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Towards cycling engagement by mapping design interventions to observed barriers: an example from Glasgow's bike share programme

Mia Shepherd [1,✉], Tripp Shealy [2], Lewis Urquhart [1], Deirdre Harrington [1] and Anja Maier [1,3]

[1] University of Strathclyde, United Kingdom, [2] Virginia Tech, United States of America, [3] Technical University of Denmark, Denmark

✉ mia.shepherd.2022@uni.strath.ac.uk

Abstract

The benefits of cycling are well-established, but how to engage people with bikes for active travel is far less understood. This study offers insights into the motivations, barriers, and design solutions associated with cycling. Interviews with 30 bike-share users in Glasgow, UK found a key motivation to be commuting time efficiency and the predominant barrier was shared space with vehicles. Alignment between the most mentioned design solution, dedicated cycling lanes, and the significant barrier of sharing space with vehicles underscores the importance of behavioural design interventions.

Keywords: human behaviour, behavioural design, cycling, mobility, transport

1. Introduction

1.1. Environmental, health and well-being benefits and cycling adoption

Cycling is a critical strategy to help meet ambitious climate goals as it produces zero direct emissions. Beyond its immediate impact on reducing carbon emissions, cycling can also help increase personal health and well-being (Green et al., 2021). Cycling is a form of cardiovascular exercise (Rynda et al., 2022) and can play a role in weight management through an increase in energy expenditure (Al-Haboubi, 1999). Engaging in cycling can also relieve stress and improve cognitive function (Crane, 2022; Leyland et al., 2019). It can also improve community cohesion (Crane, 2022), reduce noise pollution, and traffic congestion (Fosgerau et al., 2023). Despite its many positive impacts and merits, cycling remains underutilised globally as a mode of transportation (Buehler and Goel, 2022). The challenge of promoting cycling is there is not a one-size-fits-all approach to gain widespread engagement and adoption (Biehl et al., 2019; Doğru et al., 2021); it is deeply entwined with a multitude of factors exerting influence on its adoption (Biehl et al., 2019). For example, cycling in regions with mild climates may differ significantly from areas with extreme weather conditions (Goldmann and Wessel, 2021). Social norms play a pivotal role, as regions with a strong cycling culture tend to have higher adoption rates (Haustein et al., 2020; Law and Karnilowicz, 2015; Nello-Deakin and Nikolaeva, 2021). The connectivity of cycling with public transit systems also varies widely, impacting the feasibility of multimodal commuting (Kong et al., 2020). The topography of a region, hills, mountains, or flat terrain can also significantly affect the physical effort required for cycling, and thus, its attractiveness (Matias et al., 2020). Moreover, individual preferences, motivations, and perceived

barriers play a vital role, making the experience of cycling deeply personal and subjective (Biehl et al., 2019; Doğru et al., 2021).

1.2. Towards designing cycling engagement

Designing and the study of design offers a promising approach to untangling the intricate web of challenges that hinder the local adoption of cycling and provide innovative solutions that can reshape the future of sustainable urban transportation. Design and designing interventions, in this context, can help on multiple levels – it can induce behavioural changes at the individual (Micro) level, help to refine and improve the cycling experience across riders (Meso), or instigate shifts in societal norms (Macro) (Maier and Cash, 2022). For instance, taking a user-centred design approach could result in the development of a more intuitive mobile application to support bike-share programmes, ergonomic bicycle models, or more cyclist-friendly routes. Design research can help better understand user behaviours, motivations, and personal barriers. This is essential, for cycling, as individual preferences and perceived challenges play a significant role in cycling adoption (Barberan et al., 2017). The iterative process of design allows for testing, refining, and retesting of proposed solutions. As a methodological approach, design is well-suited to help increase the uptake and adoption of cycling, where trying out new infrastructure, policies, or incentives can provide feedback for continuous improvement. The current landscape of promoting cycling often reveals a gap between identified barriers and effective design solutions (Robartes et al., 2021), particularly when viewed through the lens of user-centred design (Buhl et al., 2019). The prevailing approach is to implement solutions from a top-down perspective (Pucher et al., 2010). The traditional channels for input and feedback often lack the direct involvement of the cyclist user group the changes are meant to help protect and promote (Marquart et al., 2020). Better mapping barriers and design solutions from cyclists can help bridge this gap, as it allows for a more nuanced understanding of challenges and preferences at the individual (Micro), organisational (Meso), and larger institutional societal (Macro) levels. While current solutions often revolve around addressing specific issues like bike station re-balancing using optimisation models (Zhou et al., 2022), for example in the context of a city's bike share programme, more comprehensive solutions that address user-identified barriers remain unclear. Exploring the cyclist's perception of responsibility for improving cycling is an underexplored area, presenting an opportunity for user-centred design to inform decisions and interventions that resonate with the cycling community's needs and aspirations.

1.3. Study purpose and structure of the paper

The purpose of this study was to explore the foundations for enhancing and increasing cycling engagement. The objectives were to study the challenges/barriers faced by cyclists, using a popular bike share programme, their ideas for enhancing their cycling experience, and to map the relationship between barriers and potential design interventions as solutions. The specific questions addressed in this study, include (1) what motivates people to cycle, (2) what barriers do people experience while cycling, (3) what design ideas do people provide to improve their cycling experience, and (4) how do their barriers and design ideas relate? By mapping these challenges and design ideas the aim was to contribute a deeper understanding of the transformative potential of design in shaping the future of cycling and, by extension, more broadly urban sustainability; as such, bridging design, cycling, health, and sustainability, to unlock future solutions where bicycles are not just an occasional choice but a more integral component of urban mobility. The Methods section outlines the approach to studying cyclists and the procedures used for data collection and analysis. The Results present findings to each of the four research questions and illustrates the mapping between barriers and proposed design ideas. The Discussion offers implementation strategies for design practice and future research directions.

2. Methods

2.1. Geographic region and user group

The varying areas of hilly and flat, grid-like topography coupled with the often inclement weather of Glasgow, UK make this geographic region a compelling use case for investigating challenges and design

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ideas to foster cycling adoption. Glasgow recently underwent significant redevelopment of its cycling infrastructure, marked by the implementation of the bike share network (OVO Next Bikes) in 2014, the introduction of electric bikes to the Next Bike fleet in 2019, additional Next Bike stations added in 2021 and 2022, and the construction of new cycle paths, both integrated into active roadways and independent from them over the last decade. The city's commitment to being bike-friendly and more sustainability-focused was highlighted by its recent hosting of the 2023 Union Cycliste Internationale (UCI) Cycling World Championships and the United Nations Climate Change Conference (COP26) in 2021. The local OVO Next Bikes programme reached a critical milestone in July 2022 exceeding an often-cited key performance indictor of one trip per bike per day (Médard de Chardon et al., 2017). The current fleet of OVO Next Bikes includes more than 1,100 bikes. Bike share riders are a particularly useful group for exploring perspectives on cycling because they represent a cross-section of the community engaged in this sustainable mode of transportation. As individuals who regularly utilise bike share programmes, they offer insights into the barriers and preferences associated with cycling in a real-world urban environment. Their experiences are likely to include more varied aspects of urban cycling experiences, compared to a recreational cyclist, because bike users frequently navigate within the city's topography, experience changing weather conditions, and interact with the bike-share infrastructure. Furthermore, their experiences are not influenced by varying levels of bike/gear performance which provides a comparable baseline. By focusing on this specific cohort, the study aimed to uncover the details about user motivations, and barriers, and their design ideas to enhance the cycling experience.

2.2. Sample location

Data collection occurred at multiple Next Bike stations in Glasgow. Two stations were located within the most deprived regions of the Scottish Index of Multiple Deprivation (SIMD). One East of the city and one South West of the city centre. Two stations from the least deprived regions based on the SIMD were also used. One station was West and another South of the city centre. Two locations near the city centre and near a University were also selected. The time of day and day of the week varied intentionally to capture the perspectives of both commuters and non-commuters. A total of 30 field interviews were conducted and lasted 15 minutes on average. Sixteen interviews were conducted in the city centre, six in the most deprived SIMD areas, and eight in the least deprived areas (see Figure 1).

Figure 1. Locations of data collection selected using the Scottish Index of Multiple Deprivation (SIMD); interviews occurred at multiple bike station locations in Glasgow

Individuals returning bikes were approached and invited to participate. The study protocol was reviewed and approved by the ethical review board at The University of Strathclyde. The interviews were semi-structured and included a broad range of open-ended questions about their recent cycling journey. Questions related to people's motivation to cycle included asking why they chose to cycle, what was their alternative transport mode, and if they were to recommend the bike share programme to a friend, what aspects or features would they highlight. Considering barriers, participants were asked what would enhance their cycling experience and to what extent they believed the bike share programme is embraced or utilised by others in Glasgow. Participants highlighted on a map, areas on their route that positively or negatively shaped their experience. Questions about design solutions included what would have enhanced their cycling experience, what suggestions they have to get more people cycling in Glasgow, and if they could redesign their journey, what key features or characteristics would that route include.

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2.3. Data collection, analysis, and participant demographics

Interviews were audio recorded and transcribed. Transcriptions were coded using broader themes related to bike share users' motivations, challenges, and design ideas to improve the cycling experience. Motivation, challenges, and design ideas were grouped as either Micro (affecting the individual only), Meso (affecting groups of people), or Macro (affecting everyone (assuming they are physically able to cycle). A second coder reviewed the motivation, barriers/challenges, and design ideas (solutions) to validate the emergent codes within each theme and tagging of codes as either Micro, Meso, or Macro.
The results present coded motivations, challenges, and design ideas, frequency ranked by the number of different participants mentioning the respective challenge etc. The stated barriers/challenges and design ideas/solutions were mapped to demonstrate potential connections. The mapping process linking barriers to ideas was conducted iteratively, involving multiple members of the research team to ensure not only face validity but also a comprehensive exploration of the data. The iterative nature of the mapping allowed for continuous refinement, discussion, and adjustment. By adopting this collaborative approach, the study aimed to maximise the validity of the mapping process.
Of the 30 participants interviewed, 70% identified as male and 30% as female. This is similar to the gender distribution of bike share users recorded by Sun et al. (2017) with 25.2% female representation in their data. The gender distribution of results from this study differs from that of Larouche et al. (2021) with 45.9% female representation in their data set. The most common age group of respondents in the data collected in the study was 26-35 at 40%, followed by 36-45 (23%), 16-25 (20%), 46-55 (10%) and 56-65 (7%). Eighty percent of interviewees reported a minimum level of a bachelor's degree, with 50% possessing a graduate degree, which mirrors the education level of users of the bike share programme by Zhang & Mi (2018) and Wang et al. (2021).

3. Results

3.1. Commuting and time were the most prevalent reasons for cycling

The majority of people interviewed were motivated to cycle as a form of commuting (20 out of 30) and because it was the quickest mode of transportation (18/30). More than half (18/30) said they cycled using the Next Bike programme more than three times per week. The bike share programme was primarily used for short distances with 63% (19/30) cycling one to two miles, 33% (10/30) travelling two to 10 miles and no interviewees reported cycling long distances (more than 10 miles). Whilst the highest frequency of cyclists said they were motivated because they perceived it as the quickest mode of transportation, half (15/30) also indicated they were motivated to cycle because of the health benefits it provided as a form of exercise. They were also motivated because it was less expensive than other modes of transportation (13/30). Several local universities offer a bike share programme scheme with reduced or free bikes to employees and students. About one in three (9/ 30) mentioned this incentive as motivation for its use. The station locations near their final destinations, available spaces to drop off the bikes, and not being responsible for the bike outside of the journey were positive motivators for 9 out of the 30 cyclists interviewed. Several people mentioned factors like good weather and wanting to spend time outdoors but these were not prevailing motivations for cycling. Only two of the 30 participants indicated they owned a car. When specifically asked how they would have travelled otherwise, 21 mentioned they would have used public transport (bus, train, or subway). The bus (11 mentions) was the most common alternative. Most users were not replacing car journeys with Next Bikes but mostly replacing public transport, especially bus trips. Several mentioned their choice for a bike over a bus was because they felt more in control over their journey, not waiting for a bus that may not arrive on time. A total of 18 people mentioned they would also have walked. Only about one in ten (4/30) said they would have driven or taken a taxi. For instance, one user said, "I would've walked to a subway station and then got the subway here, or maybe driven". Another user said, "to get to work I have to drive, but it's kind of a last resort". Two users mentioned using their own bike.

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3.2. The biggest barrier to cycling more often was sharing space with vehicles

Overwhelming, the most frequently mentioned barrier to cycling was having to share space on the road with vehicles (23/30). Maintenance of the Next Bikes was the next most frequently mentioned barrier (12/30). One in three interviewees mentioned the availability of bikes as stations being a barrier (10/30). Several people also mentioned problems with the Next Bikes like the phone application not accurately reflecting bike availability at each station or that it has been locked (4/30), the station coverage not reaching their destination (7/30), and generally a perception of other users neglecting or intentionally vandalising the bikes (3/30). Additional, but also less frequently mentioned, people mentioned a stubborn and negative culture around cycling (7/30), route obstacles like closed roads or challenges accessing dedicated cycle lanes (4/30), poor road surfacing (3/30), unsafe intersections (4/30), and sharing spaces with pedestrians (5/30). Few mentioned the topography (5/30) and weather (4/30) as reasons inhibiting cycling.

3.3. Dedicated cycling lanes was the most mentioned design element to enhance the cycling experience

A total of 97 design ideas to enhance the cycling experience were suggested, fewer than the listed barriers (117). The design concept most frequently mentioned aligned with the most prominently mentioned barrier. More than two out of every three cyclist (23/30) indicated more dedicated cycle lanes would enhance the cycling experience. Yet, few (10/30) provided detailed suggestions about where these lanes would be most useful, with even fewer (4/30) stating specific street names. About 30% of cyclists (9/30) mentioned reconfiguring the space provided to vehicles or more cycling rights, like providing cyclists the right of way over vehicles when turning or stopping, cyclists having entitlement over space, reducing vehicle speed limits on shared roads, and reducing lane width for vehicles as a speed reduction tacit. Another theme of ideas from about 30% of cyclists (10/30) was related to information awareness/campaigns for the public. Specifically, mentioning topics of how cycling helps improve your health/fitness, how it can be more cost-effective and convenient, that it can be done in all weathers with the correct clothing and equipment, or about the cycling infrastructure developments made in Glasgow. Interestingly, none mentioned campaigns targeting drivers changing their behaviours about sharing roads or providing space for cyclists. A handful of participants (5/30) suggested campaigns or schemes to incentivise return journeys or multi-modal ticketing discounts with the bus or transit system. Others (3/30) mentioned having more station coverage, more bikes per station, and more regular maintenance of the existing bikes.

3.4. More societal (Macro-level) barriers than design solutions

The barriers to cycling and the types of design ideas to improve cycling are listed in Figure 2 from most frequently mentioned to least frequently mentioned within the categories - Macro, Meso, and Micro. Macro encompasses overarching, systemic factors that influence cycling at the societal or city-wide level, such as city policies and cultural attitudes. Meso pertains to intermediate factors that impact cycling at the organisational or community level (Maier and Cash, 2022). Micro addresses individual-level factors that affect cycling, including personal preferences and perceptions. These levels of categorisation enabled the mapping of the multifaceted nature of barriers and design solutions, and the visualisation of possible interconnected layers of design ideas and intervention opportunities (Meadows, 2008) influencing the cycling experience. To accentuate potential "hot spots" of solutions for multiple barriers, only solutions that mapped onto three barriers or more are represented in figure 2. The design idea with the most possible influences on barriers is "more dedicated cycle lanes." (23/30) This large Macro-level design element can help address barriers, such as, "sharing space with vehicles," (23/30) "sharing spaces with pedestrians," (5/30) "need for a pleasant cycling environment," (2/30) "route accessibility," (4/30) "route interruptions," (2/30) "cycling distance," (2/30) and "culture" (4/30) and "perceptions" (2/30) around cycling. Meso-level design elements, "clearer signage," (1/30) "Next Bike maintenance," (4/30) "Increased Next Bike Stations," (5/30) "Less expensive E-bike rentals" (2/30) each match with four potential barriers. The number of Meso-level design ideas was higher than either the Macro or Micro-level design ideas. The design idea of "increasing awareness" (10/30) around cycling

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may help shift culture, and perceptions, improve understanding of cycling, and improve driver knowledge about road laws and distance between vehicles and cycling.

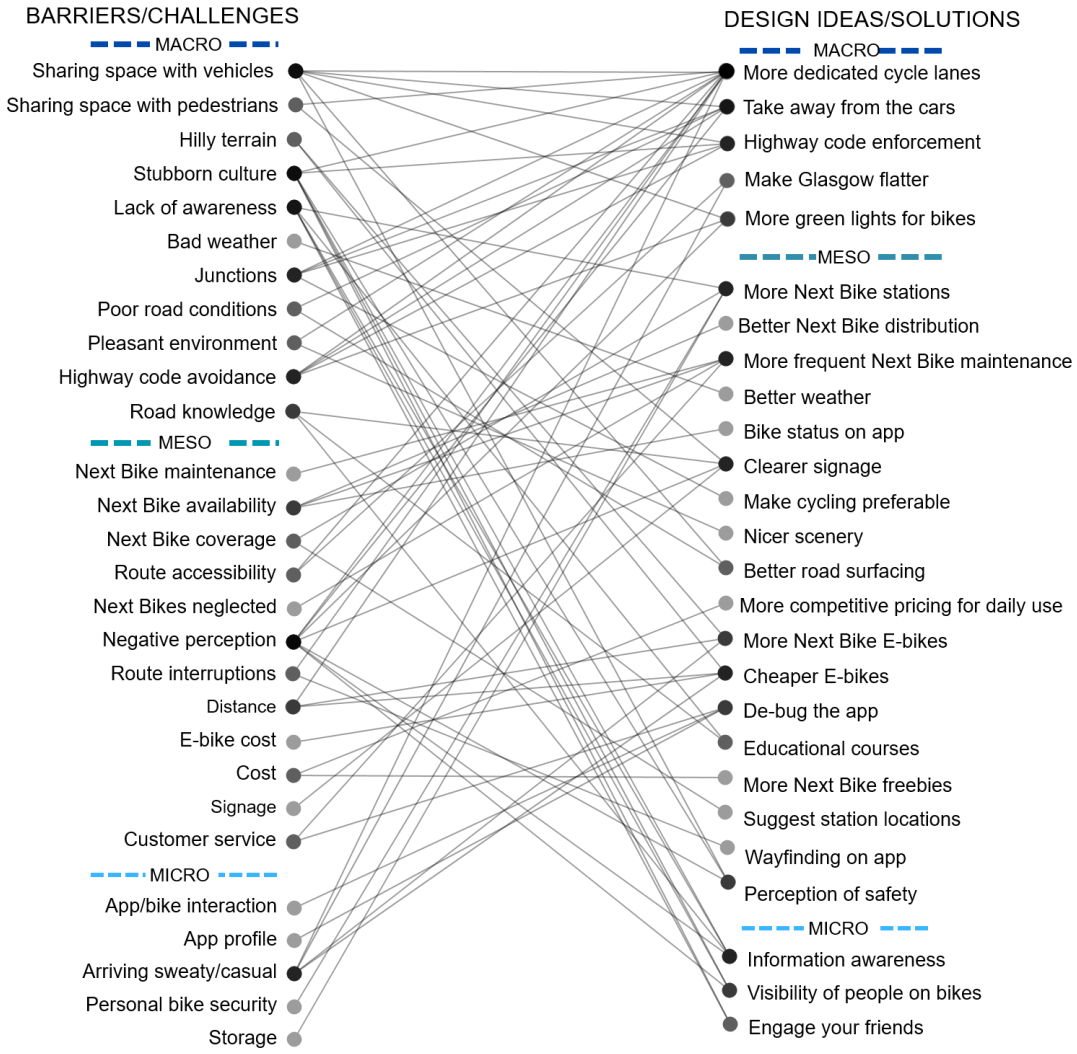

Figure 2. Macro, meso and micro-level cycling barriers/challenges and design ideas/solutions mentioned by the study participants and mapped on to each other by the researchers

4. Discussion

These findings align with prior research on cycling and reaffirm established insights into the motivations and barriers associated with this sustainable mode of transportation (Eren and Uz, 2020). These results shed light on crucial areas where design interventions are imperative. Bike lanes, a key design element, is a solution that addresses many barriers, encompassing societal, cultural, and perceptual issues, as well as addresses challenges related to route interruptions and potential distance and physical exertion. However, determining the optimal placement of bike lanes is complex (Cicchino et al., 2020; Pesshana et al., 2020), intertwined with societal acceptance that is not always straightforward (Lubitow et al., 2016) and the financial barriers facing Councils in enacting these changes. Instances like the planning, development, and construction and then subsequent removal of bike lanes in Elche, Spain, and Portland, Oregon, underscore the political sensitivity surrounding cycling infrastructure (Burgen, 2023; Maus, 2023). By engaging with residents and stakeholders, designers can gather valuable insights into the community's attitudes, preferences, and potential resistance to cycling initiatives. The practice of design acts as a bridge between the technical requirements of effective cycling infrastructure and the intricate social and cultural dynamics of a community.

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4.1. Implications for design practice

The results underscore a pattern, cyclists perceived challenges primarily at the Macro level, indicative of broader societal issues. Yet, the majority of their proposed solutions tended to operate at the Meso level addressing organizational or community-related factors, far fewer on the Macro-level, and next to none on the Micro-level. Cyclists, while adept at identifying challenges, may encounter limitations in articulating comprehensive design solutions. This discrepancy highlights an opportunity for designers to develop interventions, systemically to think and act on where the area of intervention may be and where the area of effect may be. It also opens questions on where the locus of change might be seen, i.e. whose responsibility is it to instigate Macro- and Meso-level changes to support behavioural change (Maier and Cash, 2022)? Designers can play a crucial role as facilitators, bridging the gap between user perceptions of Macro-level issues and the implementation of Meso-level solutions. The designer's expertise lies in translating user insights into tangible and strategic design interventions. This inclination towards scrutinising problems rather than prescribing solutions is a recurrent theme across various disciplines (Purcell et al., 1993; Simmons and Brennan, 2013) and the co-evolution of design (Cash et al., 2023; Dorst and Cross, 2001), emphasising the essential role of design and the action of designing in transforming challenges into actionable and impactful solutions. Designers are uniquely equipped to address the intricate challenges of promoting cycling adoption as they are trained in methodologies that facilitate comprehensive problem-solving. There is no one-size-fits-all solution for cycling adoption; it necessitates a nuanced understanding of the varied factors. Designers can employ techniques such as developing personas for different rider types, which involves creating detailed representations of typical users to better grasp their distinct needs and preferences. Additionally, designers excel at codifying design ideas, and streamlining complex concepts into identifiable patterns that aid in crafting targeted solutions. Design education also encompasses various categorisation methods that enable systematic analysis and proposition of tailored interventions (Kimbell and Stables, 2007; Schon and Wiggins, 1992). This nuanced approach, inherent to designerly thinking and design education, ensures that solutions are effective and also resonate with varied challenges associated with cycling adoption.

4.2. Implications for design research

The proposed design ideas/solutions reflect a tendency towards incremental changes in the built environment rather than embracing radical transformations. Suggestions such as slightly reducing vehicle lane widths, adding one or two more bike lanes throughout the city, or optimising traffic lights for cyclists are temperate, and indicative of a preference for gradual modifications. There is a noticeable absence of more radical concepts like car-free zones, comprehensive infrastructure overhauls, or free bikes for all. This inclination toward incrementalism may stem from a legacy, or path dependence, where existing structures and systems influence the trajectory of proposed changes. However, the urgency of climate change and societal challenges demands more immediate and radical design ideas. Designers, equipped with an understanding and the tools to navigate path dependence and fixation, can contribute by catalysing the shift towards more radical and transformative design solutions. The cyclists in this study cited speed, enjoyment, health benefits, and cost-effectiveness as key drivers in their mobility choices. These cyclists recognised the dual appeal of cycling—it's both enjoyable (motivation) and easy (ability). These align with established models of behaviour change, such as the theory of planned behaviour and the Fogg Behaviour model (Chiu et al., 2020), which emphasise the significance of motivation and ability. Leveraging these insights, design practitioners, trained in human behaviour can provide necessary insights, to offer a strategy to accelerate the adoption of cycling.

4.3. Implications to policy making

Designers can help develop innovative methods for devising efficient and effective strategies for gathering insights from a large and broad demographic, thereby contributing to a more robust understanding of the challenges and opportunities associated with cycling adoption. As such, the conclusions drawn from this study can be used to guide policy-makers and city planners in their future decision-making, e.g. towards cycling infrastructure, more inclusive, and greener cities more widely.

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The success of cycling in Glasgow, despite the local adverse weather and hilly terrain, underscores the potential universality of the insights found in this study. These results can apply to regions facing similar barriers or even those seemingly without as many impediments (e.g., more flat topography or less inclement weather). As e-bikes begin to level the playing field in terms of topography and ability, it becomes clear that conventional obstacles like hills, weather or fitness might not be perceived as significant barriers in the future or even now. These were not prominent barriers to the users in this study. Still, real challenges lie on the horizon for promoting cycling adoption and implementing the number one design element mentioned most frequently by cyclists in this study - more bike lanes. Infrastructure is a representation of cultural values (Jensen and Morita, 2017). Reshaping the form and function of physical infrastructure can imply a shift in these values and can be met with fierce resistance (Brown and Glanz, 2018; Gibson, 2005). By employing strategic communication, thoughtful framing, and innovative design solutions, designers can help mediate the potential tension between evolving values and physical infrastructure changes, fostering a more inclusive and adaptable urban environment.

5. Conclusions

This study offers insights into the motivations, barriers, and design solutions associated with cycling adoption, particularly within the context of Glasgow, UK. The results highlight commuting efficiency and time as primary motivations for cycling, while the predominant barrier is the shared space with vehicles. The alignment between the most frequently mentioned design solution, dedicated cycling lanes, and the significant barrier of sharing space with vehicles underscores the importance of design interventions. The study also reveals a pattern where cyclists perceive challenges at the societal (Macro) level but propose design solutions to address the intermediate factors that impact cycling at the organisational or community level, emphasising the need for designers to bridge this gap. Moreover, very few Micro-level design solutions were suggested, opening reflections on where the locus of change/control for behaviour change may lie, emphasising the need for behavioural designers carefully to consider the area of intervention and the area of effect. The findings also suggest a preference for incremental changes over radical transformations in the built environment. Designers, equipped with their unique skill set, can play a more pivotal role in navigating these complexities, facilitating comprehensive problem-solving, and developing innovative strategies for promoting cycling adoption. While there are some limitations to this study, including a limited geographic scope, a sample size of 30 participants, and an imbalance in age and gender distribution among participants, the findings still offer unique insights into the gaps between macro, meso, and micro barriers and interventions to designing better cycling engagement. These findings can serve as a framework and initial starting point for future behavioural design interventions related to regions facing similar challenges and emphasising the role of designers in helping shape sustainable urban transportation.

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