienbaum Architekten BDA (ARGUS). (2020). *Leitfaden Fahrradparken im Quartier—Empfehlungen für die Planung von Fahrradabstellanlagen auf privaten Flächen*. Behörde für Stadtentwicklung und Wohnen (BSW). https://www.hamburg.de/contentblob/14908662/f273a7c45bb2481ae4ad5bb324fba535

/data/leitfaden-fahrradparken-im-quartier-empfehlungen-fuer-die-planung-von-fahrradabstellanlagen-auf-privaten-flaechen.pdf.

Behörde für Verkehr und Mobilitätswende Koordinierung Mobilitätswende Fuß- und Radverkehr (BVM). (2023, February). *Bündnis für den Rad- und Fussverkehr—Kurzbericht 2022* [PDF Slides]. https://www.hamburg.de/contentblob/17001098/7b9f993360030bb44546d3b7561b931d/data/kurzbericht-2022.pdf.

IFB Hamburg (IFB). (2022). *Nachrüstung von Fahrradabstellanlagen im Bestand Förderrichtlinie zur Nachrüstung von Bestandsimmobilien mit hochwertigen Fahrradabstellanlagen für Wohngebäude und Arbeitsstätten Gültig ab 14. Februar 2022 (Stand 17. März 2022)*. Hamburgische Investitions- und Förderbank. https://www.ifbhh.de/api/services/document/3786.

"Best processes" for achieving bikeability today: What the experts can (and can't) teach you

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Keywords
bikeability, cities, active mobility, policy transfer, policy learning

Challenge Addressed / Research Problem Investigated

This paper explores the learning processes undertaken by cities striving to become more bikeable, as they seek models for best practice among mature cycling cities.

Abstract

As cities across Europe and beyond work to combat climate change, reduce dependency on cars and encourage healthier lifestyles, biking has emerged as an attractive solution. Coordination of biking efforts at the regional and national levels is often lacking, leaving cities as the primary drivers advancing the transition to bikes.

To aid ambitious cycling cities in identifying best practices for encouraging urban biking, an international knowledge base has emerged. Resources abound in the form of academic publications, web content, consultancies, study tours and international conferences. These sources highlight proven policies and infrastructure designs, often pointing to mature cycling cities like Amsterdam and Copenhagen as examples of best practice.

The academic field of policy transfer studies the process of inter-city learning. Policy transfer research tells us that direct imitation is typically ineffective, as knowledge learned in one city must be adapted before it can be applied in another locale. Researchers also note that specific policies rarely transfer from place to place. Instead, a city is more likely to learn general principles or gain intangible assets such as enthusiasm, inspiration or enhanced team dynamics.

This paper explores the intersection of best practice and policy transfer for urban biking. If it were true that best practices are clearly defined and can be learned, this could accelerate the growth of fledgling biking programs. On the other hand, if best practices are not clear or do not transfer effectively, then what is the path forward for the next generation of cycling cities?

This paper presents a case study of Bordeaux's mentorship by Amsterdam as part of the Civitas Handshake program from 2018 to 2022. Handshake was an ambitious EU-funded program intended to promote policy transfer between European cycling capitals and "future cycling capitals." Data was gathered through in-depth expert interviews (N=11) of Bordeaux's delegation to Handshake, as well as others closely linked to the mentorship. Interviews were conducted in spring 2022 as Handshake was drawing to a close, and were supplemented with

policy documents and public reports. These sources were analyzed to discover Bordeaux's learning process and identify the impact that Handshake had on the city's bikeability efforts.

The data reveal that Bordeaux's delegation 1) gained limited applicable policy knowledge through Handshake, 2) had already finalized its latest round of policy initiatives before the program's influence could be felt, and 3) credited Handshake with a boost in their own enthusiasm as well as political support for their work. These findings highlight the energizing effect of international collaboration, while also questioning the potential for relevant policy best practices to be learned from other cities.

The novel concept of "best processes" is proposed to demonstrate the value of Bordeaux's example. While mature cycling cities like Amsterdam offer a tantalizing view of a possible end goal (i.e. best practice), emerging cycling cities like Bordeaux demonstrate how the learning process might be leveraged in the 2020s.

This study can inform future research about inter-city bikeability collaboration, suggesting that more focus should be placed on ambitious early- and mid-stage cycling cities and their policy learning and implementation processes. Furthermore, it urges the re-evaluation of the role of mature cycling cities as sources of inspiration and motivation rather than as models for policy best practice. Alongside these mature cities, exemplars of policy learning "best processes" should be identified among emerging cycling cities such as Bordeaux.

Intuitively usable Cycling Infrastructure – Findings from a Systematic Literature Review

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Keywords
intuitive design, cycling infrastructure, comprehensibility, self-explaining roads, systematic literature review

Challenge Addressed / Research Problem Investigated
Even though unintuitive cycling infrastructure deters people from cycling, there seems to be little to no research on how to design intuitively usable cycling infrastructure.

Abstract
Using bicycle infrastructure in a dense urban traffic system can be a challenging task. Paying attention to other road users may be hard enough in many situations. But as recent findings show as well, cyclists regularly feel confused due to a lack of cycling infrastructure's comprehensibility. Moreover, comprehensibility acts as a key factor for assessing infrastructure's cycling friendliness and affects cyclists' perception of both safety and comfort (Friel et al., in press).

Infrastructure planning guidelines already address this issue by stating that cycling infrastructure must be comprehensible, easy to understand or easy to use. For example, the German cycling infrastructure guideline "Empfehlungen für Radverkehrsanlagen" states that cycling infrastructure at intersections must be unambiguously understandable for all road users (FGSV, 2010, p. 37). Meanwhile the Scottish brochure "Cycling by Design" states that "cycling infrastructure should be intuitive for all who use it or interact with it" (Transport Scotland, 2021, p. 9). In turn, the City of Vancouver recommends that "intersections should be intuitive and provide directional messaging when needed." (City of Vancouver, 2017, p. 6) However, these guidelines lack information on how to implement such an intuitively usable bicycle infrastructure. Moreover, there seems to be little to no research concerning this issue.

In contrast, there is a concept for intuitively usable car infrastructure called self-explaining roads (SER). This concept has been pronounced by Theeuwes and Godthelp (1995). In their paper, they describe how car drivers categorize roads subjectively and behave according to their subjective categorization. They state: "Roads are self-explaining when they are in line with expectations of the road users." (Theeuwes & Godthelp, 1995, p. 222)

In a more recent paper, Theeuwes (2021) further describes SER:

> *The underlying idea is that the design and layout of the road environment elicits automatically the behavior that is appropriate for that type of road. In other*

> *words, the road nudges the right behavior without the need for much enforcement or education. (Theeuwes, 2021, p. 1)*

In the last decades, this concept has spread from its origin in The Netherlands: It has been adopted and used for the development of road designs in several countries, e.g. USA (Mackie et al., 2013), Germany (Becher et al., 2006), and Czech Republic (Ambros et al., 2017). This human centered approach has also been used by the World Road Association (Birth et al., 2016).

Thus, the design of car infrastructure is increasingly linked to findings on the field of behavioral research, making human perceptions part of the design process as proposed in the concept of human centered or user centered design (e.g. Law et al., 2009).

However, there are relatively few efforts to integrate human perceptions in cycling infrastructure design in such a way. As Barrero and Rodriguez-Valencia (2022) describe it:

> *As part of the literature review, we revised 48 bicycle related policy manuals and/or bicycle infrastructure design guidelines [...]. We found that only two guides include the user's opinions or preferences in the bicycle infrastructure design process. [...] Despite these two exceptions, in other guides, user involvement is limited to research surveys on overall satisfaction/dissatisfaction, commute preferences, and origins and destinations. (Barrero & Rodriguez-Valencia, 2022, p. 247)*

Thus, users' needs and especially the need of intuitively comprehensible infrastructure are hardly present in today's cycling infrastructure planning processes. And while cyclists already criticize the current traffic system as not intuitively usable, this issue will be even more relevant as cycling usage may increase in the next years. Therefore, I want to further investigate the topic of intuitively usable cycling infrastructure in my Dissertation project.

As a starting point, I conducted a systematic literature review to describe the current state of research on intuitively usable cycling infrastructure and to identify major research gaps.

Searching three databases with a predefined set of keywords resulted in more than 1300 titles. Applying inclusion and exclusion criteria, eleven titles remained in the last review step and were analyzed in detail. Results show that these studies use a variety of methods and terms to describe and investigate intuitiveness of various cycling infrastructure designs. Conclusions from these studies range from very specific infrastructure design recommendations over highly general design advices to recommendations that do not refer to infrastructure design at all. I identified three main research gaps. Firstly, there are various infrastructure types that have not been covered by the studies. Furthermore, there is a need for basic research on how to apply principles of intuitive design to cycling infrastructure design in general. Lastly, a large amount of research investigated behavioral responses to infrastructural changes but was not designed to specifically assess intuitiveness. Thus, there are large research gaps to be filled by upcoming studies to design intuitively usable cycling infrastructure.

At CRBAM, I will present the findings from my literature review to further discuss the most relevant, interesting, and promising research gaps for my Dissertation. Moreover, I hope to discuss possible research designs and methods to be used. All in all, I look for inspiration to get a good starting point for my research.

References

Ambros, J., Valentová, V., Gogolín, O., Andrášik, R., Kubeček, J., & Bíl, M. (2017). Improving the Self-Explaining Performance of Czech National Roads. *Transportation Research Record: Journal of the Transportation Research Board*, *2635*(1), 62–70. https://doi.org/10.3141/2635-08.

Barrero, G. A., & Rodriguez-Valencia, A. (2022). Asking the user: a perceptional approach for bicycle infrastructure design. *International Journal of Sustainable Transportation*, *16*(3), 246–257. https://doi.org/10.1080/15568318.2020.1871127.

Becher, T., Baier, M. M., Steinauer, B., & Krüger, H.-P. (2006). *Berücksichtigung psychologischer Aspekte beim Entwurf von Landstraßen*. Bericht zum Forschungsprojekt FE 02.230/2003/AGB (Berichte der Bundesanstalt für Straßenwesen No. 148). Bremerhaven. https://edocs.tib.eu/files/e01fn19/1667721488.pdf.

Birth, S., Ágústsson, L., Allan, P., Chambon, P., Elsenaar, P., Ganneau, F., Greenalgh, M., Hollo, P., Lee, S. J., Rubio, R. L., Mallejacq, P., Rouffaert, A., Vollpracth, H.-J., Westdijk, E., de Almeida Rogue, Carlos, Aubin, D., Grasse, D. de, Douglas, J., . . . Schepers, P. (2016). *Human factors guidelines for a safer man-road interface*. PIARC. https://www.piarc.org/en/order-library/6159-en-Human%20factors%20guidelines%20for%20safer%20road%20infrastructure.

City of Vancouver. (2017). *Transportation Design Guidelines: All Ages and Abilities Cycling Routes*. https://vancouver.ca/files/cov/design-guidelines-for-all-ages-and-abilities-cycling-routes.pdf.

FGSV. (2010). *Empfehlungen für Radverkehrsanlagen: ERA R2* (FGSV R2 - Empfehlungen). Köln. Forschungsgesellschaft für Straßen- und Verkehrswesen.

Friel, D., Wachholz, S., Zimmermann, L., Werner, T., Schwedes, O., & Stark, R. (in press). Cyclists' Perceived Safety on Intersections and Roundabouts – a Qualitative Bicycle Simulator Study. *Journal of Safety Research*.

Law, E. L.-C., Roto, V., Hassenzahl, M., Vermeeren, A. P., & Kort, J. (2009). Understanding, scoping and defining user experience: A survey approach. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 719–728). ACM. https://doi.org/10.1145/1518701.1518813.

Mackie, H. W., Charlton, S. G., Baas, P. H., & Villasenor, P. C. (2013). Road user behaviour changes following a self-explaining roads intervention. *Accident Analysis & Prevention*, *50*, 742–750. https://doi.org/10.1016/j.aap.2012.06.026.

Theeuwes, J. (2021). Self-explaining roads: What does visual cognition tell us about designing safer roads? *Cognitive Research: Principles and Implications*, *6*(1), 1–15. https://doi.org/10.1186/s41235-021-00281-6.

Theeuwes, J., & Godthelp, H. (1995). Self-explaining roads. *Safety Science*, *19*(2-3), 217–225. https://doi.org/10.1016/0925-7535(94)00022-U.

Transport Scotland. (2021). *Cycling by Design*. https://www.transport.gov.scot/media/50323/cycling-by-design-update-2019-final-document-15-september-2021-1.pdf.

Smoother than smooth! – Bikeability of cobble stone: The cobble stone challenge for cycling infrastructure planners

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Keywords
Bikeability of cobble stone, bicycle transport, smoothening bike paths, living lab

Challenge Addressed / Research Problem Investigated
How to make cobble stone driveways bikeable, since cobble stone driveways are a nuisance for cyclists usually abusing sidewalks as an adaptation.

Abstract
Natural stone pavements, especially in listed residential areas (heritage protected), are usually avoided by cyclists. As a consequence, most cyclists use the parallel footpath/sidewalk. According to traffic regulations, however, this is not permitted for adults unless the footpath is explicitly admitted to cyclists. Especially in eastern Germany, there are still many cobblestone streets. But also, in Western, Southern and Eastern Europe these kinds of often centuries-old roads can still be found. As part of a research project, we are using a newly developed grinding machine to investigate how natural stone cobblestones can be ground down in a minimally invasive way so that the visual aspect remains intact (conformity with heritage protection regulations), but can still be cycled on comfortably. A second technology to be piloted in this project is the stone carpet from the companies BASF and BEMA. This is a polyurethane-bonded water-permeable chippings mixture that is not hydraulically bonded but cold-sets and thus emits considerably less CO_2 until it is laid than, for example, asphalt. However, the trafficability properties are virtually identical. The product can be colored in any color in which stones occur or glass can be colored that can be mixed in. Additionally, everlasting pictograms can be designed and implemented with distinguished colored stones.

The challenge in testing the two technologies is to explore:

a) How is the measure to be classified (extensive rehabilitation or minimal conservation measure) and what accompanying construction measures must be carried out. This concerns planning, building permits, environmental impact assessments, noise protection reports, drainage, permits under monument law (heritage protection) etc.
b) How do the employees in the building authorities cooperate? What resentment exists among planners and residents?
c) What is the scope of planning and realization as well as the construction costs compared to the conventional method: remove the pavement, saw it smooth and reinstall it?
d) How should edges and transitions be made so that they do not pose a danger to cyclists?
e) Which technologies can be used for quality control (e.g. lidar sensors, ultrasonic sensors, etc.)?

FORMAT OF SESSION

Networking and knowledge building and dissemination by bilateral discussions and common exchange among all participants in the plenary.

The cobblestone challenge and the two possible solutions to address this challenge will be briefly presented by the session leaders using two posters (or by projector, depending on the number of registrations for the session). After the introduction, all participants must participate actively! Everybody shall present his or her idea or proposed solutions, innovation/best practice from other countries, etc. in front of all other participants of this session. Each participant has ONE MINUTE to pitch his or her partial solution/solution/input/contribution (approx. 25-35 minutes in total, depending on the number of participants). A large note card is used to record what has been said and the presenter holds the card legibly in front of his/her stomach. After everyone has presented once, two participants get together for a two-way discussion and discuss the advantages and disadvantages of the solution presented for about 10 minutes. Afterwards, the pairs present their discussion status or the respective improvement through the discussion to the plenary (approx. 40 minutes). The results are photo-documented and distributed to all participants.

Benefit for the participants: broad dissemination of the entire knowledge about bikeable cobblestones among all participants, intensive networking, development of further project ideas.

Benefit for the organizers: learning about best practices, generating ideas for the ongoing project, building partnerships, developing further living labs, developing new project ideas. Development of a working group for the creation of guidelines about bike ability of cobble stone.

Bike Path Radar: New data driven opportunities for bicycle infrastructure planning and improved citizen engagement

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Keywords
Bike Infrastructure, Bicycle Data, Quality Assessment, Dashboards, Machine Learning

Challenge Addressed / Research Problem Investigated

Cycling Quality cannot be defined for different segments or at least roads in the bike infrastructure network of a city

Abstract

The German Federal government has increased available funding budget for investments in bicycle infrastructure [BMDV21a]. The Federal Government has requested the local administrations to retrieve the available fundings [St23]. However, the ADFC Bicycle Climate Test 2022 (ADFC Fahrradklimatest 2022) has revealed that the demands of cyclists, who want more space and more road safety, regarding the bike path network are rising [Ge23]. Since financial [DStGB23] and human resources [DBB21] in the administration are limited, it is unclear which cycling promotion measures should be prioritized. On which routes should the asphalt be renewed first? At which roads we may allow cyclists to cycle on the road? A detailed overview about cycle path quality could provide an important basis for decision-making. New digital solutions that reflect the user perspective could support cities in the transition process to more bike friendliness. As part of the INFRASense [BMDV21] project, the goal of a data-based quality assessment of the bike path infrastructure should be achieved. The BIQEmonitor [BIQE23] visualizes the quality of the route sections in the city regarding surface conditions and various other criteria based on real trips detected by Bluetooth sensors or an app. Intersections are evaluated based on waiting times. All relevant criteria are collected from traffic planning guidelines. The H EBRA [FGSV21] includes most of the relevant criteria for the practical decision making. Besides problems on a bike trip, there are many more criteria required for a realistic evaluation of bike path quality. For instance, the alignment of a bike path on the road is more accepted by cyclists in case of lower traffic volumes [Sc23]. The bicycle amount on a road is relevant to decide about what alignment is suitable for the bike path [FGSV2012]. Bicycle accident hotspots can reveal infrastructural deficiencies, e.g. at junctions with many turning accidents. The entries from citizen reporting portals show where cyclists are

fundamentally dissatisfied, locations with rank growth, parking violators, shards etc. (e.g. Meldeplattform Radverkehr [IVM23]). In municipal administrations, a lot of geographical data on bike path networks, topography or the alignment of bike paths is applied.

The Bike Path Radar (Radweg Radar) [UOL22] integrates all of these data sources. The website was implemented with a role concept. That means that the general public gets open access to more general, simplified information while cycling planning experts get the opportunity to create interactive and personalized dashboards that include insightful information to improve bike usage. The dashboard will be a central hub for selecting and visualizing cycling related Key Performance Indicators (KPIs) through charts and maps, empowering users to interpret and analyze bike infrastructure data. The requirements for the development are collected from leading experts in the bicycle infrastructure planning domain of Planungsbüro VIA [VIA23].

Bike infrastructure data contains traffic network information (e.g. bike routes, bike path alignment, topography). An important requirement of the traffic planning domain is that the bike path assessment should be comparable. Therefore, the whole bike traffic network was divided into segments of 50 meters length. The bike trips of the BIQEmonitor include time, speed, acceleration etc. resulting in millions of data points. The bike trips are fetched with weather data in a 15 minutes interval to allow analysis regarding weather influence on bike use. The data base also includes stationary traffic counting data (bicycles, cars, heavy vehicles etc.). Citizen Reporting data contains time, place, description, and categories regarding traffic relevant incidents. EUSKa, a digital map for traffic accidents that was introduced to German police departments in 2008 [Di11], is also part of the database.

The dashboard visualizes KPIs for roads and route sections in Oldenburg and Osnabrück. These indicators identify disturbance factors in bike use, such as waiting times, time loss, traffic volume, route quality, or weather-related accidents. At the current development state, traffic volume, accident analysis and citizen reporting data is available on the dashboard, allowing evaluation by different dimensions such as years, months, days, hours, or intervals. Selected KPIs may be visualized with graphs or maps (Fig. 1 shows an exemplary visualization). For the implementation, modern web technologies were used. React [Rea23] enables dynamic user interfaces, Recharts [Rec23] provides a variety of chart types, and Leaflet [Le23] offers interactive map functionalities for the bike infrastructure.

Fig. 1: Dynamic Bike Path Radar dashboard including maps, charts and graphs

In the past few years, citizens are claiming for more participation in political decision making [KS16]. The Bike Path Radar gives citizens the opportunity for more engagement in cycling planning by an interactive reporting portal that visualizes bike path damages. AI methods are applied to detect damages provided by users and displays these on a map. The most important asphalt road defects as cracks and potholes [Ca22] are considered. The dataset used in this research was manually created and labeled. The YOLOv8 [YO23] algorithm was employed to train the AI model on the labeled dataset. The platform implementation involves the development of both the frontend and backend components. The frontend providing a user-friendly interface for uploading images and reporting damages on bicycle paths. The backend which is based on Flask [Fl23] handles the detection of damages based on the trained AI model. The images are physically stored in an object storage, while references and additional metadata are integrated into a PostgreSQL [PSQL23] database. Fig. 2 shows an exemplary image with successful damage detection.

Fig. 2: Exemplary result of the AI model to detect bike path damages

The results are discussed with municipal representatives, interest groups (e.g. ADFC) and other researchers regarding the relevance for planning processes and road maintenance. In the next step it should be clarified what are the most relevant KPIs for bike path assessment. What exactly should be done to at a turning accident hot spot intersection? What measures should be taken at a popular bike course with more than 2.000 cyclists a day that gets a bad surface rating? Would it be conceivable to abolish the obligation to use cycle paths there? These questions will be clarified as part of further evaluation with experts and citizens.

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References

[BIQE23] worldiety, BIQEmonitor, www.biqemonitor.de, last accessed 2023/06/12.
[BMDV21a] Entwicklung einer Softwareanwendung zur Qualitätsbestimmung kommunaler Radverkehrsanlagen auf Basis von Crowdsourcing-Daten - INFRASense,

https://bmdv.bund.de/SharedDocs/DE/Artikel/DG/mfund-projekte/infrasense.html, last accessed 2023/06/25.

[BMDV21b] Flächendeckende Fahrradinfrastruktur durch das Sonderprogramm „Stadt und Land", https://bmdv.bund.de/SharedDocs/DE/Artikel/StV/Radverkehr/flaechendeckende-fahrradinfrastruktur-sonderprogramm-stadt-und-land.html, last accessed 2023/06/27.

[DBB21] dbb beamtenbund und tarifunion, Dem Staat fehlen fast 330.000 Mitarbeiter, https://www.dbb.de/fileadmin/user_upload/globale_elemente/pdfs/2021/210329_dbb_Personalbedarfe_oeD.pdf, last accessed 2023/06/27.

[Ca22] Cafiso, S.; Di Graziano, A.; Marchetta, V.; Pappalardo, G.: Urban road pavements monitoring and assessment using bike and e-scooter as probe vehicles. Case Studies in Construction Materials, Vol. 16, 2022, p.e00889.

[Di11] Dick, R.: Die Polizeilichen Online-Informationssysteme in der Bundesrepublik Deutschland. BoD – Books on Demand, Norderstedt, 2011.

[DStGB23] Deutscher Städte- und Gemeindebund, Hohe Defizite der Kommunen in den Jahren 2022 und 2023, https://www.dstgb.de/publikationen/pressemitteilungen/hohe-defizite-der-kommunen-in-den-jahren-2022-und-2023/, last accessed 2023/06/27.

[FGSV12] Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Empfehlungen für Radverkehrsanlagen (ERA). FGSV Verlag, Cologne, 2012.

[FGSV21] Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Hinweise zur einheitlichen Bewertung von Radverkehrsanlagen (Ausgabe 2021). FGSV Verlag, Cologne, 2021.

[Fl23] Flask, https://flask.palletsprojects.com/en/2.3.x/, last accessed 2023/06/30.

[Ge23] Gengenbach, S.: Fahrradklimatest zeigt viel Schatten und wenig Licht. VELOPLAN, Vol. 2, June 2023, pp. 551-560.

[IVM23] ivm GmbH, Meldeplattform Radverkehr, https://www.meldeplattform-radverkehr.de, last accessed 2023/06/30.

[KS16] Kersting, N.; Schneider, S.H.: Neue Machtansprüche in der Kommunalpolitik: Die Einstellungen von Ratsmitgliedern zu Bürgerbeteiligung. Zeitschrift für Vergleichende Politikwissenschaft, Vol. 10, 2016, pp. 311-339.

[Le23] Leaflet, An open-source JavaScript library for mobile-friendly interactive maps, https://leafletjs.com/, last accessed 2023/06/30.

[PSQL23] PostgreSQL, https://www.postgresql.org/, last accessed 2023/06/30.

[Rea23] React, The library for web and native user interfaces, https://react.dev/, last accessed 2023/06/30.

[Rec23] Recharts, A composable charting library built on React components, https://recharts.org/en-US/, last accessed 2023/06/30.

[Sc23] Schüller, H.; Niestegge, M.; Hantschel, S.; Kühn, B.; Gerike, R.; Huber, S.: Akzeptanz und Verkehrssicherheit des Radverkehrs im Mischverkehr auf Hauptverkehrsstraßen. Berichte der Bundesanstalt für Straßenwesen (bast), Verkehrstechnik, Heft V 366.

[St23] Stern, Kommunen sollen Fördergeld für Radverkehr abrufen, https://www.stern.de/wirtschaft/news/bundesverkehrsministerium--kommunen-sollen-foerdergeld-fuer-radverkehr-abrufen-33575296.html, last accessed 2023/06/27.

[UOL22] University of Oldenburg, Radweg Radar, www.radweg-radar.de, last accessed 2023/06/28.

[VIA23] Planungsbüro VIA, https://www.viakoeln.de/home, last accessed 2023/06/28.

[YO23] YOLOv8, Explore YOLOv8, https://yolov8.com/, last accessed 2023/06/30.

How bike-friendly is your street? Modelling bikeability using open data.

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Keywords
bikeability, bike friendliness, network assessment, open source, open data

Challenge Addressed / Research Problem Investigated

The parametrization of an existing, open and adjustable model for assessing bikeability from open data needs to be validated to guarantee reliable and transferable results.

Abstract

An increase in the number of people that use the bicycle instead of motorised modes is associated with positive impacts on physical and mental health, climate, safety, and economy, among others. Consequently, stakeholders around the world acknowledge the need to promote cycling as utilitarian mode of transport. This requires a bikeable street network, i.e. a street network that is convenient and safe for cycling. We identified the need to lower the barriers for decision makers in public administration and the private planning sector to assess the bikeability of street networks, without requiring GIS or data science expertise. A comparable, automated assessment of the street network may foster better informed and targeted improvements of infrastructure. Therefore, we have developed a model and open-source toolbox for bikeability assessment which utilizes exclusively open and widely available data sources such as OpenStreetMap. We now intend to conduct a validation of the model using an interactive approach.

The proposed bikeability model infers various quality indicators from network data by mapping attribute values to a universal numerical scale that represents suitability for cycling. These indicators range from characteristics of the street itself, such as the presence of separate bike lanes, the condition of the street surface, the gradient, and the speed limit, to characteristics of the street environment, such as greenness and noise. All quality indicators are then combined into a single quantitative bikeability index for each segment by computing a weighted average.

For both stages of modelling - the numerical mapping of attribute values to quality indicators as well as the weighting of each indicator - the parametrisation is essential for generating viable results. Our proposed bikeability model comes with a set of parameters that is derived from previous research on cyclists' perception of safety and comfort, as well as on the analysis of crash reports. Thereby, we model bikeability as representation of commonly perceived infrastructure suitability for cycling. We are aware that preferences may be subjective and even depend on purposes and framing conditions for individual trips. Therefore, the open-source workflow allows easy customization of all parameters to adjust the model accordingly. Still, the generic assessment of bikeability as it is commonly perceived by cyclists provides valuable

input for mobility planning and decision support. Our proposed model and its open-source implementation have been successfully utilised as basis for numerous applications such as bicycle routing, gap detection, assessment of cycling accessibility, and agent-based modelling of cyclist mobility.

We see great potential in not only presenting but interactively assessing our proposed model together with the experts attending the 7th Annual Meeting of the Cycling Research Board. We envision to conduct a live-survey with acquiring expert ratings on bikeability for exemplary infrastructure situations, followed by an on-the-fly analysis and comparison to the model results. Various street configurations illustrated through photographs will be assessed during the expert ratings in a fun and interactive way. Consequently, we aim for presenting live validation results for our model within the session. Our intention is to use the collected expert feedback to further improve and extend the bikeability model. As we share the software and its source code under MIT license, the validated and / or improved model will be available to everyone and can be used as a basis for further analyses and applications. You find the NetAScore software at https://github.com/plus-mobilitylab/netascore.

Thinking about change / Learning from uncontrollability

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Keywords
Uncontrollability, change, planning, degrowth

Challenge Addressed / Research Problem Investigated
Confronting problems produced by continued reliance on linear assumptions of change.

Abstract
Cycling studies inherits dominant models of change from transport studies. Responding to the very real needs of policy makers and transport professionals, as scholars we have become (admirably) adept in providing persuasive arguments and data to support the formation of strategic policy and to unlock funding. However, this risks coming at the cost of critical analysis of the underlying assumptions and values embedded in current policy assumptions. Models of change are predominantly linear (if X then Y), however many layers of complication are added to the factors. In other words if y is our desired outcome (more cycling) then our task as researchers is to find factor(s) that will produce the desired outcome, thus shaping our research design. If we understand complexity as a fundamental property (not just as a term to describe an added level of difficulty) then we have to shift away from linear causal assumptions (Urry 2003).

As Hartmut Rosa's (2019; 2020) work on uncontrollability shows, linear models are increasingly untenable and indefensible. More importantly, it is apt to produce results that increase existing problems. Similarly, without considering the greater political picture, cycling research that simply aims to make cycling more attractive without considering why, or analysing its broader context, risks increasing the forces that are leading to increasing unsustainability (social and environmental) (see e.g. Spinney 2020).

This workshop involves an introductory presentation and group discussion to provide a chance to explore what happens if we release our grip or dependence on linear models of change in our research design and framing of the challenges we face in policy terms. To provide a ground for novel ways of thinking and learning it embraces the challenges of pedagogy in the anthropocene (Paulsen et al 2022) which departs from standardised linear models of learning and colonial assumptions about knowledge production.

It challenges participants to think more deeply about the connections between research and policy direction. It asks us to unpack the connections between cycling research and assumptions of economic growth in light of the politics of climate change. Is more urban cycling, for example, simply a way to extend the shelf-life of economic systems deeply

implicated in accelerating climate change? Can we imagine roles for and forms of cycling that might challenge the push for greater and more efficient mobility: processes already recognised as fundamentally unsustainable (Whitelegg 2016)?

In practical terms we would be happy to have a longer parallel workshop session, allowing for the time to think and grow ideas and responses since the aim is not just to provide information.

References

Paulsen, M., jagodinski, j., Hawke, S.M. (eds.) 2022. *Pedagogy in the Anthropocene: Re-wilding education for a new earth*. Cham: Palgrave Macmillan.
Rosa, H. 2019. *Resonance: a sociology of our relationship to the world*. Cambridge: Polity
Rosa, H. 2020. *The uncontrollability of the world*. Cambridge: Polity.
Spinney, J. 2020. *Understanding urban cycling: exploring the relationship between mobility, sustainablity and capital*. Abingdon: Routledge.
Urry, J. 2003. *Global Complexity*. Cambridge: Polity.
Whitelegg, J. 2016. *Mobility*. Shrewsbury: Createspace.

How does privilege (or the lack of such) affect our transport mode choices

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Keywords
Intersectionality, Mobility planning, Planning bias, Inclusive cycling, Mobility access

Challenge Addressed / Research Problem Investigated
Reflecting on blind spots in the bicycle planning process to raise awareness for the lack of access and mode choices marginalized people face

Abstract
We all bring our own perspective and life experience into our work as cycling researchers which means personal bias is inevitably intertwined with the work we do. This workshop aims to bring awareness to these individual perspectives. By doing so we also become more sensitive to the perspectives we do not have much knowledge about. It shall help to see our diverse and individual backgrounds as assets for our research and common goal to create an inclusive cycling environment for everyone.

After a brief introduction to the topic the workshop will start with an exercise called the “wheel of privilege” - a self-assessment tool based on the work of Sylvia Duckworth and Tessa Watkins and adapted for the workshop’s focus. The wheel of privilege as a worksheet visualizes twelve categories of privileges where each participant can assess their proximity to what is considered the norm in society and therefore accumulates power. The exercise is followed by a set of questions to reflect on the experience and highlight first aha moments for individuals and as a workshop group. The wheel of privilege will be wrapped up with a group discussion on which privilege categories influence people’s mobility behavior, mode choices or general access to different means of transportation.

For the second exercise during our workshop, participants are asked to collect and discuss exemplary successful implementations that deal with the different mobility challenges presented throughout the workshop. We will brainstorm as a group about methods and projects that do address the different identified mobility needs and look for best-practice examples within and outside of the field of mobility. The results will then be clustered by different stakeholders to visualize potentials for future research collaborations.

Overall, our workshop aims to create an interdisciplinary sphere for mobility planning, to enable to think outside the box and expand our expertise and to establish a pool for further research in mobility planning.

Whither cycling research? A collaborative identification of policy-relevant research priorities

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Keywords
Policy relevance; collaborative workshop; research priorities; cycling policy

Challenge Addressed / Research Problem Investigated
Collectively identify key current priorities and needs for cycling research through a collaborative worskshop.

Abstract
Academic research on cycling as transportation has grown steadily over the past decade, paralleling the mainstreaming of cycling policy in cities worldwide. While cycling might have once been a relatively niche topic for transport and urban researchers, this is no longer the case: to a large extent, cycling has become as a transport mode like any other. While this is a positive development, it also means that the perceived need or urgency for cycling research which existed years ago has faded away. Already in 2020, Nello-Deakin argued that we might be reaching "saturation" in certain areas of cycling research, with new studies contributing almost no meaningful new insights for policy.

In this context, the present session proposes an interactive collaborative workshop to collectively identify key current priorities and needs for cycling research. While primarily geared towards policy relevance, these priorities may also include more theoretically oriented questions. Although this same question has been tackled before by Handy et al. (2014), their article dates from almost a decade ago. The aim of the proposed session is to revisit this question, taking into account both research and real-world developments over the past 10 years.

As a potential outcome of the session, its key conclusions might serve as the basis for a short collective written commentary, which would fit the character and aims of the proposed special issue in the *Journal of Cycling and Micromobility Research*. While the success of this idea is not guaranteed, the proposed session would be organised and run with this end goal in mind. Although on a much larger scale (since it applies to transport and mobility as a whole), a recent article by Ryghaug et al (2023) may provide a useful source of inspiration in this respect.

References
Handy, Susan, et al. «Promoting Cycling for Transport: Research Needs and Challenges». Transport Reviews, vol. 34, 1, january 2014, p. 4-24. DOI.org (Crossref), https://doi.org/10.1080/01441647.2013.860204.

Nello-Deakin, Samuel. «Environmental Determinants of Cycling: Not Seeing the Forest for the Trees?» Journal of Transport Geography, vol. 85, may 2020, p. 102704. DOI.org (Crossref), https://doi.org/10.1016/j.jtrangeo.2020.102704.

Ryghaug, Marianne, et al. «A Social Sciences and Humanities Research Agenda for Transport and Mobility in Europe: Key Themes and 100 Research Questions». Transport Reviews, vol. 43, 4, july 2023, p. 755-79. DOI.org (Crossref), https://doi.org/10.1080/01441647.2023.2167887.

Change management: fostering innovative municipalities

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Challenge Addressed / Research Problem Investigated

The labor shortage is a problem.

Abstract

The "Innovating Mobility" workshop aims to tackle the pressing challenges of workforce shortage and rigid structures in public administration to accelerate the development of cycling infrastructure and design more people-centric mobility concepts. In this workshop, participants will engage in a dynamic and collaborative environment to brainstorm innovative solutions. With the method of gamestorming, a collaborative and interactive workshop method that utilizes playful games and activities to foster creativity, engagement, and problem-solving we want to create a plan for municipalities, to accelerate the development of cycling infrastructure. Through little tasks such as “Prune the Future” we will identify ways that haven´t worked or slowed down processes. By “Remembering the Future” we will map out milestones and signs of a positive change in municipalities.

Competences for riding e-bikes safely - and what role does the infrastructure play?

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Keywords
E-Bikes, Competences, Cycling Infrastructure, Road Safety

Challenge Addressed / Research Problem Investigated
Define the competences necessary to ride an e-bike safely, discuss the role of infrastructure and other road users as well as the effects of new regulations (e.g. the introduction of a driving licence).

Abstract
Electrically-assisted pedal bikes (e-bikes) are a more and more popular type of bicycles, among other reasons because they allow to easier ride hills. Therefore, in hilly countries, they are an essential factor to increase the share of cycling. In Switzerland, meanwhile nearly half of all bicycles sold are e-bikes and their use is increasing, the number of accidents is also rising. This has led to a debate on safety focused on the individual level of the e-bikers, even though we do not know if the increase in accidents is simply proportional to the increase in the number and use of e-bikes. Furthermore, we are convinced that not only the cyclist plays a role to safely ride an e-bike, but also the (often inexistent or insufficient) cycling infrastructure and the behaviour of other road users (especially car drivers) are also important aspects. It is important to highlight that a substantial number of collisions between e-bikes and cars can be attributed to the actions of drivers. In the ongoing political debate, the question if e-bikes should be regulated by introducing driving licences has been raised, especially for the so-called fast e-bikes (or s-pedelecs) reaching up to 45 km/h. In the Swiss context, the current requirement to ride a fast e-bike (or a slow limited to 25 km/h under the age of 16) for individuals without driving licenses is to pass a theory exam. However, it is worth noting that 90% of the Swiss population between 25 to 64 years old possess a driving licence, and this proportion is even higher among e-bike users. Another ongoing political issue is the proposal to lower the minimum age of 14 to 12 for e-bikes with an assistance of up to 25 km/h.

Responding to a call of the Swiss Federal Roads Office research program, we investigate the competences needed to drive an e-bike safely. To understand them, we adopt a broad understanding of competences and also analyse the cyclists' motivations and cycling trajectories. Our interdisciplinary team (combining social sciences, traffic psychology and medicine) has analysed existing literature, conducted interviews with new and experienced e-bike users (in different regions of Switzerland, urban and rural, more or less hilly) and with experts of different fields related to cycling and mobility practices. We work towards

maintaining a critical perspective not limited solely to the individual level. Therefore, we also encompass other pertinent factors such as the influence of infrastructure and interactions with other road users.

In our group contribution we propose to briefly summarise the research projects' findings so far and then discuss with the participants and their different backgrounds (disciplinary as well as geographically) if our catalogue of competences is complete, how to integrate the role of infrastructure and other road users (e.g. enhance and improve comprehension and communication among road users) as well as how regulation could improve e-biking or hinder it. The participants of CRBAM will help us to test the workshop method we will realise with Swiss experts in November. The discussions will also allow us to integrate knowledge and experiences from other fields and countries to our conclusions.

Keep Africa Active: Promoting active mobility in sub-Saharan Africa

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Keywords
Active mobility, cycling safety, mobility behavior, sub-Saharan Africa

Challenge Addressed / Research Problem Investigated
Promoting active mobility for a safer and conducive environment for cyclists in Africa.

Abstract

INTRODUCTION AND BACKGROUND
In African cities, 78% of the population commutes by foot and on bicycles every day [2]. This high modal share of active mobility presents an opportunity for sustainable transportation within the continent. However, this trend is changing due to ongoing rapid urbanization and increasing economic growth. As income levels rise, people tend to shift towards private cars and motorization is becoming the future threat in Africa. It is projected that by 2030, the number of vehicles in developing countries will surpass that of developed nations [1]. Even the current transport planning and infrastructure provision in Africa have primarily focused on cars, undermining the importance of active mobility preferred by the majority. Active mobility in most African cities is one of the riskiest modes and the region has the highest rate of road traffic fatalities, with 26.6 deaths per 100,000 population [3]. Unfortunately, pedestrians and cyclists are the primary victims. This is largely attributed to the neglect of necessary infrastructure for pedestrian and cyclist safety.

At the conference, we would like to present and discuss a part of the comprehensive results of a joint research project between two German universities and three African universities to work collectively on promoting active mobility in Africa. CAMA is a collaborative research project focused on active mobility, funded by BMBF (Federal Ministry of Education and Research) and DAAD (German Academic Exchange Service). One of the goals of the project is to foster the exchange of knowledge in the promotion of active mobility between sub-Saharan Africa and Germany. As part of the knowledge exchange program, there are postgraduate students in each partner university as learning alliances.

Recently, we conducted an online survey to examine the mobility behavior of active mobility users in Ethiopia, Kenya, and Uganda, with a sample size of n=1367. The main objective of the survey is to better understand the active mobility users' perception, preferences, daily experience, and individual barriers to active mobility by providing a deeper insight into how cyclists and pedestrians feel as well as the distances cycled or walked. The findings from the online survey will be an input for the living labs and real-life experiments for the promotion of walking and cycling. The learning alliances will develop tangible local solutions for the living

labs and real-life experiment interventions. These low-cost solutions will be temporary, experimental, visible, and tactical interventions that aim to test the impact of promoting active mobility and can be easily dismantled in the short term.

The objective of the workshop is to engage participants in a discussion about the research findings of the project and encourage the development of innovative solutions and real-life experimental ideas to promote cycling in the three African countries. The workshop will be supported with maps, charts, stickers, and markers so that each group can put and present their ideas. The workshop results will be an input and experience for the planned living labs and real-life experiments in the case countries in 2024.

GOAL OF THE WORKSHOP

In the workshop, we will provide an engaging and interactive session for participants to discuss active mobility research findings and develop innovative solutions to promote cycling in African cities. The results and ideas will be an input for the planned living labs and real-life experiments in the case countries in 2024.

WORKSHOP PLAN

Part 1: Introduction: During this session, participants will receive a brief overview of the online survey results and gain an understanding of the significance of promoting cycling in Africa.

Part 2: Group Discussion and Brainstorming: in the second part of the workshop, we will provide guiding questions to individuals. Guiding questions will be based on the research findings. These questions will include topics such as minimizing the threat of motorization, promoting sustainable mobility, enhancing active mobility (especially cycling) without compromising urbanization goals, identifying barriers to cycling, and improving infrastructure to support cycling. Participants will be encouraged to jot down their insights, experiences, and innovative ideas for temporary, experimental, visible, and tactical interventions. The 1- 2- 4 all approach will be implemented to facilitate the discussion.

Part 3: Group summary: At the final session of the workshop, the teamed-up groups will summarize their discussion and present their proposed solutions. The workshop will then highlight the key points that emerged from the group discussions.

In summary, the workshop will conclude with a discussion on the next steps, which will include integrating the workshop results and ideas into planned living labs and real-life experiments in the case countries. The expected outcome of this workshop is the generation of innovative solutions, insights, and experimental intervention ideas from different perspectives to promote cycling in the three countries. These ideas will be based on the survey results and the fruitful discussions among the workshop participants.

References

1. Lloyd W. and Lewis F. (2005), Climate Change Mitigation and Transport in Developing Nations Transport Reviews, Vol. 25, No. 6.
2. UNEP (2022), Better infrastructure and policies can protect a billion African pedestrians and cyclists.
3. WHO, Global status report on road safety, World Health Organization, 2018, 26 pp.

Workshop on Enhancing Construction Site Layouts for Cyclist Safety: Incorporating Road User Perspectives

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Keywords
safety, construction work, active mobility, design

Challenge Addressed / Research Problem Investigated
Improving the safety of active travelers at construction sites that are complex, narrow, and unintuitive by empirically analyzing the status quo and utilizing the results to develop adjusted layout designs.

Abstract
INTRODUCTION AND BACKGROUND
Road construction sites pose a significant safety threat to cyclists, with studies indicating that their presence doubles the likelihood of accidents (Teschke et al., 2012). However, this topic has received limited attention in the research community, with previous studies primarily treating construction sites as a control variable within accident research (Alrutz et al., 2012; Teschke et al., 2012). To bridge this knowledge gap, the research project BRAVOUR (Needs of Cyclists at Construction Sites - Traffic Psychological Analysis on User-Specific Requirements), funded by the Federal Ministry for Digital and Transport of Germany, aims to comprehensively examine the factors that contribute to accidents in construction sites. One way in which this objective is accomplished is by utilizing the qualitative methods employed during this proposed workshop to incorporate the needs and concerns of road users at construction sites.

WORKSHOP PLAN
The workshop provides participants with an overview of current research findings on cyclists' and pedestrian behavior in construction sites.

The main component of the workshop will comprise two interactive sessions employing visual aids such as flipcharts, colored paper shapes, and printed construction layouts to actively engage the participants in the discourse. In the first session, participants will be divided into groups (3-5 people) each assigned a specific construction site. These groups will engage in in-depth discussions to explore how the unique needs and concerns of active road users (e.g., cyclist, pedestrian, person with special needs) can be met through the construction site layout. Each group will then deliver a short presentation summarizing their findings.

Consecutively, a comprehensive review of German guidelines for construction site design and safety will be presented, highlighting relevant regulations and recommended practices.

In the second session, each group will work on comparing the guidelines to the in session one developed layouts identifying discrepancies between the proposed layout and current regulations to suggest specific adjustments.

The results will again be presented to all workshop participants and assessed in terms of their ability to ensure safe conditions for each road user type.

By fostering collaborative discussions and incorporating practical exercises, the workshop aims to generate meaningful dialogue and innovative solutions for improving construction site layouts to enhance the safety of pedestrians, cyclists, and other road users. The workshop outcomes will contribute to the development of evidence-based recommendations and guidelines that promote the safety of all individuals in construction site environments.

References

Alrutz, D. (2009). *Unfallrisiko und Regelakzeptanz von Fahrradfahrern: Bericht zum Forschungsprojekt FE 82.262: Unfallrisiko, Konfliktpotenzial und Akzeptanz der Verkehrsregelungen von Fahrradfahrern*. Wirtschaftsverlag NW, Verlag für neue Wiss.

Teschke, K., Harris, M. A., Reynolds, C. C. O., Winters, M., Babul, S., Chipman, M., Cusimano, M. D., Brubacher, J. R., Hunte, G. S., Friedman, S. M., Monro, M., Shen, H., Vernich, L., & Cripton, P. A. (2012). Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study. *American Journal of Public Health*, *102*(12), 2336–2343. https://doi.org/10.2105/ajph.2012.300762.

Cyclists' Spatial Requirements – Ending the Era of Engineering Estimations

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Keywords
Bike paths, bike lanes, design guidelines, minimum width, spatial requirements,

Challenge Addressed / Research Problem Investigated
Developing recommendations for minimum widths of bicycle infrastructure while accounting for the needs and preferences of cyclists.

Abstract
Cyclists comprise a diverse group with varying preferences and requirements regarding bicycle infrastructure. While an experienced cyclist may find a particular infrastructure section comfortable, it may be deemed completely unusable by a significant portion of the population.

Constructing comfortable infrastructure can be a challenge. Considering the substantial costs associated with building physical infrastructure we neither want to build too narrow, nor too wide. Although separated bicycle infrastructure tends to be more cost-effective than other transport alternatives, it still requires considerable funding for construction and long-term maintenance. Historically, design guidelines for bicycle infrastructure in Sweden have relied heavily on engineering guesswork and estimates. To optimize the allocation of resources for cycling infrastructure, while at the same time maximizing cycling potential, one way could be to establish a "good enough" minimum width. By "good enough," we imagine a standard where all potential cyclists feel comfortable and safe using the bike paths. Developing well-researched standards for minimum width requirements in different traffic situations can assist decision-makers and traffic planners in creating a bicycle path network that appeals to cyclists while making efficient use of available funds.

This work is part of a governmental assignment handed to the Swedish Transport Agency in 2021 regarding if changed traffic rules could lead to an increase in the proportion of road users who travel by bicycle. The Swedish Cycling Research Centre at the Swedish Road and Transport Research Institute (VTI) was asked to provide scientific input to the question

regarding minimum widths on bicycle infrastructure. Should there be regulated minimum widths and if so, how wide?

To establish minimum width requirements for various types of bike infrastructure, we must first assess cyclists' spatial needs. In our work, we present a model for calculating the widths of bike paths. The results are primarily based on existing research on cyclists' behavior and preferences in different situations, enabling us to develop design guidelines. To simplify the calculation, we follow these steps:

1. Define the width of the bicycle itself.
2. Incorporate the lateral displacement variability, which represents the natural sideways wobble when a cyclist maintains balance.
3. Include different safety distances to account for other road users or objects adjacent to the bike path.
4. Include the need for extra space at start/stops, high or low speeds such as at steep hills, turn radius and leaning in corners etc.

Depending on the need for overtaking and presence of oncoming traffic we then calculate the total width of a bike path or bike lane at a specific location.

Despite the seemingly straightforward nature of this calculation, the scarcity of scientific studies in this field complicates matters. Few published studies have focused on specific parameters of cyclists' spatial needs, so conclusions often must be drawn from studies that just happened to collect the needed data. Additionally, we lack validated methods for analyzing cyclists' behavior and spatial preferences about what constitutes a "good enough" level. Our recently published report highlights several parameters that require further in-depth study. The work we have published could be used as a base model for future studies of cyclists' spatial needs and input to design guidelines.

The study found no country that currently enforces regulated minimum widths for bicycle infrastructure. Instead, most road authorities rely on design recommendations that include suggested minimum widths. While these recommendations may vary across road authorities and countries, the differences are not believed to be the primary factor driving increased cycling in different regions. The key distinction probably lies in the implementation and adherence to these recommendations.

The Netherlands is often regarded as stricter in following design recommendations, despite the absence of formal regulations. This approach has resulted in the development of a comprehensive network of bicycle infrastructure that instills a greater sense of safety among cyclists and encourages higher usage. In accordance with the Dutch practice, our findings indicate that planners in the Nordic countries express skepticism towards regulated minimum widths. Instead, they emphasize the need for more detailed and explicit design recommendations.

By highlighting the importance of translating design recommendations into practical implementation, we can promote the creation of cycling infrastructure that is truly effective and meets the needs of cyclists. It is not solely about the presence of well-defined design guidelines but also the commitment to incorporating them into planning processes and knowing which qualities are lost when we fail to live up to the recommended standards.

Link to full report (in Swedish): https://urn.kb.se/resolve?urn=urn:nbn:se:vti:diva-19782